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Papers.

CELLULOSE AND ITS DECOMPOSITION IN THE SOIL BY MICRO-ORGANISMS.

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The literature on the decomposition of cellulose in nature is growing daily, owing to the fact that this substance or group of substances forms the largest single constituent of plant tissues introduced in great abundance into the soil, in the form of animal manures, green manures and various plant residues. Notwithstanding the numerous contributions to the subject, we still know comparatively little concerning the organisms active in the decomposition of cellulose and the chemical processes involved. Since most investigators of soil organisms were looking for bacteria active in the particular processes under examination, and since the bacteria decomposing cellulose are rather specific in nature, the difficulties are easily understood. The question of direct or indirect participation of celluloses in the formation of dark-coloured organic residues in the soil has also called forth recently considerable discussion, especially from the point of view of the origin of peat and coal. The following paper is a summary of the investigations on the decomposition of celluloses by micro-organisms carried out at the Department of Soil Chemistry and Bacteriology of the New Jersey Station by the author and his associates.

Microorganisms concerned in cellulose decomposition in the soil.

Micro-organisms capable of decomposing celluloses in the soil are found among bacteria, fungi, and actinomyces. The ability of protozoa and other invertebrate animals to decompose cellulose in the soil still remains to be investigated.

Various attempts have been made to classify the cellulose decomposing bacteria into aerobic and anaerobic forms, thermophilic and denitrifying forms, but it is doubtful whether any sharp lines of demarcation can be drawn between the different groups, since a thermophilic form may be at the same time an anaerobic organism or may be capable of reducing nitrates to atmospheric nitrogen. If any division is to be made among the bacteria decomposing celluloses, it should not go further than the separation into the aerobic and anaerobic species and even here the division is not very sharp. Each of these two groups may of course contain thermophilic and non thermophilic forms, organisms capable of bringing about the complete reduction of nitrates and those that are unable to do so. The group of aerobic bacteria includes a number of species capable of decomposing pure celluloses with a varying degree of rapidity ; here belong spore-forming and non-spore forming bacteria, rod-shaped forms, spherical and spirochaete-like forms.

Very few of the anaerobic bacteria capable of decomposing celluloses have been so far isolated in pure cultures, so that it is impossible to say at present whether these represent various forms or only limited groups of organisms.

It is not a difficult matter to demonstrate the presence of aerobic bacteria in the soil capable of decomposing celluloses, isolate them and even count them or obtain approximate information as to their abundance in a given soil. For the study of the various organisms isolated by KELLERMANN and his associates (8,9), cellulose-agar can be used. Anumber of organisms can be thus isolated which form a range of varieties, as demonstrated by a study of their cultural characteristics and morphology, but which can be included into two or three groups or species. These organisms decompose cellulose only to a limited extent and can grow readily on media containing other sources of carbon than cellulose. However, the soil harbors various cellulose-decomposing aerobic bacteria, which prefer cellulose as a source of energy and which cannot even grow with any other carbon source. Ordinary agar media are unsuitable for the study and isolation of these organisms. Silica gel media containing cellulose as the only source of carbon and inorganic sources of nitrogen and minerals are very suitable for the study of these organisms (2,16). Pure ground cellulose is suspended in a solution containing the necessary minerals in the proper concentration. The mixture is poured over the surface of a dialyzed silica gel plate and the excess of moisture is removed by drying the plate at 55°-60°C. The plates are inoculated with particles of soil and incubated at 28°-30°C. Growth will take place in the form of yellow or orange spots, within 2 to 4 days, around the soil particles. By diluting the soil with various volumes of sterile water, then adding some of the final dilutions to a series of plates, the approximate number of these bacteria can be determined.

Anaerobic bacteria capable of decomposing cellulose are present in the soil only to a very limited extent. This can be demonstrated by adding paper to the soil and introducing enough water to saturate the soil; the decomposition of the cellulose will proceed in a normal soil saturated with water at first very slowly. This is due to the fact that the fungi and aerobic bacteria (as well as the actinomyces), which are very active in the decomposition of cellulose under aerobic conditions in normal soils are prevented from attacking the cellulose, while no extensive flora exists in normal soils which would decompose celluloses, when the soil is covered with water. This flora, consisting of anaerobic bacteria has only to be developed. Decomposition of cellulose under anaerobic conditions will take place only after a month or more has elapsed. But once decomposition sets in, it proceeds very rapidly. When cellulose is again added to such an active soil, decomposition sets in immediately. Decomposition of cellulose under anaerobic conditions is carried out largely by spore-forming bacteria, with the formation of acids and gases (10).

When cellulose, in the form of ground filter paper, is added to the soil and the resulting increase in the development of micro-organisms is determined by the ordinary plate method (14), it is found that bacteria and fungi developing on the plate are both stimulated, but to a different extent, depending upon the soil conditions (17,18). As shown in Table I the addition of nitrogen to a soil receiving a heavy application of cellulose brings about a decided increase in the rapidity of cellulose decomposition. This is accompanied by a decided increase in the number of fungi and bacteria. Nearly all the fungi decomposing cellulose in the soil are capable of developing on the agar plate and, in spite of the various limitations of the plate method for determining the abundance of fungi in the soil, the results thus obtained can still serve as an index of the development of fungi due to the addition of cellulose to the soil. However, the increase in the numbers of bacteria resulting from the addition of cellulose to the soil, as determined by the plate method, is not due necessarily to an actual increase in the cellulose decomposing bacteria,

TABLE I. — *Influence of 1 per cent. cellulose, with and without $NaNO_3$ upon the development of micro-organisms in the soil after 17 days.*

Soil	Soil reaction	$NaNO_3$ added	Fungi		Bacteria (including Actinomyces)	
			Start	End	Start	End
	pH	per cent.				
Unlimed and manured soil.	5.4	0	87,300	320,000	6,500,000	21,400,000
		0.1	87,300	3,100,000	6,500,000	40,600,000
Limed and unmanured soil	6.5	0	20,000	47,000	7,760,000	17,400,000
		0.1	20,000	200,000	7,760,000	47,200,000

since these do not develop at all or only to a very limited extent on the ordinary synthetic medium used for counting soil bacteria. The increase in the cellulose decomposing bacteria has to be followed by special methods. The bacteria developing on the ordinary plate, as a result of cellulose decomposition, are secondary organisms which either decompose the products formed from the cellulose by the fungi and the cellulose-decomposing bacteria or which utilize as sources of energy the cells of these organisms themselves.

Table II shows that the addition of an excess of water greatly depresses the presence of fungi in the soil as well as of bacteria developing on synthetic media under aerobic conditions. A direct determina-

TABLE II. — *Decomposition of celluloses and the development of bacteria and fungi in the soil, in 26 days.*

Cellulose added	$NaNO_3$ added	Moisture content (on basis of waterholding capacity)	Fungi		Bacteria and actinomyces	Cellulose decomposed
			Plate method	Microscopic method (*)		
per cent	per cent	per cent				per cent
0	0	50	54,400	1	8,000,000	—
0	0	100	18,000	0	800,000	—
0	0.1	50	62,000	1	8,200,000	—
0	0.1	100	24,700	0	2,100,000	—
1	0	50	120,000	3	16,800,000	20.8
1	0	100	20,000	0	1,000,000	33.1
1	0.1	50	340,000	4	71,000,000	84.2
1	0.1	100	20,200	0	17,300,000	20.6

(*) The figures indicate the relative abundance of fungus mycelium, as demonstrated microscopically.

tion of the abundance of *fungus mycelium* using the microscopic method, and staining the soil with methylene blue (6, 17) reveals a marked parallelism between the numbers of fungi as determined by the plate method and the relative abundance of the mycelium as indicated by the microscopic method. The addition of nitrogen to the soil greatly hastened the decomposition of cellulose under aerobic conditions, where fungi and aerobic bacteria are active, but not under anaerobic conditions, where anaerobic bacteria are entirely concerned in the process.

Various experiments established the fact that in humid acid soils fungi are largely responsible for the decomposition of celluloses. Whenever the fungi are eliminated cellulose decomposition comes to a standstill. The elimination of the fungi can be accomplished by treating the soil with volatile antiseptics or heating to 65°-75° for 1 hour. When partially sterilized soil is inoculated with fresh soil, cellulose decomposition takes place very rapidly, even more so than in untreated soil; this is accompanied by an extensive development of the fungi, as can be demonstrated both microscopically and by the plate methods (17).

The fungi decomposing celluloses are represented in the soil by a number of genera, including *Aspergillus*, *Penicillium*, *Trichoderma*, *Fusarium*, *Verticillium*, *Cephalosporium*, *Humicola* and others. The *Phycomycetes* do not decompose true celluloses. The type of fungi developing in the soil as a result of the addition of celluloses depends on the reaction of the soil, moisture content, and the nature of the available nitrogen.

The actinomyces capable of decomposing celluloses are represented in the soil by several species. Owing to the fact that these organisms do not grow at a greater acidity than pH 5.0 and owing to their slow growth, they are active in this process only to a limited extent and under certain conditions (17).

Nature of cellulose decomposition by micro-organisms. — The process of cellulose decomposition can be followed either by measuring the disappearance of the original cellulose added to the soil or by the evolution of CO_2 in the soil receiving the cellulose in excess of that evolved by the soil not receiving any cellulose.

By extracting the cellulose from the soil with SCHWEIZER's reagent and precipitating the extract with hydrochloric acid and washing, the amount of cellulose left in the soil undecomposed can be determined (3). A definite amount of cellulose, in the form of ground filter paper, is added to the soil and, after various periods of incubation, the soil is analysed for residual cellulose. The amount of cellulose decomposed is found to depend on the moisture content of the soil, reaction and aeration, which determine the type of organisms participating in the decomposition processes, and upon the period of incubation and the amount of available nutrients,especially nitrogen, which modify the quantity of cellulose decomposed under a given set of conditions. The controlling influence of the available nitrogen upon the amount of cellulose decomposed is readily understood when one keeps in mind the fact that the micro-organisms synthesize a definite quantity of cell substance for every unit of cellulose decomposed; the greater the amount of cellulose decomposed the greater is the quantity of cell substance synthesized and, since this cell substance is more or less definite in composition, the greater will be the amount of nitrogen and minerals required. A definite ratio has been found to exist between the cellulose decomposed and the nitrogen transformed by the micro-organisms from an inorganic to an organic form, this ratio being about 30-35 to 1, *i. e.* for every 30 to 35 parts of cellulose decomposed in the soil by micro-organisms 1 part of soluble nitrogen is required. Since the available nitrogen is present in the soil only in limited amounts, the rapidity of cellulose decomposition will be controlled in ordinary soil by the rapidity with which the nitrogen is made available (15). Of course when the period of incubation is prolonged, the ratio will become wider and wider, since the synthesized cells of the micro-organisms will be in their turn decomposed and a part of the nitrogen will again be made available and will be utilized for a further decomposition of more cellulose. This is also the reason why in soils of different fertility cellulose will be decomposed at different rates, since the more fertile the soil the more rapid and abundant is the liberation of the nitrogen and minerals in an available form (Table III).

The ideas of CHRISTENSEN (4) that the ability of the soil to decompose cellulose can serve as an index of its fertility, of NIKLEWSKI (12) that the decomposition of cellulose in the soil is largely controlled by the presence of available nitrogen, of CHARPENTIER (3) and BARTHEL and BENGTSSON (1) that the favourable influence of manure upon cellulose decomposition is due to the presence of available nitrogen and not to the introduction or a new microflora are thus confirmed and explained. The more fertile a soil is, the

TABLE III. — *Influence of available nitrogen upon the decomposition of cellulose in soils of different fertility.*

$NaNO_3$ added to 100 gm. of soil	Cellulose decomposed (1 per cent added)	
	Unfertile soil, 6 weeks incubation	Fertile soil, 4 weeks incubation
mgm	per cent	per cent
0	36.9	42.2
25	41.7	66.7
100	59.7	97.2

greater will be the amount of nitrogen liberated in the form of ammonia and nitrate in a given period of time. Since the quantity of cellulose decomposed in a given soil is in direct relation to the available nitrogen, the more rapidly this nitrogen is liberated from the complex organic nitrogenous compounds of the soil the more rapidly will the cellulose be decomposed by the micro-organisms in the soil. This points to the futility of all the attempts made in the past to inoculate the soil with bacteria or other organisms which decompose the soil organic matter more actively than the native flora. A change in soil conditions as a result of treatment will bring about a corresponding change in the flora. The introduction of a supposedly " more vigorous flora " will prove of no consequence when the soil conditions are not favorable for this flora.

The decomposition of cellulose in the soil can also be followed by the course of evolution of CO_2. This method first suggested by NIKLEWSKI (12) has the advantage over the direct determination of residual cellulose in that the process can be followed uninterruptedly for any length of time. The amount of CO_2 produced from the control soil is of course subtracted from the CO_2 produced from the soil to which cellulose has been added, the assumption being that the decomposition of the soil organic matter is not influenced by the addition of cellulose.

The carbon liberated as CO_2 forms only a part of the cellulose decomposed. This is due to the fact that part of the carbon is stored away in the form of cell-substance or other synthesized materials, and part is left in the form of various intermediary substances or products of cell metabolism. The latter is especially abundant in the decomposition of cellulose under anaerobic conditions. The ratio of the carbon liberated as CO_2 to the carbon of the cellulose decomposed will thus depend upon the nature of the organisms which bring about the decomposition of the cellulose. In well aerated soils where fungi and various aerobic bacteria are the most active agents in the process of cellulose decomposition, about 50 to 65 per cent. of the carbon of the cellulose may be liberated as CO_2, about 30 to 35 per cent. of the carbon utilized for the synthesis of cell substance, and only about 5 per cent. left in form of intermediary products. Under anaerobic conditions only about 20 per cent. of the carbon of the cellulose decomposed may be liberated as CO_2 and a small amount of it utilized for synthetic purposes, while a large part of the carbon is left in the form of organic acids or liberated as methane. The results in Table 4 show the ratio between the cellulose decomposition, nitrogen assimilation, synthesis of cell substance and CO_2 evolution by a pure culture of a fungus (*Trichoderma* sp.) grown in sterile soil to which a synthetic solution containing a definite amount of nitrogen and minerals has been added. The economic coefficient indicates the ratio $\frac{\text{cellulose decomposed}}{\text{dry mycelium synthesized}}$;

TABLE IV. — *Decomposition of 1 per cent. cellulose by a pure culture of Tricoderma in sterile soil.*

Incubation	Cellulose decomposed	CO_2 produced (excess over control)	Nitrogen assimilated	Dry mycelium synthesized	Cellulose decomposed / Nitrogen assimilated	Economic coefficient	Respiration equivalent	Plastic equivalent
days	*mgm. C.*	*mgm. C.*	*mgm. N.*	*mgm.*			*per cent.*	*per cent.*
7	281.9	114.2	17.9	378.0	35.1	1.7	40	59
14	389.4	179.9	20.4	472.0	43.1	1.8	46	54
21	400.0	209.5	21.7	429.0	41.1	2.1	52	47

$$\text{respiration equivalent} = \frac{\text{carbon of } CO_2 \text{ liberated}}{\text{carbon of cellulose decomposed}}$$

$$\text{plastic equivalent} = \frac{\text{carbon of mycelium synthesized (6)}}{\text{carbon of cellulose decomposed.}}$$

Role of cellulose in the formation of " humus " in the soil. — The literature of soil science is full of statements concerning celluloses as the mother substances of soil " humus ". Even among the most recent contributions to the origin of coal, various suggestions are made as to the probable processes whereby cellulose is converted into " humus " and then into coal (11). Some claim that celluloses give rise to dark coloured substances, similar to the formation of dark bodies when sugars are boiled with acids or alkalies. Others claim on the other hand, that celluloses are decomposed completely without leaving any residual materials and they cannot serve, therefore, as the mother substances of " humus ". Unfortunately most of these claims are not based on experimental evidence, but are pure and simple speculations.

As a result of numerous experiments on the decomposition of cellulose, under aerobic and anaerobic conditions by bacteria, fungi and actinomyces in pure and mixed cultures, it can be stated definitely that celluloses do not contribute directly to the soil organic matter or " humus ". Celluloses are, next to the sugars and starches, among the most readily decomposable constituents of the plant material commonly added to the soil. All soils harbor numerous organisms capable of attacking celluloses. These will be decomposed under aerobic or anaerobic conditions completely; in the first case to CO_2 and water, in the second case with the formation of various organic acids and gases. No dark coloured substances are ever formed from pure celluloses. Practically 100 per cent. of the carbon of the cellulose decomposed can be accounted for by the cell substance synthesized and by the intermediate and final products formed including the CO_2.

Indirectly however celluloses do contribute to the accumulation of organic matter in the soil (" humus ") which is more or less resistant to decomposition. As pointed out above a part of the carbon of the cellulose, amounting to as much as 30 to 40 per cent. in the case of fungi, is utilized by the organisms for the synthesis of cell material. This newly synthesized substance can again undergo decomposition, but not completely; only a certain part of this cell substance is readily decomposed by other organisms. A certain part amounting to 20 per cent. or more of the synthesized cell substance is resistant to decomposition and possesses all the properties which are characteristic of the soil " humus ". A detailed study of the origin of " humus " in the soil, from the point of view of microbiological processes, is now in course of publication.

SUMMARY.

1. In normal aerated soils, celluloses are decomposed largely by fungi, certain aerobic bacteria and to a lesser extent by *actinomyces*.

2. Anaerobic bacteria capable of decomposing celluloses are present in normal soils only to a very limited extent but are found abundantly in bog soils.

3. The aerobic bacteria capable of decomposing celluloses are represented in the soil by a number of groups, some of which are very active while others bring about only a disintegration of cellulose fibres. Some of these bacteria, especially the active forms, cannot use any other source of carbon but celluloses.

4. The fungi are represented in the soil by a large number of species capable of decomposing true cellulose. The *Phycomycetes* are unable to carry out this process.

5. Among the numerous actinomyces found in the soil, only a few species are capable of decomposing celluloses actively.

6. The type of organisms taking an active part in the decomposition of cellulose added to a given soil will depend upon the nature of the soil, its reaction, moisture content and presence of available nutrients. A special set of conditions will favour the development of certain organisms, which bring about the decomposition of celluloses in preference to others.

7. The decomposition of cellulose in the soil can be measured quantitatively either by the disappearance of the cellulose or by the evolution of CO_2, especially under aerobic conditions.

8. Celluloses are decomposed completely by micro-organisms in the soil; under aerobic conditions part of the carbon of the cellulose decomposed (50 to 65 per cent.) is liberated as CO_2, part of the carbon (25-35 per cent.) is utilized by the organisms for the synthesis of cell substance and only a small part (5-10 per cent.) is left in the form of intermediary products. Under anaerobic conditions, a much smaller part of the carbon of the cellulose decomposed is liberated as CO_2 and is assimilated by the organisms, while a considerably greater part is left in the form of various intermediary products, largely organic acids.

9. There is a definite ratio between the amount of cellulose decomposed and the nitrogen required by the organisms for the synthesis of cell substance. This ratio is usually 30 to 35 in the case of fungi. It becomes wider in the soil, with a mixed flora, and with continued incubation, especially in the absence of an excess of nitrogen, due to the constant liberation of more nitrogen from the soil organic matter and especially from the cell substance previously synthesized.

10. Directly cellulose does not contribute to the formation of "humus" in the soil. Indirectly, namely through the cells of the micro-organisms, it does. Since a certain part of the carbon of the cellulose decomposed is reassimilated by the organism for the synthesis of cell substance, and since a part of this synthesized material is resistant to further rapid decomposition, a part of this material will become an ingredient of the soil "humus".

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PREPARATION OF A SOIL FOR PRACTICAL SUSPENSION ANALYSIS

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To enable us to get the most exact values for the final physical composition of a soil, the different suspension apparatus in use have been considerably improved in recent years. But not to lose anything from this increase in precision, one has to take all the care possible to eliminate every possible source of error from the *preliminary preparations* of the soil for suspension analysis. It is this preliminary preparation of the soil, by the methods now in use, that leaves much to be desired. The procedure proposed by the standardisation section for amelioration in 1924 was as follows : the fine soil, of less than 2 mms., is soaked during the night and then boiled for an hour. The soil so treated is then thoroughly pounded several times, with constant changing of water, until the water shows no turbidity: only then starts the real suspension method (1). It is quite evident that this energetic rubbing may, according to the character of the soil, introduce considerable errors, e. g., the small part-weathered fragments of stone, which would have kept their same composition undisturbed in the soil for many years, are often crushed to atoms by this pounding. And the same applies to silt particles and still finer material. In this way the final composition of the resulting material is quite unlike that of the original soil sample, being finer and much richer in clay. And this difference will be the more pronounced the richer the soil originally was in weathering material, the more closely it approached in character a definite type of soil, and the softer the original material was. If the soil particles are unaffected by prolonged soaking and boiling, it can be assumed that under the influence of the slow prolonged weathering in the soil they will keep their original composition for long enough to give the soil definite physical characteristics which are not the

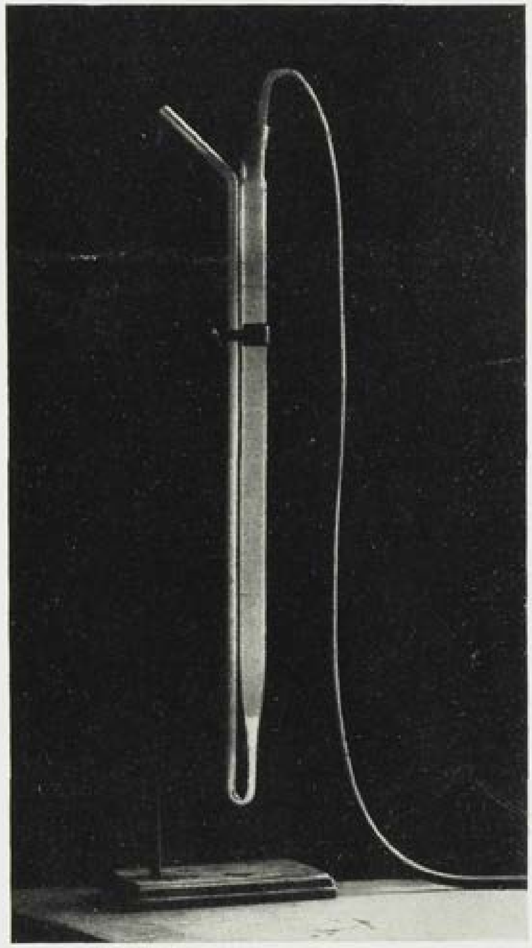
(1) The preparation of the soil by simple shaking without warming has, so far, not yet been generally accepted, and hence it is impossible to take up a critical attitude with regard to it.

same as those produced by the same particles energetically pounded to bits. It is therefore not a criterion of purity of a given constituent particle determination that after suspension nothing further can be rubbed off (especially if the products of suspension have been dried on the water-bath or in the hot-air oven, i. e. at a high temperature !). To decide properly the question of purity the microscope must be used.

Boiling has this advantage that the constant agitation keeps the particle in an uninterrupted whirling motion, and this motion by rubbing the particles *gently* against each other rubs off the adhering clayey coating, without hurting its physical constituents as does the *energetic* rubbing. But the disadvantage of boiling is that, despite the uniform warming of the water and soil, tension is set up, which may cause a disintegration of the different small stones or stone particles present, and this the more readily, the nearer the given soil sample originally was to the weathering zone. This also leads to errors varying with the character of the minerals in the soil. Boiling of a soil sample is also inadvisable because of the danger of coagulation of the smallest particles when the " suspension residues " have to be still further separated into their different sized particles.

Thus boiling or strong rubbing are very similar in their action to the boiling of a soil sample with concentrated hydrochloric acid, as in chemical soil analysis, since, in both cases we are doing something rarely accomplished by weathering.

The best method of preparation of soil samples for analysis would therefore be one possessing all the advantages of the boiling method without the sources of error introduced by heating, i. e. a kind of " cold heating ". By placing some soil soaking in water in a vessel attached to an air pump and drawing for an hour a current of air from below through the soil-water mixture, so as to keep the mass in an agitated condition, the author believes he has got very near to our " cold boiling ". The KOPECKY method of suspension analysis, using 25 gms. of soil, as employed in most laboratories, makes it possible to use for the above preparation of the sample the usual laboratory water-pump, unless indeed we are dealing with an extraordinarily coarse soil, in which case the sample must be divided up. The " cold boiling " is the more vigorous and the current of air passing through the mixture is greater, the smaller the difference between the diameter of the mouth of the pump and that of the glass vessel. In addition, the glass vessel must be capable of holding enough water to enable a



Kopecky's Coarse Sand cylinder for "cold boiling" soil samples.

proper agitation of the earth to be kept up, and there must be space enough above the column of water to make it impossible for anything from the water-soil mixture to be carried away by the air current. From among all the different vessels present in every soil science laboratory, the coarse-sand cylinder of KOPECKY seems the best for the carrying out of the " cold boiling ". The illustration shows the arrangement of the apparatus.

The far-end side piece, after it has been half filled with the soil-sample and water for soaking, is attached by means of a rubber cork and a piece of ordinary tubing to the water pump (pressure tubing must not be used, to prevent the production of an excessive pressure and the smashing of the glass vessel). Through the narrow, open end, a constant current of air is drawn from below through the column of water, at such a rate, that about 150 agitations are produced in the mixture in a minute. Certain rules and precautions will occur to any one who has experience in suspension analysis e. g. that the narrow, open end, shall, when filling, be closed by a piece of rubber tubing and a pinch cock, and opened only *after* the pump has started working, so as to prevent sucking back and choking of the narrow end by earth, or that water can be added to the open end when the earth shows a tendency to stick in the bend. This method of preparing soil samples for analysis has also this advantage that the apparatus can be left working for any desired length of time, without having to add water or pay any further attention to it.

The correct procedure is then as follows: the fine soil is soaked in water and after a time the larger lumps are crushed with the fingers, so as to allow a better penetration of the water. After soaking for several hours, preferably the whole night, the soil sample is then treated for an hour with the air-pump, after which the suspension analysis is proceeded with in the usual prescribed manner.

Although it is intended to deal with the preparations for suspension analysis of the different, separate types of soil e. g. the special treatment required by humus soils, in a later and special paper, yet I would point out now in a number of soils the differences produced in the KOPECKY suspension analysis by the different ways of preparatory treatment. In the work described in the table given, carried out by the author in collaboration with Dr. HENKEL, examples are given not only of samples treated by the air pump method but also of those treated by the boiling method but without excessive pounding, so that differences in results can be attributed solely to the application of heat. The results prove that the different soil-samples have behaved very differently. While some underwent very little change on heating others suffered considerable disintegration.

Differences in the results of Kopecky's suspension analysis due to differences in preliminary treatment.

Soil	Preliminary treatment	Coarse sand	Fine sand	Silt	Clay
		%	%	%	%
Alluvial sandy moor soils	boiled	65	4	7	24
	air pump	72	16	2	10
Jurassic sandy soils	boiled	8	59	13	20
	air-pump	9	60	14	17
Marshy sandy soils	boiled	19	21	31	29
	air-pump	19	22	34	25
New Red Sandstone soils	boiled	34	58	1	7
	air-pump	33	59	2	6
Oberrortliegendes Sandy loamy soils	boiled	20	22	20	38
	air-pump	21	23	17	39
Lettenkohl loamy soils	boiled	20	16	10	54
	air-pump	28	15	9	48
Loess loamy subsoil	boiled	11	10	27	52
	air-pump	12	10	51	37
Keuper, clayey soil	boiled	8	12	26	54
	air-pump	9	19	32	40
Alluvial clayey loamy soils I.	boiled	24	14	17	45
	air-pump	28	19	11	42
Subsoil of above	boiled	15	19	11	55
	air-pump	21	29	18	32
Alluvial clayey loamy soils II.	boiled	6	20	17	57
	air-pump	13	28	22	37
do III	boiled	17	12	20	51
	air-pump	29	18	21	32
do IV	boiled	23	12	13	52
	air-pump	30	14	13	43
Clayey soils of the upper shell limestone	boiled	6	6	26	62
	air-pump	5	5	7	83
Clayey soil of the lower gypsum Keuper	boiled	8	10	20	62
	air-pump	7	11	26	56
Clayey soils of the lower Rotliegenden	boiled	12	13	18	57
	air-pump	13	13	22	52
Keuper Fireclay	boiled	34	58	1	7
	air-pump	33	59	2	6

BACTERIOLOGICAL METHODS FOR THE INVESTIGATION OF SOIL FERTILITY.

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During the infancy and early stages of soil bacteriology in the later decades of the nineteenth century, great expectations were aroused as to the information that this science might give on the conditions of soil fertility. However as these expectations were subject to some disappointment, the whole question is now made the object of more sober consideration. Still we must not infer that scientific research has lost interest in that branch of soil science — on the contrary — all over the world, the numerous and important problems which soil bacteriology presents, are being made the subject of careful study, especially those dealing with the relation of soil microorganisms to the chemical and physical factors governing soil fertility.

Two main directions are followed: 1) Floristic research (qualitative and quantitative studies on the composition of the soil's microflora), and 2) Physiological research (studies on the changes in soil matter).

1. FLORISTIC RESEARCH.

The determination of the soil content of microorganisms — the basis of all study along this line in the early days of soil bacteriology — was almost completely abandoned after 1902, when REMY introduced experiments in quantitative decomposition. However of late the former method has been largely resumed, not only as an auxiliary but also as a comparatively independent method for studying soil fertility. It was with this method that HILTNER and STOERMER (1903) and RUSSELL and HUTCHINSON (1909-12) made their fundamental studies on partial sterilization of soil, while a number of other investigators — FABRICIUS and FEILITZEN (1905), ENGBERDING (1909), TEMPLE (1911), FISHER (1909-1911), BEAR (1917) — to name only a few — have used it for the study of the influence of lime, stable manure etc. on the microflora of the soil. Later H. J. CONN (1910-22) developed the counting method to a very considerable degree and combined the plate counting method (using synthetic media of a well defined chemical composition) with a method for direct microscopic counting of micro-organisms, in soil suspensions. Even though the results of these two methods are far from identical [the direct counting method gives 5-20 or even 40 times as high figures as the plate counts, a result partially confirmed by WHITTLES (1923) and WINOGRADSKY (1925)], the results were constantly found to run parallel when different soils were compared or when the number of microorganisms was increased by adding stable manure or other organic matter to the soil. The determination of the number of bacteria thus becomes, if not a picture of the total soil flora, at least an index of the bacteriological condition of the soil. CONN has chiefly used his methods for the study of the composition of the soil micro-flora, the seasonal variations in the numbers of bacteria and the relative importance of various groups of soil bacteria in the transformation processes in the soil. Quite recently the plate method has been further developed in England by THORNTON (1922), and FISHER, THORNTON and MACKENZIE (1922), and in the United States by LIPMAN and BROWN (1910), FRED and WAKSMAN (1922), WAKSMAN 1922 *a* and 1922 *b*. These studies show among other matters, that apart from the effect of less suitable media of an undefined and irreproducible composition the negative results so often obtained by earlier investigators must be largely due to the following facts : The number of bacteria in a given soil is, even under constant external conditions far from constant ; in the first place it may show remarkably large " rhythmical " fluctuations, often within periods of a few hours (THORNTON 1923) and secondly it varies inversely to the number of active protozoa and especially amoebae in the soil (CUTLER, CRUMP and SANDON 1922). Furthermore as the number of bacteria in a seemingly uniform soil plot varies greatly within closely adjacent localities, in making investigations so many duplicate samples, each a composite of several individual samples, should be taken that the variability in bacterial numbers can be determined and a reliable account made for the experimental error (FISHER, THORNTON and MACKENZIE, 1922, WAKSMAN, 1922). Finally not only should the numbers of bacteria be considered but attention should also be given to the other groups of heterotrophic soil organisms, especially actinomycetes and fungi. (WAKSMAN, 1922). When these points are duly taken into consideration in connection with fertilising experiments in the field, it is possible, as shown by WAKSMAN (1922) the most thorough student of the problem, to obtain results which show a distinct correlation between crop producing power and number of bacteria and actinomycetes in the soil. WAKSMAN (1921) has also worked out a special method for making quantitative determination of the number of fungi in the soil. The number of micro-organisms and especially the ratio of fungi to bacteria and actinomycetes may not only be determined by the amount of plant food in the soil, but is also to a marked degree influenced by the reaction of the soil, the fungi predominating in acid, and bacteria and actinomycetes in neutral and alkaline soils. Our own investigations on a number of Danish soils have fully confirmed these facts. In another paper WAKSMAN (1917) has shown that fertile soils harbour greater numbers of fungi both as regards species and individuals than do poor soils. The fungous flora shows a certain relationship to soil character, soils from warm and dry regions being very rich in *Aspergilli*, whereas the *Mucorales* and *Penicillia* are the predominant forms in soils from colder climates, and the *Trichodermae* are specially numerous in strongly acid and water-logged soils. This has been found to a certain extent to hold good for Danish soils. The actinomycetes too show some relation to soil conditions, their relative number being high in neutral and alkaline soils, but in soils with a pH value below 5.0 both their relative and absolute number are very markedly reduced. This, however, has not been confirmed by the Danish soils. Later on WAKSMAN and STARKEY (1924) in a very interesting paper have shown that the micro-flora of soils of different fertility is differently affected by the addition of nutrients, and that the different effects show a correlation with the deficiency in plant food. Among more occasional observations on the positive correlation between bacterial numbers and crop-producing power mention should be made of the work of NOYES and CONNER (1919) and NELLER (1920).

Note should be made in this connection of the fact that S. WINOGRADSKY (1925) has quite recently worked out new refined methods for direct microscopic analysis of the microflora of the soil. The preliminary results reveal very striking differences between soils of different characters and further reports are awaited with much interest.

2. PHYSIOLOGICAL RESEARCH.

For an account of the physiological research work in soil fertility reference should be made to the report of HARALD R. CHRISTENSEN delivered before the IV International Conference on Soil Science in Rome, 1924, in which is a detailed description of the "principle of inoculation" introduced by the author. This principle, based on microbiological matter transformation experiments, aims directly at estimating the influence exerted both by the actual microbiological and the chemical condition of the soil on the course of transformation in soil matter.

CHRISTENSEN's studies, in which the principle of inoculation was used, dealt specially with mannite, cellulose, and peptone decomposition, and it was found that the course of these transformations under the given conditions is to a particular degree governed by the reaction condition and the supply of easily soluble phosphoric acid compounds. The principle seems to allow a microbiological determination of these and possibly also of other soil characteristics.

Since then other investigations have been made along these or similar lines. The following deserve mention:

a) *Mannite decomposition.*

WAKSMAN and KARUNAKAR (1924) found, in agreement with CHRISTENSEN (1922), that the addition of phosphates exerts a markedly beneficial influence upon mannite decomposition in acid and somewhat infertile soils (from unfertilised plots and plots constantly treated with physiologically acid fertilisers), while it was without any effect in fertile, nearly neutral soils. The authors have further observed a complete correlation between the speed of mannite decomposition and the amount of crop yield in soils from 7 differently treated plots in a permanent fertilising experiment.

b) *Cellulose decomposition.*

The determination of the speed of cellulose decomposition as an index of the supply of plant food in the soil and measured by the carbon production seems to have been suggested for the first time by B. NIKLEWZKI (1912). Recently C. CHARPENTIER (1921) has worked out a method for quantitative determination of cellulose in the soil and this has led to renewed interest in the study of the relation of cellulose decomposition to soil conditions. By means of this method CHARPENTIER was able to show that a soil's content of certain nitrogen compounds in a particular degree governed the rate of cellulose decomposition. The addition especially of stable manure accelerated the process. BARTHEL and BENGTSSON (1923) state that when soil is mixed with 1 % Cellulose and various amounts of ammonium salts, the amount of cellulose decomposed within a certain time is almost proportional to the amount of nitrogen added. The effect of stable manure is nearly proportional to its content of ammonium nitrogen, whereas its bacterial content seems to have no significance. WAKSMAN and HEUKELIKIAN (1924) arrive at similar results. By addition of cellulose to the soil and determination of its rate of decomposition they attempt to obtain an index of the content of available, i. e. readily nitrifying nitrogen in the soil. When sodium nitrate is also added, an index of the phosphorus compounds available for the cellulose decomposing micro-organisms is obtained. STARKEY (1924) using CO_2 production for measuring the decomposition rate, observes that cellulose and organic substances rich in cellulose, such as rye straw, are decomposed more rapidly in fertile than in poor soils, and in agreement with WAKSMAN and HEUKELIKIAN he notes that addition of nitrates has a far more pronounced effect in fertile than in poor soils (in which phosphoric acid now becomes the limiting factor).

c) *Protein decomposition.*

The results of the numerous investigations made by CHRISTENSEN (1914), and described in his lecture at Rome in 1924, to which reference has already been made, tend to show upon the whole that a weak power of peptone decomposition under all circumstances indicates decidedly unfavourable soil conditions. Soil reaction was found in a special degree to govern the speed of peptone decomposition. Otherwise the various scientists who have studied the protein decomposing power of soils in relation to soil fertility have reached very dissimilar and contradictory results. Several scientists, e. g. FISHER (1911) and TEMPLE (1919) find no correlation; BROWN (1916) on the other hand finds correlation and BURGESS (1918) finds differentiation only between very fertile and very poor soils. WAKSMAN (1923) who has studied the problem very extensively, is convinced that the degree of ammonia production in solution or soil cultures only affords very incomplete information concerning soil conditions, and that the process is a function of too many variable factors to serve as a useful index of soil fertility.

d) *Nitrification.*

In earlier investigations CHRISTENSEN (1914), using solution cultures in which the nitrifying power is primarily governed by the number of nitrifying organisms introduced with the soil, noted no, or only slight differences between the nitrifying power of the individdual soils. Sphagnum peat in which nitrifying organisms were not found is an exception. In further studies, not yet published, it has been found that the nitrification rate of ammonium salts is primarily determined by the ability of the soil to neutralize the acids formed by the process — in other words — by the buffer effect of the soil. An unquestionable correlation between nitrifying capacity and soil productivity has however been shown to exist in many of the numerous experiments chronicled in the literature on the subject: ASHBY (1907), LOEHNIS (1905), GUTZEIT (1906), VOGEL (1910), KELLERMANN and ALLEN (1911), GREAVES (1913), LIPMAN (1914), BROWN (1916), BURGESS (1918), NOYES and CONNER (1919), WAKSMAN (1923 b and c), and others. This may probably in the main be explained by the well-known fact that the reaction condition of the soil may affect soil fertility to a very considerable degree. It is therefore important to realize that a nitrification experiment will generally furnish no other information on soil conditions than that which could be obtained by a chemical determination of the buffer effect of the soil. It is interesting to note in this connection that the fine correlation found by WAKSMAN (1923 c) between nitrifying capacity and crop production of unlimed soils is less pronounced in the case of limed soils; in the latter instance it was found that liming greatly stimulated nitrification in somewhat infertile soils without markedly increasing the crop yield, BEAR (1917), and BARTHEL and BENGTSSON (1920) agreeing in their results that the course of nitrification is first and foremost determined by the reaction and buffer content of the soil. This is, however to a certain degree complicated by the fact that according to the results of GAARDER and HAGEM (1920-23) and MEEK and LIPMAN (1922) strains of nitrifying organisms exist which possess different pH optima and pH limits for growth. This may partly account for the vigorous nitrification known to take place in certain acid forest soils WEIS (1910 and 1924), C. OLSEN (1921). That the course of nitrification depends so little on factors other than the reaction condition is probably related to the fact established by MEYERHOF (1916-17) that the mineral nutrient requirements of the nitrifying bacteria are very minute. This fact will probably render an attempt to obtain indications of the mineral nutrient supply in soils by means of nitrification experiments hopeless.

e) *Nitrogen fixation.*

The dependence of nitrogen fixing bacteria on the reaction condition of the soil has manifested itself clearly in a number of various investigations. Those applied to *Azotobacter* have led to the working out of the so-called Azotobacter-test for the determination of the lime requirement of soils, and applied to the nodule bacteria of leguminous plants has led to research work on the relation of various nodule bacteria to soil reaction (FRED and DAVENPORT (1917) on several nodule bacteria, STEVENS (1919) on lucerne and sweet clover bacteria, BRYAN (1922-23) on lucerne, clover, and soya bean bacteria, and WRIGHT (1925) on soya bean bacteria). These investigations are valuable for ascertaining whether a given soil, as indicated by its reaction, is adapted to the cultivation of the leguminous plants in question. GAINEY (1918-23), GAINEY and BATCHELOR (1923), CHRISTENSEN (1923), CHRISTENSEN and TOVBORG JENSEN (1924) and E. J. PETERSEN (1925) have shown that the critical limit of acidity for the development of *Azotobacter chroococum* lies at pH 5.8-6.0 In a quite recent paper GAINEY (1925) shows in agreement with earlier similar experiments of CHRISTENSEN (1914) that *Azotobacter* will soon die out if introduced into soils with acid reaction. WAKSMAN and KARUNAKAR (1914) experimenting with a number of soils of different fertility and mixed with 1 % mannite have found that no nitrogen fixation occurs in soils with pH value below 6.0, whereas it was more or less vigorous in soils having a higher pH value. The same authors, studying the nitrogen fixation in a 2 % mannite solution inoculated with 5 % soil obtained no correlation between the intensity of nitrogen fixation and soil productivity. Judging from these results nitrogen fixation seems in a high degree to be determined by *Azotobacter*, the presence of which undoubtedly indicates favourable soil conditions. Besides requiring definite reaction conditions, Azotobacter has a definite rigid need of available phosphoric acid compounds, a fact upon which CHRISTENSEN (1914) and recently NIKLAS and HIRSCHBERGER (1924) based a biological test for the determination of easily soluble phosphoric acid compounds in the soil. BEIJERINCK (1925) has recently described a new Nitrogen fixing bacterium said to be rather characteristic of poor soils.

f) *Carbon dioxide production.*

The carbon dioxide producing power has often been suggested as an index of the total microbiological activity of the soil. Such determinations were first carried out by PETERSEN (1870) and WOLLNY (1897). Since then numerous scientists have dealt with the problem, though we can only mention here a few of the papers: STOKLASA and ERNEST (1905) considered the carbon dioxide production by soil bacteria to be of much importance in rendering phosphoric acid compounds available to higher plants. HESSELINK van SUCHTELEN (1910) noted that the carbon dioxide production reacted more readily to the addition of nutrients to the soil than did the bacterial numbers. LEMMERMANN, ASO, FISCHER and FRESENIUS (1911) who have carried out extensive studies on carbon dioxide production in the soil observed that this production from organic matters, such as vetch straw, horse manure, and green rye, was stimulated by small amounts of lime, while heavier doses sometimes had the contrary effect. STOKLASA (1912) found a positive correlation between bacterial numbers, carbon dioxide producing capacity, and soil productivity. NELLER (1920) found a more vigorous carbon dioxide production in limed than in unlimed soil. WAKSMAN and STARKEY (1924 a) distinguish between " respiratory power " (CO_2 evolution from the untreated soil) and decomposition power " (CO_2 evolution from soil + 0.5 % dextrose); they find the " respiratory power " correlated with bacterial numbers, the nitrifying power, and the crop producing power; the same holds true, to a certain degree, of the " decomposing power ". However, a soil treated with physiologically acid fertilisers behaved abnormally; although its productivity was very poor and its respiratory power weak, it had a strong decomposing power because of the very active fungous flora, to which the treatment had given rise. Studies on the problem are at present being carried out at the State Laboratory of Plant Culture, Denmark.

g) *The carbon-nitrogen ratio in the soil.*

This has quite recently been made the object of some very noteworthy considerations by WAKSMAN (1924) who calls attention to the fact that the amount of nitrogen liberated as ammonia + nitrates depends upon the quantity and quality of carbon compounds available as sources of energy, and the nature of the organisms which consume them. The fungi, which are gigantic organisms in comparison with the bacteria, have a more economic metabolism than the latter and synthesize large amounts of protoplasm ; therefore when a certain amount of carbon food is consumed and transformed into microbial protoplasm and respiration products by fungi, far greater amounts of nitrogen are assimilated than is the case when the same amount of carbon food is consumed by bacteria. The actinomycetes stand midway between the two other group. An example taken from practical agriculture may be quoted : cellulose is, according to WAKSMAN and HEUKELIKIAN chiefly decomposed by fungi, especially in acid soils ; this accounts for the unfavourable effect of straw manuring, undoubtedly due more to assimilation of soluble nitrogen than to denitrification.

These circumstances seem to explain a part of the function of lime in the soil ; in acid soils, which harbour a great number of fungi in proportion to bacteria, large amounts of nitrogen are constantly kept assimilated as fungous mycelium — CONN (1922) has indeed by direct microscopical investigation found fungous mycelium especially abundant in acid soils containing much undecomposed organic matter —, because a relatively large amount of carbon food is constantly added in the form of plant residues poor in nitrogen. When such a soil is limed the bacteria and actinomycetes find a favourable reaction, and are enabled to compete with the fungi and carry out a relatively greater part of the soil metabolism. The decomposition of the organic nitrogen compounds now takes another course which results in liberation of more ammonia and nitrates than hitherto. A determination of the reaction condition of the soil and of the carbon-nitrogen ratio will therefore be of much value for the understanding of the course of microbial matter transformations in soil.

Speaking generally it is important to realize that the soil bacteriological investigations briefly sketched here have very considerably extended our knowledge of the soil micro-flora and the conditions of its development in directions favourable or unfavourable to agriculture. Particular stress should, as hitherto, be laid upon special studies of morphological and physiological character, although, with knowledge such as we have at present, it is premature to accept uniform, standardised bacteriological methods for estimating soil fertility. Regarding the question of a rational development of that part of soil bacteriology concerning the influence of soil conditions on bacterial life and metabolism in the soil, attention should be called here to the vast importance of using methods already tested in connection with reliable vegetation experiments (pot or field experiments) and especially with permanent fertilising experiments, in which the estimation of crop development and the variations caused in the chemical condition of the soil furnish a reliable control of the influence of the factors in question upon plant growth. We shall then be able to judge of the value of the methods used for the study of soil fertility. We suggest therefore that such experiments be carried out in great numbers in the different countries of the world under various conditions of soil and climate. In the extensive bacteriological research work in connection with experiments of this kind, international co-operation in the form of interchange of soil samples, for instance, would be very desirable.

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Abstracts and Literature.

Soil Physics.

Temperature and Salinity.

Cotton Research Board, Fourth Annual Report 1923.

Part V of the report of the Cotton Research Board for the year 1923 states the researches prosecuted by Mr. MACKENZIE TAYLOR during that year on temperatures and on freeing the soil from salt. The writer studied the temperature of the soil during the fallow period, called the sharaqi period, and the effects of these temperatures from the point of view of the partial sterilization of the soil, which he considers as the principal benefit of the sharaqi period.

The observation of surface temperatures has enabled the sharaqi to be divided into three periods :

(*a*) a warming up period up till about 1st July, during which no partial sterilization is produced ;

(*b*) a period of high temperature, from the 1st July up to the 21st August which corresponds with an active partial sterilization ;

(*c*) a period of diminished temperatures, after the 21st August, corresponding with a decline of the partial sterilization.

Now, since the introduction of perennial irrigation which allows of summer crops, the area of lands subjected to the sharaqi regime has been decreasing at the same time as the sharaqi, period has been becoming shorter consequent on the earlier planting of maize, which takes place in July at precisely the period when fallowing is most beneficial.

The experiments undertaken by the writer have shown that it would be profitable, in order to obtain subsequently higher yields of cotton, to postpone the sowing of maize until the 10th August. In studying the effects of summer fallow on the soil protozoa in Egypt, the writer remarks, that in spite of the partial sterilization which is produced during that period, the number of protozoa definitely remains constant. A change in condition however was experienced indicated by a decrease in activity.

The reclamation of soils containing chloride and carbonate of sodium was also the object of researches on the part of the writer.

It is known that this reclamation is at the present time based on the cultivation of rice, which is a summer crop and as such does not fully benefit by flood water.

The writer tried whether it was possible to eliminate the rice crop in order to save the water which is absorbed and to utilize that water, at flood, at a time when most was available, for washing the soil. The experiments made have shown that the elimination of chloride of sodium by simple washings is arrested at a given moment, that a hydrolysis of the sodium-clay complex, a deflocculation of the colloids is then produced ; the water no longer runs off in the drains and the soil becomes alkaline.

The growth of rice prevents these drawback. The rice is sown precisely, in the course of the process of freeing the soil from salt, at the moment when, after preliminary washings, the hydrolysis of the sodium-clay complex begins to take place. The roots establish themselves in the surface layer of the soil; they generate carbon dioxide in sufficient quantity to transform the sodium hydrate formed by the process of hydrolysis, first of all into carbonate and then into bi-carbonate of sodium. This latter substance, not being alkaline, prevents the deflocculation of the soil colloids and hence the soil remains permeable. The successful growth of rice therefore plays a capital part in the reclamation of the soil. Unfortunately a successful rice crop cannot be guaranteed. Accordingly the writer has tried whether it is possible to do without it and to devise a method whereby the sodium clay complex might be hydrolysed and the alkaline products of this hydrolysis, due to the action of continuous washing of the soil, removed. Experiments to date point to the possible use of sodium bisulphate.

On the Effect of Drainage on the Physical Condition and the Mechanical Construction of Soil.

JANOTA RUDOLF, O účinku drenazé na fysikalni stov a mechanickon stavbu půdy. Sborník výzkummych ústavů zemědělskych, sv. 16. *Ministerstvo zemedelstvi*. Prague, 1925.

The investigations on the effect of drainage on the physical condition and the mechanical composition of soil were carried out by the Pedological Section of the Technical Bureau of the Bohemian Land Cultivation Board, in the years 1920-1924, in the loamy and heavy soils of N. E. Bohemia, in the districts where these soils are for the most part drained. The soil investigated consisted of light Podsol brown earths, or heavy Cretaceous soils with an underlying layer of marl. Nineteen cases were considered in drained, and nine in undrained situations. With regard to the mechanical construction and physical condition, 90 soil profiles were examined in all, mostly to a depth of over 1.0 m., by 414 physical and 407 mechanical analyses.

For the investigation a combination of KOPECKY's physical and mechanical analysis was used, and samples of soil which were always taken from several depths of the same sounding in the natural bed. On the drained situations the soundings were chosen at different distances from the drain, mostly at 1.0 m. or 3.0 m. distance, in between the drains. The results of the mechanical analyses, together with the determination of the carbonate of lime, are compared in tables.

From the results of the investigation the following statement can be made: —

Where drainage had been carried out, a free underground water-level up to the depth of the drainage was not noticeable in any of the situations under observation, and its formation in the soundings between the drains could not be followed up. By drainage a quick removal of the excessive moisture of the soil is effected, and the firmly bedded soils are changed by drainage from a humid to a dry condition. The distribution of moisture in drained soils can be determined by the physical analysis, and the effect of the percolation of water through the soil in respect to the formation of individual levels can be checked by mechanical analysis.

The formation of the type of soil follows as a function of the percolation of water through the soil, and is therefore of great importance in cultivation technics. By reduction of the contents of electrolytes, fine soil substances are released in the upper (elluvial) layers, and deposited at the depth to which the penetration of the percolating atmospheric water as a rule reaches (illuvial level). The impoverishment of the upper layers and the enrichment of the subsoil can be followed in the results of the mechanical analyses.

In the cases given, in loamy soils the difference in content of the fine constituents, which can be washed out, of the arable crust and the illuvial layer goes up to 10 %, and in heavy soils up to 20 %, according to composition.

The process of the formation of Podsol soils also arises from the washing out of the carbonate of lime from the elluvial levels A,A1 and its deposit in the illuvial level B.

For measuring the amount of drainage, the investigation and characterization of the red-brown illuvial level B1, which in the cases in question usually shows itself at a depth of 0.75-1.0 m., is of the greatest importance. It is expressed by the greatest content of fine constituents which can be washed out in the soil profile concerned, by a high carbonate of lime content, by notable enrichment by iron compounds, by the smallest pore-volume and consequently the worst structure and lowest absolute air capacity which in technical practice influences conditions of permeability.

According to the investigations carried out, the illuvial level (B) signifies practically the limit for the penetration of atmospheric deposits, the lower limit of the changing of the physical condition of the soil during the time of vegetation, and therefore probably also of the total activity of the soil in a chemical and biological respect. From the technical cultural standpoint it denotes the most impermeable layer in the soil profile concerned, on to which oozes the water containing the precipitates, whose five constituents are redeposited, causing thereby a continual closing of the pores of the soil.

In loamy soils the illuvial level still remains fairly permeable; in heavy soils the absolute air capacity sinks to below 0.5 % of the volume, causing this layer to become inaccessible to the penetration of water, air, and consequently also roots.

The moisture condition, during the time of vegetation, undergoes considerable alterations in the alluvial levels only, whilst the deeper layers show a similar condition of moisture in the spring and autumn. In loamy situations the momentary condition of the humidity is lower in spring than the absolute water capacity, and the humidity is evenly distributed in all layers. In heavy soils the upper layers are usually saturated in spring to the absolute water capacity, sometimes beyond, in which case the elluvial layers often become marshy. The deeper layers below the illuvial level at the same time show a lower degree of humidity, because the influence of the atmospheric deposits does not reach to this depth.

The aeration expressed by the momentary air-content is greatest in the elluvial layers, falling gradually until reaching the illuvial level, below which no notable alterations in air-content take place. The aeration is greater in autumn than in spring. The above differences are greater in loamy soils, and consequently these soils are also more active than the heavy soils. In the latter the greater aeration of the upper layers is caused by intensive drying and the falling out of colloidal substances. The crumbly structure attained in this way, however, is in an unstable state, and its maintenance must be supported by surface drainage.

From fairly numerous results of the investigation of the places brought under observation, it appears, however, that the infiltration of the water, and the concentration of the percolation through the soil in the direction towards the drain, after a long time also exerts a notable influence on the lixiviation process, which is especially important in heavy soils. The effect of drainage on the metamorphosis of the type of soil of the drained situations is shown in the following manner:

In the upper layers the content of fine constituent parts capable of being washed out and of the carbonates increases from the drain towards the central point between the drains. At the same time the pore volume sinks with the increasing distance from the drain. From this it can be concluded that the elluvial layers are cleansed most by the drain, and so show the best structure.

In the illuvial layer, on the other hand, the content of fine constituent parts capable of being washed out, and of carbonates, is greatest near the drain, where also the pore volume is smallest; towards the middle between the drains the content of fine constituent parts and carbonates is less, and the porosity greater. The illuvial level, as a result of the deposit of the fine substances near the drain, possesses the worst structure, and is most impermeable, which is very important particularly in heavy soils.

By the influence of the drainage the physical condition of the soil undergoes rapid alterations, especially in the upper layer, with diminishing tendency as the depth increases, and in such a manner that in the illuvial level these alterations, particularly with heavy kinds of soil, almost disappear.

For the percolation of the water through the soil, the composition and structure of the soil in the illuvial level B is decisive; for the valuation and characterization of the conditions of the soil for drainage purposes, the samples of soil concerned must be taken from this level for analysis.

As the illuvial level B in loamy soils is fairly permeable, in such soils a deeper drainage (up to 1.40 m., max. 1.50) can be chosen, in order to force the percolation of the water to the drain through a stronger layer of soil. The humidity distributed in this manner through a greater layer of soil, with corresponding capillary attraction, gradually becomes of value at a time of dryness.

In heavy soils the unfavourable condition is caused by the precipitated water, scanty aeration and high water capacity as a result of a superfluity of colloidal substances. The improvement of the structure of the heavy soil can be effected by the elimination of the colloidal constituent parts, by quick removal of the humidity, or by intensive drying. For this purpose, in these soils, superficial drainage (about 1.0 m. deep) is better, stopping at the illuvial level, and connecting directly with the elluvial layers, from which it quickly drains off the water. By this means, the washing out of the colloidal constituents by the drainage water in the upper layers is assisted, and so its coherence and excessive water capacity are reduced. In heavy soils the illuvial level represents the natural depth of the drainage, as it separates almost completely the elluvial layers from the deeper ones. Under our climatic conditions the influence of frost does not reach the depth of the superficial drainage, and moreover, this never conducts water in the full profile in winter, so that the pipes cannot be injured by freezing.

The achieving and maintaining of the crumbly structure is much more difficult in heavy than in loamy kinds of soil. In these situations, after carrying out the drainage, liming is advisable in order to get a coarser structure ; for this purpose, in marly situations, the deposit from the deeper layers can be advantageously used, whereby the carbonate of lime originally washed out can be partially given back to the upper layers. In laying drains in heavy soils, it is better to cover the drain with soil from the upper elluvial layers, in which there is a lower content of fine parts that can be washed out, and which are therefore more permeable. L. SMOLIK.

Experiments in Sub-irrigation.

ROSSI E. *Nuovi Annali dell'Agricoltura del Ministero dell'Economia Nazionale*, p. 25 to 50, year V, No. 1-2. Rome, 1925. Provveditorato Generale dello Stato, Libreria.

An irrigation system in which the water rises from the subsoil to the roots, that is to say sub-irrigation or subterraneous irrigation, appears more rational than the application of water at the surface of the ground or the usual irrigation. Sub-irrigation should imitate what happens in semi-arid countries during the dry season, in which care is taken by suitable cultivation to keep the surface of the soil thoroughly friable and broken up, however dry, while the moisture is allowed to replenish the roots from the reserve in the sub-soil by means of the natural capillary action.

Conceived in this way the chief aim of sub-irrigation should be to reduce the loss of moisture by evaporation from the surface of the soil, a very important object when little water is available.

Attempts at sub-irrigation are not lacking, especially in America ; but apparently it is only at Sanford in Florida that sub-irrigation has given better results than surface irrigation ; elsewhere it has generally been abandoned.

At the present time three systems of sub-irrigation are known :—

1. LEE's system suggested for orchards. A subterranean system of iron pipes, composed of a main pipe of 15 cm. and lateral ramifications of 7.5 cm. is arranged running along the rows of trees and has an aperture which can be opened or closed from outside corresponding with each tree.

2. The SANFORD-MONTERISI system consists in placing, at a depth of 40-45 cm., a series of earthenware pipes 20-25 cm long, and 80 mm. in diameter inserted in each other in such a way that the water escapes freely at the junctions. These pipes branch out from a closed main system of piping situated in the highest part of the field. The distance between the lines of underground irrigating pipes is 5.40-7.20 m.

3. Systems of *porous pipes*. ULPIANI proposed to make use of very porous earthenware pipes cemented one to another so as to form a perfectly closed system which could be immediately filled with water. The water exudes slowly through the pores of the earthenware and is absorbed by the soil with the greater avidity, the drier the soil.

The MONTERISI system was adopted on the farm of the Station near Bari, selecting a plot of ground which at a depth varying from 50 cm. to 1 m. presented a slight formation of crust, very friable however and probably not continuous. The water under pressure coming from the Apulian aqueduct was introduced by means of a flexible connection directly into the head of the subterranean system of pipes, after having passed through a Meinecke meter.

For experimental purposes the lines of pipes were placed at various distances between 2.50 m. and 5 m. and at depths of 40 cm. and 50 cm. For comparison with the sub-irrigation, surface irrigation with the furrow method, that is to say by infiltration, was practised in plots adjacent to those sub-irrigated. The soil is reddish alluvial sandy-loam, rather friable.

The porosity was determined at the beginning of the experiments and at the end, namely in September ; in the unirrigated plot, which was kept carefully hoed, the caking of the soil was nil at the surface and negligible at a depth ; in the sub-irrigated plot it was nil at the surface, slight at a depth ; in the surface irrigated plot it was high at the surface, considerable at a depth.

Diffusion of the water around the system of piping.

Vertical diffusion from the system of piping to the surface. — In one hour and a half (capillary ascension measured in Wahenschaffe's tube) the water ascended 25 cm., in eight hours it already reached 40 cm. After which the ascension took place more and more slowly, though despite this after 36 hours 50 cm. was passed. In the soil, directly after the water had been administered the following degrees of moisture were recorded :—

	4th row (50 cm.)	5th row (40 cm.
In contact with the pipes	20.00-21.22 %	20.75-22.3 %
10 cm. above	17.13-19.50 »	20.00-21.13 »
20 » »	15.05-18.35 »	18.52-19.25 »
30 » »	12.45-15.20 »	16.70-18.42 »
40 » »	9.50-10.15 »	— — »

The higher figures were recorded within 20 metres of the inlet, the lower figures in the 20 metres further away.

At 10 metres distance from the system of piping, where certainly its influence could not reach, there was, at a depth of 40 cm., a degree of humidity, slightly less than that at the surface of the sub-irrigated ground.

Lateral diffusion. — In 1924 after 1-7-14-21 days from the third sub-irrigation, the humidity, at 1 m. from the pipe, at 20 cm. depth, gradually decreased from 13.35 % to 8.00 % ; at 40 cm. depth, from 13.60 % to 8.50 % ; at 2 metres from the pipe at 20 cm. depth from 12.30 % to 7.02 % ; at 40 cm. from 13.18 % to 8.45 %. At 4 metres distance from the pipe the humidity scarcely exceeded 10 % in the first 24 hours, at 6 metres it remained much below this. At 8 metres distance the effect of the sub-irrigation was not felt. At 4 metres, 7 days after the watering, the humidity had already decreased to below 10 % ; at 2 metres after 14 days, at 1 metre after 3 weeks.

Diffusion between the systems of piping. — In 1923, in which the reserve water in the soil was greater, after the sub-irrigation in July a degree of humidity in excess of 15 % was maintained for over 14 days, even between the systems of piping 5 metres apart. After the sub-irrigation in August however, the humidity after 7 days had already decreased below 10 % between the systems of piping 5 metres apart and after 14 days between the two rows 2.50 m. apart.

In 1924, after the 3rd sub-irrigation given at the end of July, at 20 cm. depth, 15 % of humidity was attained and maintained for some days only between systems of piping 2.50 and 3 metres apart, 10 % was maintained for 7 days also at a distance of 5 metres, for 14 days at 3 metres, for 2 days at 2.50 metres.

At a depth of 40 cm. 15 % of humidity was reached and maintained for 14 days between systems of piping 2.5 m. apart, for 7 days between pipes 3 and 4 m. apart, for a few days between pipes 5 m. apart. 11.10% of humidity was maintained for 21 days at 2.50 and 3 m., for 14 days at 4 and 5 m. distance between the pipes ; however at 4 m. distance after 21 days 9.90 % of humidity was still found at a depth of 40 cm.

Such records, made in the hottest and driest season and repeated every time at various points at different distances from the inlet, permit of the conclusion that in our installation a distance of 4 m. between the system of piping may be adopted even for a rotation of 3 weeks, while a distance of 5 m. requires a rotation of 2 weeks, if it is desired to maintain, at least at 40 cm. depth, a humidity of 10 %, the minimum necessary for the growth of herbaceous plants.

Diffusion below. — Much more water penetrates and is maintained below the systems of piping than above them. Part of this reserve rises by capillarity, but substantially this system of sub-irrigation tends, in soils of our type, to enrich the subsoil with water at a depth to which it is certain that the roots of common summer grown plants do not reach.

Diffusion according to the initial humidity— The moister the soil is before the application, the greater is the humidity obtained by the same quantity of water and the longer is it maintained. Therefore it is better to begin sub-irrigation in spring, when the soil still has a greater humidity than 10 %, and not to wait until the humidity falls below that percentage. The reserve of humidity in the subsoil also influences the rapidity with which the water runs through the sub-irrigating system of piping. As summer advances the drying is more rapid after each application.

In the tests in 1923 a total of 4493 cubic m. of water was required per hectare; in 1924 even more was required. Such a high consumption must be caused, in addition to that by ordinary evaporation (even with sub-irrigation there is loss of water by ordinary evaporation) and by the very strong transpiration of the plants in summer months, by the dispersion of water, in the subsoil, as in fact there have been means of recording.

The water's rate of progress is rapid in the immediate vicinity of the inlet, then progressively slower until it requires a very long time to get through the last metres. This is obviously due to the progressive decrease in the power of flow. To obviate this drawback I experimented with longer pipes of 70 and 95 cm. in 1924 in a new installation. These preliminary experiments prove that, at least in our conditions of soil, time and water are saved by using pipes of various length, placing the longest at the inlet and then gradually the shorter. For the installation of a field of sub-irrigation, according as use is made of pipes of various lengths or of pipes all 25 cm. long, an expenditure of 9200 to 10 000 lire It. per hectare has to be met. At 9200 lire, counting on a duration of 10 years, there would be an annual cost of amortization and interest of L. 1380.

For surface irrigation, calculating a maximum of 15 irrigations from the 1st May to the 30th September, which really in this climate should not ever be necessary, the cost of labour does not exceed 800 lires. The factor therefore which would make sub-irrigation preferable to surface irrigation is the consumption of water.

Principal conclusions.

Surface irrigation causes the soil to cake strongly at the surface, considerably at a depth; sub-irrigation slightly at a depth, not at all on the surface. A few hours suffice to cause the moisture from underground pipes to rise to the surface. A depth of 50 cm. is to be preferred, because pipes at 40 cm. keep the surface moister, thus favouring evaporation and the development of surface weeds. Laterally to the pipe however humidity is maintained longer at a depth and favours the development of plants with tap roots and bulbs, including some weeds which cannot be got rid of by hoeing. The distance between the system of pipes should not exceed 5 metres; at 8 metres there would be no effect.

With the system of open junctions (SANFORD-MONTERISI), experimented with by us, most of the water is lost in the subsoil, if the latter is permeable, and is not utilised by surface rooted plants. This leads to a waste of water, which however, decreases at every successive irrigation. It is best to make use of pipes of different lengths to render the escape of water at each junction constant, with great saving of time and water.

Among the plants experimented with, maize, beans, tomatoes and cotton produced more with surface than sub-irrigation, while soy-bean, lentil, sorghum, sesame, *Vigna sinensis* (forage) produced more with sub-irrigation.

With regard to dry cultivation, the increased production obtained with sub-irrigation pays for the cost of the installation and consumption of water for plants which grow all the summer, while for early produce and for some varieties of soy-bean the advantage depends on the course of the season. Super-irrigation costs less including labour and water than sub-irrigation with the MONTERISI system, but I abstain from a final judgement, having worked in soil conditions unfavourable to this system.

THE AUTHOR.

Tests of Surface Tillage for Maintaining Humidity in the Soil.

ROSSI, E. Agricultural Experimental Station of Bari, No. 6, pp. 27, and 1 diagram, April 1926.

Various experiments carried out by eminent agriculturists have demonstrated the utility of surface tillage for maintaining existing humidity in the soil. The tests therefore, dealt with in the above noted account, were made with the aim of determining the importance of the phenomenon itself, working under quite special conditions of soil and climate (Southern Italy), rather than to demonstrate the fact now long established. The enquiry was further extended to the greater or less influence which surface loosening of the soil (2-3 cm.) and working it to a certain depth (12-15 cm.), might have on the question. Results were obtained on ground which was planted with vines, one part of which was prepared after the manner of the district, with furrows designed to get a large collection of water during the spring rains along the rows of vines, planted precisely at the bottom of the furrow. The humidity was determined at different depths by taking always for each plot of the 4 types :—(unworked — surface loosened — worked to about 15 cm. — with furrows) two samples at the same point, the first at about 20 cm. depth the second at about 40 cm. depth.

The soil which was the subject of the experiment is a soil derived from the decomposition of the so-called " calcareous tufas " belonging to the Pliocene or Post-pliocene formations. These are sandy calcareous rocks, more or less coherent and containing scattered fragments of mollusc, echinoderms, foraminifera, corals and other more or less macroscopic marine fossils. After Cretaceous they are the most common soils in Apulia.

The experiment, was started on the 14th March, and finished on the 30th August.

In the course of the experiment fully 20 observations were made.

The best result was given by the plot loosened at the surface and by the plot arranged in furrows, which after the initial preparation of the soil on the 14th March, was worked again to relevel the surface on the 16th May ; the other two plots were loosened on the 17th April, the 16th May and the 23rd June ; on this latter date the surface of the fourth plot, which, as noted above, was kept in furrows up to the 16th May, was slightly loosened. The minima percentages of humidity (mean of the humidity of the soil) in a thickness of 10 cm at a depth of about 40 cm. occurred :—

In the unworked plot	on the 1st August :—	3.085 %
In the plot loosened at the surface	on the 10th August :—	5.025 %
In the plot loosened to a depth of 15 cm	on the 10th August :—	5.45 %
In the plot arranged in furrows .	on the 23rd July :—	5.625 %

The maximum difference between the humidity of the loosened plots and the unworked plot was recorded :—

for the plot loosened at the surface, on the 7th May :—	4.90 %
for the plot loosened to a depth of 15 cm. about the 7th May :—	3.75 %
for the plot arranged in furrows on the 16th May :— .	3.79 %

On the days in which the maxima differences of humidity were registered there remained in the plot loosened at the surface and in the plot arranged in furrows a quantity of water double that remaining in the unworked plot, and not much less than the quantity of water which remained in the plot loosened to a depth of about 15 cm.

The humidity fell below 6 % twice in the plot loosened at the surface ; once in the plot arranged in furrows ; fully 6 times in the plot loosened to a depth of about 15 cm ; while in the unworked plot, from the 16th May to the 20th August, or for fully 11 observations, the humidity almost always varied between 3 % and 4.95 %.

It is a noteworthy fact that on the arrival of the dry period, the surface of the unworked plot became more and more compact, until a pan 5-6 cm thick was formed, so hard that it required great effort to break it every time that samples were taken. Below this pan the soil continued to remain very loose and the water contained in the soil, owing to its intimate and uninterrupted contact with the hard stratum over its whole surface, had been able to go on evaporating until the humidity was reduced to such a minimum, as is seldom reached in soils of sub-humid regions and only very exceptionally in those of humid regions.

Contribution to the Mechanical Analysis of the Soil.

SEIWERTH, A. Prilozi mehanickoj analizi Ha. Glasnik za Lumske pokuse I. 1926. Zagreb.

The writer gives some results of comparative analyses of soils carried out by means of ATTERBERG's and KOPECKY's apparatus, using distilled water and aqueduct water of the town of Zagreb.

In table 1 are found the results for soil particles having a diameter of less than 0.002 mm. of parallel analyses made at the same time with distilled water and acqueduct water in ATTERBERG's apparatus. The figure shows the parallel test of sedimentation of a loam in distilled water and aqueduct water. After 24 hours of sedimentation, for 20 cm. of height, the soil in the aqueduct water is almost entirely found at the bottom. The liquid was so clear that the dark line behind the apparatus could be seen. On the other hand suspension in distilled water remains so dense that the dark line behind the apparatus could not be seen through the liquid.

In Table 2 are set out the quantitative differences found in the different samples of soils by washing them with distilled water and aqueduct water in KOPECKY's apparatus. The parallel analyses were made with each sample of soil always in the same apparatus. In the same table it is seen that the small differences in temperature for the same soil in the same water are without perceptible influence on the results of the analyses.

Table 3 shows that even slightly greater differences of temperature have not had any greater influence.

From the heading " duration of washing " of table 2 it is seen that the time required to carry out an analysis varies very much according to the samples, but it is generally shorter in distilled water than in aqueduct water. For sample K, table 4 shows the influence of the too hasty stopage of washing on the results of a mechanical analysis.

For the cylinders of KOPECKY's apparatus the time in which one litre of water runs off is 201.03″ and not 202″ as is found in books. But it is seen from table 5 that this small difference in the time of running off has no influence on the results of analyses. In the same table are found the results obtained by washing soil or quartz sand when the time of running off is 202″ or 200″. L. SMOLIK.

Effect of Mulches on Soil Temperatures, during Warmest Week in July 1925 at Davis, California.

SMITH, Ph. D. sen. University of California, Davis.

The highest soil temperature found was in the bare plot, where on July 17, 1925 at a depth of one-half inch the electrical resistance thermometer registered 143 degree Fahrenheit. Temperatures were obtained at a depth of one-half inch in only two plots and the results showed that in the bare plot it was 10 degrees warmer during the day on the average and 5.6 degrees cooler at night than on the plot covered with perforated black paper. In these same two plots temperatures were obtained at the six inch depth. In the bare plot the average day temperature at 6" depth for the week was 0.9 degrees higher and the average night temperature was 0.6 degrees higher than on the area covered with perforated black mulch paper.

In the bare plot where temperatures were obtained at depths of ½, 3, 6, 12, 24 and 36 inches, decided differences were found between the day and night temperatures down to a depth of 12 inches.

Where a black paper, mulch paper non-perforated, was used, the average temperature for this warm week at a depth of 3 inches was 97 degrees as compared to 91.1 on the bare plot. The next warmest plot was that covered with perforated black paper where it was 90.9, followed the gray paper non-perforated plot with 87, and finally the gray paper perforated with 85.7 degrees

The maximum temperatures at the 3 inch depth occurred usually about the same time which was two hours after the maximum air temperature was reached. The range in these soil maxima was 13 degrees at the 3 inch depth.

The minimum temperatures at the 3 inch depth occurred on the average 1 hour and 40 minutes after the minimum air temperature and showed a range of 7.4 degrees.

Temperatures taken at the 12 inch depth showed that under the black non-perforated paper it was on the average 5.5 degrees and under the perforated black paper one degree warmer than in the bare plot during the day, while under the gray non-perforated paper it was 3.6 degrees colder and under the gray perforated it was 4.9 degrees colder than in the bare plot.

The average night temperatures at the 12 inch depth were highest under the black non-perforated paper and lowest under the gray perforated paper.

The maximum temperatures at the 12 inch depth occurred usually at about the same time, which was 8 hours after the maximum air temperature was reached, and showed a range in the various plots of 11.6 degrees. The minimum temperatures at the same depth occurred on the average 6 hours after the minimum air temperatures and showed a range of 10.6 degrees.

The colour of the soil surface or the colour of the paper mulch and whether the paper is perforated or not produce a marked effect on soil temperatures.

The warmest soil during this week was that covered with non-perforated black paper and the coldest was that covered with the gray perforated paper. X.

The Application of Archimedes' Law to the Mechanical Analysis of Soil.

SMOLIK J. Využití Archimedova zákona při mechanickém rozboru půd. *Zemědělský Archiv*. Prague, 1925.

Archimedes' law can be applied with advantage for the simplification and shortening of the practical mechanical analysis of mineral soils according to KOPECKY.

For this purpose the various particles, after being separated into their size categories, are transferred from the cleansing cylinders into weighed Erlenmeyer flasks (the various sizes of flasks 1 ½ litres, 500 ccm., 300 ccm., serve very well) which are filled with water and then weighed. The net weight of each category in the water is multiplied by 1.6, and so the weight in the air is obtained.

If it is a question of percentual data, then the net weight in the water is multiplied by 3, when 53.33 g. of soil are taken for the analysis, or by 3.2 if 50 g. of the soil are taken. VERF.

Soil Chemistry.

The Use of the Quinhydron Electrode for Measuring the Hydrogen-Ion Concentration of Soils.

BAVER, L. D. (Ohio Agr. Exp. Station), *Soil Science*, Vol. XXI, pp. 167-179. Baltimore, Md., 1926.

A study of the quinhydrone method for determining the hydrogen-ion concentration of soils leads to the following conclusions:

1. The saturated calomel cell is the most convenient to use since it is most constant and does not require a reversal of poles below pH 7.68.
2. For accurate results 0.05 gm. of quinhydrone per 15 cc. of solution is sufficient. The quinhydrone may be added in solution provided a fresh stock is prepared each day.
3. The potential is very constant with this electrode with the exception of soils above pH 8.0. It is reached quickly and easily.
4. The quinhydron and ordinary hydrogen electrodes compare closely. Variations were obtained from 0 to 0.2 in pH, which is considered close enough for most soils work.
5. The most desirable soil-water ratio to use as a standard with the quinhydrone electrode is the ratio of 1 : 1. It gives results comparing closely with those obtained with the ordinary hydrogen electrode.

The quinhydrone method has a very distinct advantage over the ordinary hydrogen electrode inasmuch as the apparatus required is simpler, both in construction and operation, and requires a much shorter time to reach equilibrium. The method is applicable to field as well as laboratory purposes. J. S. JOFFE.

On the Degree of Resistance of various Limestones to Acid Solutions circulating in Agricultural Soil.

BOTTINI, E. (Torino S. Stazione Chimico-agraria). *Le Stazioni sperimentali Agrarie Italiane*, Vol. 52, No. 7-9, pp. 268-288. Modena, 1926.

A large number of products are called limestones which, while having allied chemical compositions, are very different in structure and physical properties; this diversity of structure evidently entails a different degree of resistance to physical and chemical agents, and hence a different behaviour of the various, types of limestone towards agricultural soil and the roots of plants. The researches made by the writer admit of the following conclusions :—

1) Limestones as regards their behaviour towards acid liquids (aqueous solution of CO_2), 1 % aqueous solution of acetic acid, 5 % acetic acid, N/10 hydrochloric acid, and N/10 nitric acid), may be divided into three groups. The first group includes the marly, concretionary, sandy and fos-

siliferous limestones, which are those most easily decomposed. The second group includes the argillaceous limestones which are more resistant than the previous kinds. Lastly, the third group includes dolomitic, saccharoid and compact limestones which are those least easily decomposed.

2) The decomposition of limestones follows fairly closely their respective specific weights, the smaller the specific weight, the more easy the decomposition. Exceptions are in the first group, the concretionary limestones and, in the third group, the dolomitic limestones. For these latter, however, the anomaly is easily explained by their peculiar composition.

3) The degree of resistance of limestones varies with their geological disposition, limestones belonging to the deepest strata of the ground being less easily decomposed than those belonging to more recent strata.

4) It is thus clearly proved that in soil investigations not only should the content in $CaCO_3$ be taken into account, but also its behaviour towards decomposition which varies according to the nature of the soil itself.

Contribution to the Explanation of the Effect of Colloidal Silicic Acid in increasing Production in Sandy Cultivations.

DUCHON, F. *Zeitschrift für Pflänzenernährung und Düngung.* Part A, 4th Year, Vol. 5.

The favourable effect of colloidal silicic acid on productivity where there is insufficient phosphoric acid manuring in sandy cultivations rests mainly on the physical qualities of the colloids, which improve the physically unfavourable conditions of the sand. The physical improvement then shows itself in a better utilization of the apparently small but actually sufficiently large additions of phosphoric acid. The natural soils contain, with suitable tillage, sufficient, indeed abundant quantities of colloids. Sterile sands, poor in colloid substances, of similar character to the sand used in pot cultures can be improved in practice by stable manure or green manure, which has therefore been introduced and proved in practice. By this means the production factors of the food material supplied in the form of artificial manures is increased at least in the same measure as by the use of colloidal silicic acid in pot cultures. And so the use of colloidal silicic acid has no importance in practice. Just as the established suitability of the Na in pot cultures to take the place of K to a certain degree has no significance, so colloidal silicic acid as a means of saving phosphoric acid is also of no importance. The means by which one can be assured of the highest production factor of the phosphoric acid manure, are to cover the natural soils with those which in practice increase the fermentation processes of the soil. Such being the case then, if we want big agricultural harvests, it will not be possible to replace full manuring which contains the indispensable phosphoric acid manure, in other words we must use easily soluble phosphates.

L. SMOLIK.

On the position of the Practical Agriculturist to the Question of the Acidity of the Soil.

EINECKE A. *Illustr. Landw. Ztg.* Year. 45, No. 28, p. 339. 1925.

The author warns against the under estimation of the importance of the question of soil acidity for the condition of the soil and the health of plants. The comprehension of the " condition of the soil ", first emphasized by HUNIG, appears to be of special importance for guarding against acid and alkaline injuries. For example we know that a mineral soil which is rich in fine earth, humus and lime in a finely distributed condition, and possesses normal water characteristics, shows a strong " digestive capacity " for all manuring materials, and so an exact knowledge of the contents of fine earth, humus and lime in the soils of a farm is of the greatest importance to the practical agriculturist.

He also points out the importance of the fact that by using physiologically acid manuring material on soils which are already acid great damage to plants may easily occur, therefore a proper consideration by the agriculturist of the questions pertaining to liming in exact amounts is essential, and the suitable application of physiologically alkaline, neutral or acid manuring materials must be striven for. He gives warning against the agriculturist relying on the results of his own investigations with the various " acidity testers " etc. K. SCHARRER.

Studies on the Influence of Lime on the Soil.

GEHRING, A. and WEHRMANN, O. *Landw. Versuchsstat.*, 103, 279, 1925.

Taking the speed of nitrate formation as a measure of the influence of lime on the soil, we got the following results :— quick-lime, marl, " without manure ", lime of potassium and residual lime. The influence of the residual lime on the physical condition of the soil shewed no better results than those of normal lime manuring, while biologically it was distinctly injurious. Certain associations exist between physical quality on the one side and CO_2 production and nitrification on the other Only the residual lime and the lime of potassium do not obey this law ; the first named material, in a mechanical respect, produces nearly as great an effect as quick-lime, but as regards CO_2 production and nitrate formation it remains far behind the unmanured plot, evidently because of its high content of chlorides, which have a disinfecting effect. On account of its high potash contents the lime of potassium shows an inclination to cause coagulation. As regards the breaking up of the organic matters in the soil effected by manuring with the various kinds of lime, it appears that, measured by the quantity of CO_2 produced, quick-lime has the best effect, followed by residual lime, marl and lime of potassium. D. MAYER and HISSINK have mentioned processes for separating absorptive combined lime from that soluble in acid. The former works with a 10 % NH_4Cl solution, the latter with N/1 NaCl solution. Comparative experiments of the authors induced them to work in accordance with the more detailed but more exact methods of HISSINK. They also give an account of a theory of method for determining the highest combination capacity of lime, and, in conjunction with the process of HISSINK, the so-called *lime saturation factor*; 25 g. of the same soil has 40 ccm. saturated quick-lime solution poured over it, and is then shaken for 30 minutes. A few drops of phenolphtalein are then added, and CO_2 is introduced until colour appears. The CO_2 lying over the liquid is removed by introducing air, while that in solution in the liquid is removed by heating for a short time to 60° and by blowing air through. A further 20 ccm. of the saturated quick-lime solution is allowed to run in, it is shaken for 30 minutes, CO_2 again introduced, and this process is repeated until the desired quantity of liquid, 100 ccm., is reached. After the last saturation of the remaining lime with CO_2, as much solid sodium chloride is added to the quantity of liquid as is necessary to make the solution normal. It is then heated to 80-90°, allowed to stand for 12 hours, and the exchangeable lime is determined by separating the absorbed lime from the carbonate in the manner suggested by HISSINK. The quotient, determined according to HISSINK, of the available contents of absorbed lime and the maximum content, determined by the authors' methods, gives the degree of saturation of the soil. At a saturation degree of 70 the requirement of lime of the soils examined ceases. With soils having a degree of saturation of 70-72, the authors could not obtain increased crops by applying more lime. There consequently appears to be a parallelism between the degree of saturation and increased production. It further appeared that if no hydrolytic acidity occurs in a soil, there is also no necessity for lime; in such cases, therefore, it is superfluous to carry out the methods of determining the degree of saturation. K. SCHARRER.

Critical Investigations on Neubauer's Seedling Method.

GUENTHER, E. *Zeitschrift f. Pflanzenernährung und Düngung*. Vol. V, Sect. I, Part B, 1926.

The author examines the influence of light and of the soil reaction on assimilation of foodstuffs by seedlings. The analysis figures of the same soils under different light conditions during growth show that the influence of light plays a subordinate part, and under normal conditions can be entirely neglected. With a soil in which, having otherwise the same contents of food materials, different degrees of acidity were produced by the addition of calcium carbonate, it is clear from the results of the analysis that the difference of soil reaction does not affect the food assimilation by seedlings, unless it is very marked. L. G.

Taking Samples of Soil from the Field.

HAEHNE, H. *Zeitschrift für Pfanzenernährung und Düngung* Vol. V, Sect. I. Part B. 1926.

Mixed samples, which came from a different number of places distributed uniformly over the field under investigation, were examined by

NEUBAUER's seedling method and the results compared, in order to be able to work out a definite rule for taking samples of soil from the field. It appeared that an average sample from 10-15 places in fields which can be described as uniform is quite sufficient, whilst if taken from only 5 places, the probability of finding the correct average is too small. The average of the samples and not any individual one must be using for udging the field. GOERNER.

Nitrification Studies.

HALVERSEN W. V. Oregon Agricultural Experiment Station, Cornwallis.

Nitrification tests were run on a series of fertiliser plots to determine the relative value of several methods. These plots are located on Willamette silty clay loam, which is a prominent soil type of the Willamette Valley. It normally has a pH value of about 5.5 and is one of the most fertile soils in that locality. In these tests the power of the various soils to produce nitrates from their own organic matter, from 30 mgs. of N as ammonium sulphate, from the same amount of ammonia sulphate added with 210 mgs. of $CaCO_3$ and also from 0.1 % of blood meal was determined. In all cases 100 gms. soil were used at optimum moisture content. The nitrate production in the soil itself was so small during the 28 days incubation period as to give little information : the other methods gave parallel results except on one plot which received heavy applications of sulphur, superphosphate and potassium sulphate, in which case the blood meal gave comparatively higher yields of nitrate. It is significant that on plots which had received excessive applications of lime in the field, the yield of nitrates was proportionately higher in the tests where the $CaCO_3$, was added with the ammonium sulphate. Over this wide range of acidity and fertiliser treatment the merits of one method over another were not apparent, though a range of H ion concentration from 5.2 to 7.2 and a wide variation in buffer content prevailed.

The nitrate content of fallow plots adjacent to the fertiliser plots which had received 0, 2, 4, and 6 tons of lime respectively per acre was determined at several intervals during the growing season, and showed that lime promotes the production of nitrates in this type of soil. The most nitrate is found where the largest application of lime is made, even though that application is excessive. The production of nitrates in the soil is in agreement with the laboratory tests and is quite necessary and should be taken in consideration in determining the nitrifying power of a soil. Numerous analyses, however, of soils on which crops are growing fail to yield more than a trace of nitrates until the crop is harvested.

That a difference in the physiological efficiency of the nitrifying flora of soils exists is shown by the parallel results obtained when nitrification tests are run in both soil and solutions. However, the fact that nitrification is more dependent on the soil conditions than the biological efficiency is evidenced by the failure of soils to produce larger quantities of nitrates after being inoculated with a soil infusion containing organisms of a higher physiological efficiency. X.

On the Retension of Superphosphates in Acid Soils.

KAPPEN, H. *Deutsche landw. Presse*, 52, 489 and 496, 1925.

On the basis of his experiments, the author comes to the opinion that the fear that superphosphate-phosphoric acid can form such compounds in the free acid soil as to check the plants, or at least have less effect than on other soils, is unfounded. His vegetation and chemical solution tests showed that the presence of excessive Al- and Fe- sesquioxide did not have any ill effect on the absorption of the Al- and Fe- phosphates as both of these are easily assimilated by plants. K. SCHARRER.

The Recovery Power of a Soil as indicated by Incubation.

MARTIN, F. C. Laboratory of Plant Nutrition, University of California. Berkeley, California, 1926.

A brief review of the characteristic behaviour of a fertile fine sandy loam soil under conditions of continuous cropping with barley and of continuous fallowing, as reported in earlier papers from this laboratory, is given.

This soil was used as a culture medium for various crops in an absorption study in the greenhouse, as the result of which the crops, maize, oats and turnips, reduced the concentration of the liquid phase to a low level and entirely depleted the nitrate.

These residual soils were incubated at 27-29° C. after the removal of the different crops and screening to remove some of the larger roots. The moisture was kept constant (14 %). The soils were studied by displacing the soil solutions by the BURD and MARTIN method at from 9 to 161 days after incubation was started, then determining the total concentration (conductivity) and the composition with respect to the more important plant food constituents.

The results of the preliminary study of a soil by this method showed that during the first few days an indication may be gained as to the residual effects of different types of plants on the activity of the soil organisms producing nitrate. After maize and after turnips, their activity increased much more rapidly during the first two weeks than in soil after oats, bearing out the observations of LYON and BIZZELL several years ago on maize and oats on field plots of soil. Continued incubation for five months showed that following all three crops, the concentration and composition reach levels which are very close to that reached in this soil after eight years fallowing in a container in the field.

The method gives promise of application to the study of the potentialities of a soil for supplying constituents to its liquid phase when its equilibrium is disturbed, giving the information in a very short time.

Comparison of the Methods of Determining the Concentration of Hydrogen Ions of Soils.

NIKLAS H. and HOCK A. *Landwirtschaftliche Versuchstationen*, 104, 87, 1925.

The colorimetric method of MICHAELIS was compared with the colorimetric process of CLARK and LUBS, with the result that the agreement can be described as very good, as the differences between the electrometric and colorimetric measurement of the soil reaction, according to the experiments of the authors, did not amount, on the average to more than 0.1 in pH values, and the electrometric method being recognized as a basis, the above pigments can be so far considered as excellently suitable for the examination of the soil. K. SCHARRER.

Electrometric Titration in its Significance for the Lime Requirement of our soils.

NIKLAS, H. and HOCK, A. *Landwirtschaftliche Versuchstationen*, 104,93, 1925.

For carrying out the electrometric titration 50 g. soil are shaken for half an hour with 125 ccm. 7.5 % KCl solution, then, after decanting, 10-20 ccm. are pipetted, and, with the help of the universal indicator recommended by the authors, the soil reaction is arrived at by the aid of an electrometer. Then the alteration of the actual acidity is traced, which is apparent if to the soil solution are added known quantities of acid or alkali, whereupon the number of ccs. of acid or alkali introduced are drawn on the abscissa, and the corresponding values for pH on the ordinate of a coordinate system, and the titration curves appertaining thereto are constructed. Most acid mineral soils, with electrometric titration, show their chloride of potassium extraction curves, which point to the presence of $AlCl_3$, consequently to changeable acidity, whereas forest soils show quite a different course of curve, because with them the acidity is caused by humus acids and phosphoric acid. When soil suspension methods are employed, the course of electrometric titration proceeds with difficulty; with sandy and light loamy soils it is successful, but with the heavy loamy and clayey soils, and with many humus soils, it is quite impossible in consequence of the poisoning of the electrodes by the soil colloids. If the total acid in a soil is ascertained by the DAIKUHARA method, using methylene red as indicator, then the quantities of lime calculated from that are certainly minimum values, and are mostly to be considered as insufficient, whereas by the DAIKUHARA method, using phenolphtalein as indicator, values result which are too high, whereby one dose of the amount of lime indicated as wanted might under certain circumstances be too much for many plants. The figures arrived at on the basis of electrometric titration for chemical neutrality lie between the two limits, and may be considered as serviceable results. K. SCHARRER.

On the Quantity and Chemical Composition of Colloidal Clay.

NOVAK, V. SMOLIK, L.: O mnozstsvi a chem. slozeni jilu Kolloidniho. Zpravy.

The following is a summary:

1. Colloidal clay in its widest sense amounts to more than 9 % of the total mass of the soil.

2. The content in colloidal clay proper amounts to 7 % of the total mass of dry soil.

3. The ratio between SiO_2 and (Fe_2O_3, Al_2O_3) in colloidal clays, properly so called, varies between 2.5 and 1.04 : 1. The ratio between SiO_2 and Al_2O_3 runs from 4.3 to 2.6 : 1.

4. The content of colloidal clays proper in alkaline and alkaline earth bases is generally relatively high.

5. The organic part of colloidal clay is gene ally more easily dissolved in a 10 % solution of hydrochloric acid than the inorganic part. Accordingly, it is thought that nutritive substances are more easily set free from organic combinations or complexes than from inorganic combinations.

6. It appears that the basis of colloidal clay in the wider sense is a pseudo-combination of humic matter with alumo-silicic acid. Colloidal clay proper is probably only composed of alumo-silicic acid. The absorbent power of colloidal clay proper, owing to the lesser surface activity of the inorganic colloids, is less considerable than that of clay in the wider sense. L. SMOLIK.

Researches on Nitrification and Denitrification in Oxidizing Media.

PARISI, E (Istituto superiore agrario, Bologna). *Le Stazioni sperimentali agrarie italiane*, Vol. 58, No. 10-12, pp. 449-472, bibl. Modena, 1925.

The nitrification of ammonia occurs regularly in an atmosphere of pure oxygen. This fact, which the writer has proved, enables the phenomenon of nitrification to be studied more intimately and furnishes the method of establishing a complete balance of nitrogen.

The author's experiments show that the combustion of organic matter, such as may be indicated by the production of carbon dioxide, is in proportion to the quantity of oxygen consumed. In permeable soils, then, ammoniacal nitrogen and nitrous nitrogen are completely transformed into nitrates, in an atmosphere containing oxygen; in waterlogged soils, on the other hand, especially in the presence of amino-acids or amides in sufficient quantity, ammonia and nitrous acid are readily broken down and their nitrogen is set free into the air in a molecular state. In such cases, the total decrease of nitrogen is equal to the weight of the nitrogen set free.

Very probably the group $>CHNH_2$ reacts on the nitrous acid according to the formula $>CHNH_2 + HNO_2 = CHOH + H_2O + N_2$, in this way causing a loss of nitrogen double that which would occur through simple denitrification. In a soil containing 15-20 % of water, the consumption of oxygen is more intense than in a waterlogged soil. The presence of sugar however can increase the consumption of oxygen in waterlogged soils to an extraordinary extent. A. F.

Is Soil Reaction of Importance for the practical Agriculturist ?

TRENEL, M. *Zeitschrift f. Pflanzenernährung und Düngung*. Vol. V, Sect. 4, Part B, 1926.

The work deals with the dependence of liveliness of growth of the different cultivated plants on the soil reaction. The reaction cards of the estates examined are appended. It is shown that the determination of reaction by electrometrical methods in suspensions containing KCl shows this dependence better than do measurements in watery suspension.

Soil reaction more acid than pH 6.0 injures beetroot, barley and clover. Oats and wheat do well up to pH 5.2 ; potatoes were found insensible up to pH 4.2 ; with rye an optimum could not be recognized. Sorrel and equisetum cannot be considered as definite signs of soil acidity.

The geological conditions of the soil must be taken into account in judging. Referring to this, investigations of the sub-soil, which are given in the reaction cards, deal with this point and are of great value to the agriculturist. L. G.

Soil Biology

Soil Sickness.

DE GILLIS H. (R. Stazione Chimico-Agraria Sperimentale di Portici). *Le Stazioni Sperimentali Agrarie Italiane*, Vol. LVIII, No. 10-12, p. 373-439, 1 Tab. Modena 1925.

In spite of the numerous investigations on the so-called sickness of the soil, the problem of its determining causes not only remains obscure but demands the recording of experimental researches, based on sure method and extending to the study of the phenomenon down to its characteristic beginnings.

The author has therefore initiated a plan of systematic researches with the object of solving this problem. In this, his preliminary note, he reports on the experiments made with mustard, peas and *Miagrum sativum*. The phenomenon of decreased production is sketched clearly in these researches ; in some cases there was an increase rather than a reduction of production, but these were quite isolated exceptions, after which the phenomenon renewed its normal course.

The process of sickness however is not found to be so quick as is generally allowed, though the plants selected were those considered best suited for the purpose. Undoubtedly then the phenomenon is subject to the action of external agents ; thus the summer season makes it more active. It is not possible at present to say whether this corresponds with a more active vegetative growth evolution or with other conditions.

Moreover the sickness exercises greater influence on germinating seeds and on plants in the first stage of growth and it is quite possible that the damage sustained then may be the principal cause of subsequent defects.

The writer proposes to follow up his researches by investigating the effect of aqueous extracts of the soil when it has reached the most suitable degree of sickness, if not of absolute unproductivity. A. F.

Humification Experiments.

CAUDA A. (Asti. R. Istituto Tecnico Gioberti). *Le Stazioni Sperimentali Agrarie Italiane*, Vol. 59, No. 1-3, pp. 99-105. Modena, 1926.

The aptitude of agricultural soil for transforming cellulose intohumus varies from one soil to another owing to the presence or absence of humifying bacteria and depends on its constitution and composition.

The author investigated this bacterial activity in various soil samples :— meadow soil, soil under willow trees, willow mould, plane tree mould, of which only the willow mould caused total humification of wheat straw and the fruit sheaths of maize.

The humification takes place at a high temperature (30°C.), with cold it slows down or is prevented. From other experiments the author deduces that ammonium sulphate also retards and hinders humification. Immersion in water prevents, while light does not hinder the formation of humus.

Coprinus and the bacterium of peat cause a noticeable transformation into humus ; the former gives rise to colonies of the appearance of paraffin, with development of ammonia, while a bacterium is isolated with colonies mostly white, red, yellow, brownish, capable of humifying straw with much blackening and giving off an earthy smell of beet.

We cannot speak of a true transformation into humus in the case of the ordinary mushroom or of fermented tobacco.

The Effect of Sulphur on the Microflora of the Soil.

FIFE, J. M. (Utah Agr. Exp. Station), *Soil Science*, Vol. XXI, pp. 245-252, 1926.

This is a report of a study made on the influence of varying amounts of sulphur on the soil microflora as measured by numbers, ammonification, nitrification, azofication and the rate at which the sulphur is oxidized to sulphates.

Three soils were used in the experiment soil " A " with a low organic matter content, soil " B " with a high organic matter content and soil " C " with a medium organic matter content.

The sulphur applied ranged from 100 to 1000 pounds per acre.

According to the author sulphur greatly stimulated ammonification in all three soils with soil A leading. Nitrification was stimulated in soil B by sulphur in all concentrations with the exception of the highest applications. Sulphur was very toxic in soil A. Although the sulphur was very toxic at all the lower concentrations in soil C, a great stimulation occurred in the higher concentrations. The sulphur was without effect on azofication during the short time the soil was under observation. There was a general decrease in the number of bacteria over the period the counts were made in the treated and in the untreated soils. Soils A and C showed a very slight increase in bacterial numbers. J. S. JOFFE.

The Bacterial Types Occurring in Frozen Soil.

LOCHHEAD, A. G. (Central Exp. Farm, Ottawa, Canada) *Soil Science*, Vol. XXI, pp. 225-231. Baltimore, Md.

This is a report of an investigation on the bacterial types occurring in frozen soils of Eastern Canada. The field soils had been frozen for more than 2 months. The number of bacterial colonies appearing on albumin agar at 3° C was less than 10 % of those at 20°C, most of the bacteria of frozen soils being incapable of low temperature growth. At 20° C the most abundant type was the group of non-sporulating short rods, non-liquefying or slowly liquefying, and the next most abundant group was that of *Actinomycetes*. Rapidly liquefying rods and micrococci were found to be numerically unimportant. At 3° the non liquefying short rods formed a higher proportion of the bacterial colonies, the other groups showing even less capability for low temperature growth than these forms. The microflora of frozen soils does not appear to exhibit characteristics different from those found at other seasons. Sixteen type species, isolated from nutrient agar plates at 3° have been described, as well as their frequency. Two types predominate — both non-sporulating short rods — one slowly liquefying, one non-liquefying, and they appear to be representative soil types of other seasons which develop better at more moderate temperatures.

J. S. JOFFE.

Handbook of the biophysical and biochemical Investigation of the Soil.

STOKLASA, J. in collaboration with DOERELL, E. G. With 91 text illus. pp. 812. Paul Parey, Berlin, 1926.

The book contains what the title promises. It is a work which recapitulates our present day knowledge in the field of biophysics and biochemistry of the soil, with a clear arrangement of the matter, a clear representation and full comprehension of the subject. Space forbids more than a short summary, which will suffice however to show that its comprehensive and enlightening account of soil problems is of the greatest scientific importance.

In the section on biophysical and biochemical examination of the soil the general methods of soil examination are first of all described, particularly the mechanical analysis of the soil and the determination of water capacity, also the analysis of the soil air. Further sections deal with its chemical analysis, the determination of the soil colloids, of its electrical conductivity and its catalytic agents. The section on soil reaction gives a comprehensive account of the numerous electrometric and colorimetric methods. There follows then the description of the special chemical examination of the soil, particularly of the determination of foodstuffs in soil extracts. Of especial interest is the next section on radioactivity in the soil and in the soil air, and its influence on the germination and development of plants.

The second main section of the book covers the methods of biological investigation of the soil. After general observations on the micro-organisms present in the soil, the bacteria of the rhizospheres are described, and the methods of the examination of edaphons demonstrated. After a comprehensive description of the bacteria taking part in the nitrogen cycle in nature, there come sections entitled : Synthesis of albumen in the soil, methane-decomposing and hydrogen-oxidizing bacteria, sulphur bacteria, desulphurizers, iron bacteria, actinomyces, soil fungi, soil algae, protozoa. There follows then a description of them. Determination of the results of bacterial respiration is then described, as are biological absorption, and biochemical methods for determining the hydrated phosphoric acid and oxide of potassium contained in the soil in an assimilable state. The further chapters concern :— soil respiration, carbon dioxide as basic factor, methods for determining the carbon-dioxide produced by the soil, connection between organic substance and heterotrophes, between the chemical character of the organic matter and the respiration process, breaking up process of the cellulose in the soil, oxidization processes of the nitrogen-containing organic substances in the soil, respiration intensity of the micro-organisms, respiration of forest soils, composition of drainage water as an indication of the bio-chemical processes in the soil, effect of stable manure on the mechanics of the respiration process in the soil, influence of radioactivity on the dissimilation process of the micro-organisms in the soil. It is in short an outstanding work which should be in the library of all soil scientists.

SCHUCHT.

Soils and Vegetation.

The Significance of Traces of Elements upon the Growth of Young Orange Trees.

HAAS, A. R. C. and REED, H. S. Riverside, California, Citrus Exper. Station.

Characteristic injury to the foliage of young orange trees is often observed in sand culture experiments. The injury does not occur in sand cultures where tap water is employed in making the nutrient solutions, but is prominent where carefully distilled water and pure chemicals are employed. The difficulty is overcome by adding to the supposedly complete culture solutions minute amounts of a suspension containing aluminium sulphate, potassium iodide, titanium sulphate, potassium bromide, strontium nitrate, lithium nitrate, manganese sulphate, boric acid, and ammonium nitrate. It is improbable that all of these ions are necessary for alleviation of the difficulty, and future work is in progress to ascertain those which are essential. X.

Contribution to the Question of the Influence of Pure Spruce and Beech Stocks, as well as Mixed Stocks formed by both kinds of trees, on some qualities of Forest Soils.

KVAPIL, K. and NEMEC, A. (From the Biochemical Institute of the State Forest Testing Station at Prague). *Zeitschrift für Forst- und Jagdwesen*, year 57, pp. 193-231. With 11 tables, 3 diagrams and 2 illus.

The authors show, from a big series of physical, chemical and biochemical examinations of the same soil, that the influence of pure spruce stock on the sandy, primitive mountain loam of East Bohemia (in the forest part of Tremosnice near Caslau, height above sea level 420 m., average yearly temperature 8.4° C., annual precipitation 646 mm.) is much more unfavourable than that of pure beech stock. The favourable conditions induced by the latter were reached, or even surpassed, if beech and spruce were mixed.

Kopecky's suspension analysis shows that all three soils (at a depth of 35 cm.) maintain a normal and fairly similar condition.

But the fine sand content of the pure spruce soil is the greatest, amounting to 32.5 % by weight, which points to a more unfavourable physical condition of the soil.

Following BURGER's view that the air capacity is the most important indicator of the fruitfulness of forest soils, these are the only physical figures to be worked out, and are in absolute values: beech 22.37; spruce 15.00, mixed stock 26.73. These figures themselves suffice to show the unfavourable influence of the pure spruce stock, and the favourable influence of the pure beech and also of the mixed stock.

The *analysis of nutrient matter* (boiling the soil with 10 % Hydrochloric acid) gives a corresponding picture:

Table III. (abbreviated).

Kind of wood and type of soil	Content of nutrient matter in % of dry weight				Organic matter in %
	P_2O_5	K_2O	SO_3	CaO	
Beech, mineral soil	0.228	0.039	0.449	0.117	4.73
Spruce »	0.005	0.021	2.599	0.081	1.58
Both mixed »	0.144	0.047	2.699	0.187	4.89

Determinations of nitrogen were made by methods which I shall explain at another time for humus and mineral soils (surface layers). They were then separated and differentiated again into nitrogenous compounds, soluble in concentrated HCl, such as amides and diamino-acids. The spruce humus most rich in total amount of nitrogen (1.473) contains it however in a very insoluble form, so that it only passes into the mineral soil to a small degree. These unfavourable food conditions for the trees, obtaining in woods of pure spruce, can be made just as favourable as those in pure beech woods by mixing spruce and beech, as the following figures show :— Beech humus 0.867 % N, beech mineral soil 0.231 % N., spruce humus 1.473 % N, spruce mineral soil 1.58 % N, mixed stock humus 1.269 % N, the like mineral soil 0.282 % N.

The *acidities* (total, relative to titration acidity, actual and exchangeable acidity) are such in their values that the spruce humus is most acid with 4.6 pH, and with 6.2 pH the mineral soil of the mixed stock is almost neutral. They were determined colorimetrically by MICHAELIS' method (indicators without buffers).

The *catalytic power* (action of catalysis) of the soils showed itself to be in the closest dependence on the degree of acidity, whilst the most acid was least capable of releasing oxygen from hydrogen peroxide.

The *ammonifying power* was also shewn to depend on the degree of acidity and the amount of organic matter present, Tests by Remy's method gave the following results :—

Spruce 19.42 mg.; beech 85.44 mg.; both mixed 75.33 mg. N. (10 g. humus overlying mineral soil and 100 cm. 1 % Witte peptone solution).

The values of the *assimilation of the atmospheric nitrogen* were in the same relationship in the humus beds of the three stocks as were the bio-chemical qualities investigated up to now, in that pure beech showed a recovery of nitrogen of 14.85 %, pure spruce only 11.6 %, and the mixed stock 39.2 %. The mineral soils, gave rather a different result. The mixed stock, with 49.5 %, was the best, then followed pure beech with 27.8 %, and the spruce even showed loss of nitrogen (denitrification).

The nitrate formation, determined by the VHAMOT-PRATT method by reduction of the nitrate into picric acid, is shewn by the following figures, according to which pure spruce again comes out most unfavourably:

From Table VIII.

1000 g. humus in relation to mg. nitrate (net value) yielded:

Beech humus	128.2;	spruce 94.2;	the two mixed 168.3
Beech soil	77.4;	spruce 59.3;	the two mixed 88.8

The *phosphoric acid adsorption* was shewn to be exactly proportional to the degree of acidity. The acid spruce humus could only retain 16.6 %, while the mineral soil of the mixed stock, on the other hand retained 74.10 %.

The *cellulose decomposition* is demonstrated by illustrations. According to that, the three humus layers are approximately alike in operation. The strips of filter paper are but little consumed. But in the mineral soils, on the contrary, the strips of paper pressed by the mixed-stock soil are almost completely decomposed, while those in the spruce soil are almost completely untouched.

The *fermentation intensity*, determined by ALBERT and LUTHER'S method in Ivanoff vessels with quicksilver manometer, is likewise smallest (40 mm.) in pure spruce soil; in beech and mixed-stock soil on the other hand being three times as great.

The *measurement of the chemical light intensity* in bunsen Roscoe units by WIESNER and CIESLAR'S method leads to the conclusion that each individual corona of the mixed stock absorbs a somewhat greater quantity of light than the corona of the pure beech and particularly of the pure spruce wood.

According to all the data, there appears to be no doubt that for the sandy original mountain loam investigated, and the climate and conditions mentioned, which occur so frequently, the mixed forest formed of leafy and needle woods influences the general condition of the soil more favourably than pure stocks, and very much more favourably than the pure spruce stock. The important bio-chemical factors of the soils, are affected most.

GROSSKOPF.

Regional Soil Science

The Vegetation of Switzerland.

BROCKMANN H. JEROSCH. First series, Part I. Der Boden. Rascher & Co. Zürich, January 1925.

Of this very important work of the well known botanist and geographer, the first part on the soil interests us the most. The author states his intention clearly in the headings of both chapters :— I. " Attempt to define the soils of Switzerland " and 2. " Surface formations and soil conditions in their relationship to vegetation ".

It may be surprising that a geographer and botanist should be the first to give a survey of the kinds of soil occurring in Switzerland, and of their distribution. The reason lies in the very small attention paid in the Swiss colleges to pure soil science and in a noticeable absence until recently of systematic, geographical, scientific soil investigation. That under these circumstances the work under discussion was a bold venture is clear, and it is to be expected that in many respects, from the point of view of a soil expert, many deductions of the author must appear as somewhat hasty.

In the first chapter the author gives, by the aid of the (somewhat altered) scheme of LANG a survey of the climatic types of soil, and advances the statement that in Switzerland there must be almost all types of soil, from arid to ultra-humid. As arid soils the author understands places where, especially in the mountains, through the action of water, lime encrustments occur, or where, under overhanging rocks, in caves, etc., there are efflorescences of salt. Included as humid soils occurring in Switzerland are yellow brown and humus soils, and as ultra-humid soils, podsol soils. The soils in the high mountains are partly designated as frost soils.

The author emphasizes with reason that as a result of the geological youth of Switzerland, and also especially because of the continual metamorphosis through demolition and upheaval, there are still present immature or very slightly disintegrated soils. This explains the great importance of the mother rock, and there results, therefore, as a consequence of the geological multi-formation of the surfaces a mosaic of the most varied kinds and conditions of soil.

In the 2nd. chapter the " superficial forms and soil conditions in their relation to vegetation " are dealt with.

In the centre the last two glacierizations, with their erosive action (principally by water) and discharges (moraines and fluvio-glacial boulders) form the character of the soil. The soil is conceived climatically as brown earth, which in any case, through the mother rock, is of very varied kinds.

The soil of the Jura is represented as being very dependent on its geological origin, and a tendency towards the formation of brown earth is assumed.

It is clear that the Alps must exhibit the most extended variety of soils. With the lack of exact investigation, it is naturally very difficult to get an insight into the actual conditions. BROCKMANN, therefore, ventures " no longer to pass by such important matters without bringing them within the range of our consideration ".

Encrustments, as mentioned above, are comprehended as arid soil formations. In relatively dry valleys (Wallis, Schanfigg) the author expects the appearance of yellow soil, and sees, in the various places where loess occurs, soils which incline towards the formation of yellow soils. A study of the effect of the wind on soil formation in the Alps is certainly well justified.

Ultra-humid climate at great altitudes, and in the valleys with high precipitation, on the northern border of the Alps, leads to Podsol soil.

In conclusion, three short sections are devoted to the frost soils in places where no chemical disintegration can take place, and to the soil movement and minute life of the Alpine soils.

The " attempt " of BROCKMANN has given the soil expert a very stimulating work. Of technical soil literature only that of LANG, WIEGNER and Graf zu LEININGEN is quoted. Further literature appears to be unknown to the author (for example RAMANN, Soil formation and soil classification). There are no analyses at all. The author states many times, however, that " at many places only individual observations were made " and " there might be omissions " (p. 34 and p. 49).

We consider that in reality the soil formation in Switzerland possesses a more humid character than is generally assumed to-day. More or less certain formations of Podsol soils are not rare in the centre of the country (particularly on gravel and loess), as a number of recent observations and works satisfactorily prove (WIEGNER, JENNY, JENNY and BRAUN-BLANQUET, MEYER, SIEGRIST and GESSNER). If the work of BROCKMANN-JEROSCH stimulates to detailed investigations, it will certainly have rendered a great service. GESSNER.

On the Causes of the Displacement of the Coast Line.

CREMA, C. Spostamenti della linea di spiaggia presso Favazzina nel Golfo di Gioia. *Boll. del R. Ufficio geologico d'Italia*, Vol. I, No. 9, pp. 1-13, 1 map, 1 fig. Rome, 1925.

Between the stations of Bagnara and Favazzina on the Tyrrhenian coast railway a retrogression of the sea coast, formed in that locality by deposits of the Favazzina torrent, has been ascertained. As principal cause of this phenomenon is to be considered marine erosion no longer counterbalanced by fresh deposits of materials by the torrent, the latter having changed its habit in consequence of the earthquake of 1908.

No other action can presumably be invoked to explain it, not even gradual earth movement which sometimes helps to cause variations of the coast line, seeing that no authoritative observations admit of such taking place on the coast investigated, and also the action of such slow movements could not attain appreciable importance in face of the so much more energetic action of tidal waves. Such phenomena may always, as in the case under survey, develop great importance, but only when the littoral is of a rocky nature.

Such changes in proximity to the mouth of a stream should always be regarded as possible whenever it is desired to effect the regularization of catchment areas. A. F.

The Reclamatian of the Lower Friuli.

FERUGLIO, D. and FERUGLIO, E. (Staz. Chimico-agraria sper. di Udine). La zona delle risorgive del Basso Friuli fra " Tagliamento " e " Torre ". *An-*

nali della Stazione chimico-agraria sper. di Udine, Ser. III, Vol. I, pp. 1-479, II Tab., 4 maps, bibl. Udine, 1925.

The vast zone which the writers deal with in this geological, hydrological, and agricultural paper comprises fifteen thousand hectares of land situated in the centre of the Friulian plain, for the greater part swampy and everywhere under difficult drainage conditions The soils have a diversity of texture and composition, but are almost always covered over by a considerable humiferous layer and variously clothed with self sown marshy and shrubby vegetation.

Few efforts have as yet been made by private agriculturists to free their property from the curse of these spring waters, which if suitably controlled and adapted to irrigation would, owing to their very excellent temperature and composition, actually tend greatly to increase the agricultural value of the land.

The reclamation of this zone is evidently beyond the power of private initiative and can only be expected to be undertaken as a public enterprise.

In the region investigated, from the point of view of reclamation, three zones may be distinguished :— An upper zone which includes the perimeter of the springs, in which the importance of the overflowing from the artesian strata is considerable ; an intermediate dry zone, such as can succeed with a rational arrangement of drainage ; a lower circum-lagunary and delta zone, for the most part still marshy.

Provisions contemplating the mechanical raising of the drainage water are only necessary for the third zone. In the first and third zones there is absolute predominance of marshy growth, while in the second zone cultivated fields, more or less dry meadows and wooded areas prevail, the last of which however have to a great extent disappeared. The regularization should primarily be directed to the streams which collect most of the water into the irrigation channels of the springs so that the great masses waiting for dispersion of the side rivers (Tagliamento and Torre) may be promptly collected and got rid of.

Other essential works should be completed so that on the one hand the main streams and the torrential water courses may no longer form an obstacle or a danger to subsequent operations of agrarian reclamation, and on the other hand a sufficient quantity of irrigation water may be supplied.

Then considering the considerable extent of the zone represented by gravelly-sandy alluvia, with little natural fertility, ground elevated from the important superficial accumulation of humus, it is understood that a simple drying process of the land would undoubtedly lead to a great decrease in production. The zone would therefore be transformed into an area needing irrigation and for this purpose the considerable power of the overflow from the water holding strata in the upper zone is such as to assure any increase in consumption.

In the circum-lagunary zone the irrigation water would also serve very well for removing salt from the soil.

Agricultural improvement should go therefore hand in hand with these water schemes and the technical agricultural programme should be based on the irrigation schemes. Water meadows and grasslands, cattle breeding, dairying, the cultivation of osiers, poplars, alders and, in process of time, the erection of human habitations in the hitherto unpopulated zone may be expected. The work will be facilitated by the fact that, under a recent ruling, the zone investigated is comprised in the first category of lands for reclamation. A. F.

Soil Formation, Colonization and Succession of Plant Associations on the Aar Terraces.

GESSNER, H and SIEGRIST, R. *Mitt. der Aargauischen Naturforschenden Gesellschaft.* Vol. 7, pp. 54, 1925.

The authors examined the meadows of the Aar Valley at different heights in the neighbourhood of Aarau in the Centre of Switzerland. The results of the soil examinations are given briefly:

A) In the so-called *high water channels*, the districts of the real river bed, the recent deposits (sand and gravel freshly washed out by high water) show a high but evenly distributed content of lime with on the average 25 % of $CaCO_3$. Also the humus content of this sand, poor in vegetation, is remarkably high (4 ± 0.4 %). On passing over to the fertile forest land, the humus content rises in the uppermost layer to 8 %. A slight washing out of lime is already confirmed here. Soil reaction neutral to weak alkaline.

B) *The lower terraces.* — Result of the last ice period, bears mixed woodland. Corresponding to the great age of this stage, the disintegrating progress of the soil in a humid climate is here plainly shown. The beginning of podsol formation is demonstrable by muriatic acid extractions, complete washing out of carbonates up to 1.2-1.8 m. deep, distinct washing out of sesqui-oxides and increase of the same in the lower lime free layers Reaction weakly acid, humus content up to 22.4 %.

C) *High terrace.* — Result of the ice period prior to the last. On account of the great age of these deposits, the formation of podsol soil is more sharply marked, and can be confirmed by the naked eye (photo). The upper levels of the soil are perfectly free from lime, and have a strong acid reaction (pH up to 4.9). The humus content falls with increasing depth, the subsoil being rich in $CaCO_3$. Unfortunately, only the podsol layer is sufficiently analysed.

Many tables, drawings and photographs make the work very clear. It must be given credit for first emphatically drawing attention to podsol formation in Central Switzerland. H. J.

The Diamond fields of South West Africa.

KAISER, E. Die Diamantenwüste Südwest-Afrikas. Explanation of a special geological map of the southern diamond fields 1 : 25 000, drawn up by W. BEETS and E. KAISER. 2 volumes with many tables, maps and illustrations. Dietrich Reiner (Ernst Vohsen) Berlin, 1926.

Seven years after the loss of the South West African protectorate a work has appeared which represents, scientifically, the most important production emanating from this field of labour. Whilst PASSARGE's exhaustive work on the Calahary only touches the eastern portion of the former colony, and SCHULTZE's able work "Aus Namaland und Kalahari", along with a general description of the country, plunges into an affectionate consideration of the natives, we have here before us a work which, starting from the interesting coastal deserts of South West Africa, collects there fruitful detailed results, and makes use of them for far-reaching conclusions with respect to the waste districts of other parts of the earth.

It is impossible, within the limits of a short description, to do justice to all the details of this exhaustive work, nor can the numerous individual contributions be gone into, which have been made to it by BEETZ, BOEHM, MARTIN, WAUFF, STORZ, STROMER, WEISSERMEL, WENZ, and WILLMANN. They go deeply into the results obtained by investigating special geological, palaeontological and petrographical questions. The sections written by BEETZ are closely connected with the investigations of KAISER, so that they must be considered in conjunction with them.

Diamonds were discovered in the year 1908 in the most desert parts of South West Africa. The discovery soon proved itself much more important than was at first supposed, and gave rise to the founding of several diamond companies. The most important of these was the German diamond company, to which belonged the extensive diamond district south of the Lüderitzbuchst railway. That this monumental work has been made possible is mainly due to the former Director of this Company, Dr. HEINRICH LOTZ, who made it possible to send Professor KAISER, and was able to provide special sums for the carrying out of the work.

The whole work is based on the geological map on a scale of 1 : 25000, which was drawn up by KAISER and BEETZ. It is in 7 sheets, included in the first volume of the work, and even on the desk, in its special representation, permits a glance into one of the most interesting waste regions of the earth. The importance of the work, however, goes far beyond the explanation of the special geological maps, and gives in particular the picture of the origin of the desert. In the first volume, after a short survey of the geology, the structure of the old mountains of the primary formation of South Africa is given. The primary formation consists of gneiss, mica schists and chlorite schists. There also appears granite-gneiss, which is metamorphosed from younger granite, also veins of these granite injections, and converted basic rocks of volcanic origin.

Above the primary formation lie the Concip and Nama formations B. dealt with by BEETZ. As a result of extensive travel in the interior of South West Africa, it was possible to parallel these old fossile-free sedimentary layers with the formations in the interior already arranged earlier by RANGE; in consequence of the special mapping of the desert regions, the Nama formation in particular could be here drawn up in detail. Even in these oldest sedimentary formations numerous volcanic rocks appear. Whilst in the older crystalline foundation mountains acid volcanic rocks are most prominent, basic rocks predominate in the suspensory stage of the primary formation and the Concip formation. In part these volcanic rocks possess great geological age, in opposition to the alkali rocks and allied rocks, which did not arise until during a jurassic-cretaceous levelling period, which followed the levelling of those formations. These alkali-syenitic rocks were specially examined and described in the Granitberg and in the Klinkhardtgebirge. On these levelling surfaces the old layers were then deposited in younger eocene and miocene forms, as described by BEETZ at the beginning of the second volume. In these layers were found, amongst other things, interesting remains of vertebrates which STROMER von REICHENBERG has described thoroughly. These throw new light on the geological past of South Africa. In the tertiary deposits we already find diamonds, which then, by working up, have in part undergone such enrichment that they represent the richest diamond appearance of the whole region. The primary beds whence the diamonds originate must therefore be older than eocene, and approach very nearly to the age at which the South African geologists place the upper lime of Kimberley. KAISER and BEETZ come to the opinion that neither dark blue beds under the sea, nor the Orange River, nor the Benguela come into question as conveyors of the diamonds; the origin of the diamonds must rather be sought inland in South West Africa under the deposits of the dry climate. The dry flows of the oldest tertiary time have in their course carried to the coast the diamonds washed out of the mother rock, and bedded them in the layers deposited by them. There, where the eocene sea has spread out the layers, or the lower miocene rivers have washed them out, they appear in a richer state. The richest beds have been blown out of this deposit again by the wind.

These isolated samples of the work must suffice to show the special results of the two investigators.

The other great undertaking which KAISER has set himself is to follow up all the factors of the desert formation in their relation to each other. So he shows us in a masterly way the processes of the mechanical rock preparation and rock deposit in a dry climate. Water and wind are dealt with thoroughly. It is shown how far-reaching are the effects of water even in the dryest parts of the desert, where they would be least expected, and where many investigators have spoken of a purely mechanical rock preparation. Attention is also drawn to the importance of the wind, for which this wind-ravaged part of the coastal deserts is particularly notorious. The investigations on the re-deposit of silicic acid are also of very great importance. Their elimination again takes place in the coastal districts in greater proximity to the source of origin than in a humid climate. Nearly all the rocks are silicated. Under new formations of silicic acid formation are understood all the processes which play a part in and after penetration of the silicic acid coming from outside into the mineral residues present. The carbonate rocks of the Nama formation in particular present a good field of reaction for the silicic acid. Also the tertiary Pomona quartz and the surface lime are strongly silicated. The silicification processes are extended over a long period of time, beginning with the chalk period. An optimum is given by the passing over from normal arid to extreme arid climate. For the formation of a strong silicated covering, a long maintenance of the form of the upper surface of the land is necessary. Of the young, sedimentary, new formations in the desert climate, the wind borne sands are thoroughly dealt with. The appearance of these is different in sand drift and sickle shaped dunes. Both are streamline bodies, but of quite different form and origin.

The work is splendidly produced. Two coloured title illustrations after pastels of the well known South African painter AXEL ERIKSON give a picture of the beautiful colours of the desert. 54 tables explain the landscape and geological profiles, indicate the morphogenetic processes, and again give the fossils dealt with. 32 stereo-illustrations make possible a glance at the small forms of the desert. Numerous text illustrations explain the text. The special geological maps are supplemented with maps of the Granitberg, a morphological map of the Wannen country, and one of a journey amongst the dunes. The price for the beautiful work is low, its appearance being made possible by contributions to the costs of printing which were granted to the publisher. RANGE.

The Composition of the Fractions Separated by Mechanical Analysis from some Transvaal soils.

MARCHAND, B. de C. and van der MERWE, C. R. *South African Journal of Science*, Vol. XXII, pp. 104-118. Johannesburg, 1925.

A brief review of the literature on the above subject, outside South Africa, is given and then the mechanical analysis and the chemical composition of the various fractions discussed of (*a*) sandy soil types and (*b*) heavy soils. The mechanical analysis is done according to the (HALL) beaker method and the soil separated into seven fractions.

Typical mechanical analysis of sandy soils from four different rock formations are given as well as the ultimate chemical analysis of each fraction. The silica decreases while the alumina, iron oxide and phosphoric oxide increase, as the size of the particles decreases. The phosphoric oxide is concentrated to a great extent in the clay fraction. Lime, magnesia and potash also increase as the size of the particles diminishes up to the very fine silt fraction which usually contains more of these constituents than the clay. In sandy soils derived from granite, the coarse fractions, however, show a higher percentage of potash than the finer fractions.

With regard to the heavy soils, the heavy red loams and the black clay soils (turf soils) are taken as samples.

With the heavy red loams (derived from ferruginous, basic igneous rocks) the silica decreases regularly and alumina, magnesia, and phosphoric oxide increase generally as the size of the particles decreases. The potash shows considerable irregularity, but the finer fractions as a rule are richer in that constituent than the coarser ones. Since these soils have a high clay percentage (40-50), the phosphoric acid and also potash are largely concentrated in the clay fraction.

The black clay soils are also derived from basic igneous rocks (see MARCHAND: " The origin of the black turf soils of the Transvaal " this Review, Vol. IV, No. 3, page 6, 7), and contain a varying amount of free calcium carbonate. Silica and lime decrease, as a rule, as the particles decrease in size. The general tendency is for the alumina, iron oxide, magnesia, potash and phosphoric oxide to increase from the coarser to the finer soil fractions, with slight irregularities here and there.

In conclusion the physical properties and the composition of the clay fractions of the above two types of heavy loams (red and black) are compared and the very marked differences discussed. MALHERBE.

Seasonal Variation in Salinity of Nile Water at Rodah (Giza) with Special Reference to Alkaline Carbonates.

ALADJEM, R. *Technical and Scientific Service Bulletin*, No. 69. Ministry of Agriculture, Egypt.

Chemical research on Nile water has been made since 1812 by several writers, but until the recent work of M. Victor MOSSERI no attention had been paid to alkaline carbonates and the resulting alkalinity of Nile water at certain periods of the year.

The writer's researches which were carried on for two years (1924 and 1925) have dealt with samples of water taken weekly from the Nile, below the Rodah bridge, at a depth of 2 metres.

The total amount in solution, the alkaline carbonates, the total bicarbonates and the chlorides have been determined. The WINKLER-CAMERON method, inaugurated in Egypt by M. V. MOSSERI, has enabled the bicarbonates and the soluble carbonates to be separately determined.

From tables and diagrams drawn up by the writer it is shewn that the salinity of the Nile is at its maximum when the river is at its lowest, and that the bicarbonates form the most important fraction of the soluble total.

The origin of this alkalinity should be sought in the White Nile, being the result, according to all evidence, of the evaporation of the water which reduces the alkaline bicarbonates to carbonates. This change occurs either during the flow of the water of Lake Albert to Assouan, or in the reservoir of Assouan itself.

The waters of the White Nile are themselves enriched in alkaline carbonates by the Bahr el Gebel, which, during its passage through the Sudd, loses about half of its volume of water by evaporation.

Moreover, the waters of Lake Albert, of which some samples supplied by Dr. HURST have been analysed by the writer, are very rich in bicarbonates and contain a relatively high proportion of alkaline carbonates; but these waters do not appear to contribute to the alkalinity of the White Nile.

Most of the dissolved matter contained in Nile water is formed of bicarbonates, especially bicarbonates of magnesium and calcium.

The quantity of chlorides is very small, the maximum (47 parts per million expressed as NaCl) taking place at low water in May. The chlorides become appreciable, not only in consequence of the concentration of the Nile water at that period, but also because, like the bicarbonates, they are brought in by subterranean water which is discharged into the river.

Alkalis only form a small fraction of the dissolved matter in Nile water, which confirms previous researches of M. Victor MOSSERI, and the writer shows that this water contains in solution more lime and magnesia than potash and soda. If this had not been the case Egyptian lands would long ago have become sterile. V. M. M.

Carbonates and Bicarbonates in Solution in Nile Water.

MOSSERI, V. M. Bull. Inst. of Egypt. 1925.

The presence in irrigation water of alkaline carbonates and especially of sodium carbonate beyond a certain, always very small, percentage is objectionable. What matters most is the nature of the salts remaining after the evaporation or absorption of the irrigation water.

Though the Nile water and the subterranean waters do not ever contain dangerous proportions of alkaline carbonates, they have on the other hand appreciable quantities of bicarbonates, among others alkaline bicarbonates, which sometimes are transformed into very harmful alkaline carbonates.

The composition of the matter in solution in Nile water had only hitherto formed the subject of fragmentary and incomplete researches; the writer is the first person to make a systematic study of the question and to make separate determinations of the carbonates and bicarbonates, which he has done by means of the WINKLER-CAMERON method .

These determinations, started in 1906 on irrigation and drainage water as well as on subterranean water, have been made regularly since 20 April 1924 on the waters of the Nile itself, being taken every 7 days at a depth of 2 metres at two different places of the river at the Cairo level.

Besides carbonic acid of the carbonates and bicarbonates, the writer determined the total soluble content and the chlorine, and estimated the total CO_3 of the carbonates and bicarbonates. These data expressed on the one hand in milligrammes per litre and on the other in percentages of the soluble total have been condensed into two tables and compared with the approximate discharge of the river above the Delta dam.

It appears from these figures that the alkaline carbonates (and silicates) are most abundant (6 to 11 milligrammes per litre expressed as CO_3) during the last three months of low water (May, June, July) : the alkaline reaction with phenolphthalein is then appreciable ; while it is scarcely perceptible during the rest of the year and becomes nil from the middle of November to the end of January.

The bicarbonates are present throughout the year ; their quantity, expressed in HCO_3 and in milligrammes per litre, varies from 98 to 159 with a maximum in June and July and a minimum from September to December.

The fluctuations of the bicarbonates as well as those of the total of carbonates and bicarbonates (total CO_3) are similar to the variations of the chlorides, except in May and June. The quantity of various elements, expressed in percentages of the total soluble content, show that, expressed in CO_3, the alkaline carbonates (and the silicates) represent 0 to 5.5 %, the bicarbonates 55 to 44 %, the total of carbonates and bicarbonates 36 to 45 % of the total soluble content.

The writer, after having pointed out that in order to discuss these results usefully the quantity of silicates must be determined as well as the nature and the proportion of the various bases present in the Nile water at different periods of the year, insists on the importance of this question, which should not be lost sight of in works for regulating the river.

V. M. M.

The Fertility of Egypt.

MOSSERI, V. M. *Comptes Rendus du Congrès International de Géographie du Caire*, Vol. IV, pp. 135-168.

In the first part of his paper the writer deals with the agricultural wealth of Egypt and its principal factors, namely :— geographical position, climate, the peculiar character of the peasants, the soil and the river which waters it.

The remarkable geographical position of Egypt has had the most fortunate results on its commerce, supported almost exclusively, so far as exports are concerned, by agricultural produce, and on its flora, of which numerous representatives especially most of the plants cultivated at the present time are of foreign origin.

As the writer remarks, the history of the botanical acquisitions made by Egypt in the course of centuries is not only the history of its agriculture but also that of its external relations. According to SCHWEINFURTH, that history is divided into six periods, in the course of which Egypt borrowed much from tropical Africa, Arabia, Babylonia, Persia and India, Syria and Armenia, the Balkan Peninsula and more recently from America, thus collecting in its midst, thanks to the fortunate combination of the soil conditions, climate and irrigation, the greater part of the agricultural flora of the world. Recent attempts at new introductions have also been fortunate.

The climate of Egypt, regular, free from injurious extremes and from excessive dryness allows of the production of superior cottons in the Delta, cultivation of maize in Lower and Middle Egypt and of bersim, the most valuable of the Egyptian leguminous crops, from Assouan to the Mediterranean.

Although uniform as a whole it has however sufficiently marked differences between the south and north to impose on the agriculturist some discretion in the choice not only of the species but also of the varieties to be grown. It is thus that the growth of fine cottons is the speciality of Lower Egypt, that Upper Egypt, where coarse cottons are produced, is preeminently the region of the sugar cane for industrial use, of sorghum, onions, lentils and even of the bean ; that maize is uncommon outside Lower and Middle Egypt ; that rice, dinebe and samara are reclamation crops confined to Lower Egypt and the Fayoum.

After having sketched the character of the Egyptian fellah, whose aptitude is remarkable, and indicated the measures which should be taken to safeguard the qualities and health of rural labour, one of the principal factors of the prosperity of the country, the writer deals with the investigation of the soil of Egypt and the Nile. The genesis of these soils and the investigation of the Nile water are here related, as they have already been at greater length by the writer in previous publications (notably in " Agrological notes on the Egyptian Soil "). In the second part, the writer examines the conditions which in former times, under the regime of irrigation by basin, assured the maintenance of the fertility of the Egyptian soil ; he passes in review, as he had already done in a previous publication (" On the Egyptian soil under the regime of irrigation by inundation "), the many benefits of the fallow period, called *sharaqi*, the suppression of which under the present irrigation system is very harmful.

V. M. M.

Contribution to the Characterization of Soils of Hanâ, Czecho-Slovakia.

NOVÁK, V. Prispevek Kcharakteristice pud. Hané. *Zpràv vyzkumnych ustavu zemedskych c.* 3 *Ministerstvo zemedelstvi Prague* 1925.

This essay is a preliminary study of the typical soils of Hanâ. Hanâ is the flat country of Central Moravia, celebrated for its crops of malting barley. The general characteristics and the climatic seasons of this country are first of all described. The description of three sections of the soil of the following places :— Ivanovice, St. Ves near Prerov, and Hulin is given. The characteristics of the soil profiles are given by mechanical and chemical analyses.

The soils investigated are all " tchernozion " black soils slightly degraded. These black soils appear in two variations. The Ivanovice profile shows black soil with a tinge of brown — this is the soil of the drier places — with a layer of humus of a maximum depth of 70 cm., while the St. Ves and Hulin profiles show a darker, black soil, — this is the soil of the moister places with a layer of humus of a greater depth than 70 cm.

L. SMOLIK.

The technical investigation of the soil of the fields of the Agricultural School at Zhar in Moravia, and the immediate neighbourhood.

NOVÁK V., HRDINA J., and SMOLÍK J. Půdoznalecký prozkum pozemků hospodařské školy na Moravě a přilehlého okolí, Sborník vyzkumných ústavů zemědlěshých, sv. 14. *Ministerstvo zemědělství*. Prague, 1925.

The soil is that of a crystalline schist area. The Land Investigation Station at Brünn utilizes a large portion of the school fields for plant investigation. About 200 ha. were examined in detail. The summary of the investigation is seen graphically on the coloured map (scale 1 : 5000).

The soils are grouped as follows according to their genetic relationship.

1. Holocene meadow soils, 2. Podsol soils on diluvial drifts. 3) Podsol soils on gneiss detritus. 4) Podsol soils on diluvial deposits. 5) Podsol soils on disintegrated gneiss.

Further differentiation of these soils was carried out according to texture. On the average, the texture of the field mould was as follows:

Size of grain mm.	Contents %
0.01	40 - 45
0.01 - 0.05	20 - 25
0.05 - 2.00	40 - 30

A great lack of lime and of assimilated potash was determined by NEUBAUER'S method. L. SMOLIK.

Agricultural Importance of the Tocra District.

SCARTA, H. (R. Uff. Agrario della Cirenaica). *Rapporti e monografie coloniali del Governo della Cirenaica.* Series I, No. 7, 18 Tab., 1 Map. Bengasi, 1924.

From an agricultural point of view the soils of the Tocra district may be divided into argillaceous-sandy soils (along the littoral strip from Tocra to Bersis), fairly deep (even over 3 metres), with rocky subsoil (calcareous bed which forms its foundation); there are also soils of conglomerate type containing river-borne pebbles and rubble of superficial erosion.

Judging from appearances, they are fertile soils with high hygroscopic power; this may be presumed with greater reason from the fact that they are soils formed of thousand years old deposits of mud brought down annually by floods.

The various alluvial strata which cover the calcareous bed have different depths at different points.

Considerably different in appearance are the soils in proximity to the Sebka, being composed of the finer elements of the alluvium: dusty in summer, swampy in winter, they have visible saline efflorescences which may become regular crystallisations. The saline concentration decreases gradually as one gets further from the lake basin of the Sebka. The approximate extent of economic territory considered by the writer is about 250 sq. km., of which about 85 % is utilizable for pastures, which are grazed at different seasons according to their position, and a proportion of 15-25 % utilized or utilizable for the growth of cereals.

The population of the Tocra hinterland may be calculated at 2952 souls, with a total of 30 904 head of cattle over a pasture area of 21 200 ha. The area cultivated under cereals varies very much from year to year according to the rainfall. In 1922-23, a year of copious and regular rainfall, it was 3720 ha., in the following year, a year of very irregular rainfall, it was only 85 ha.

The area made fit for irrigable cultivation is 158 ha. of which only 41 ha. are permanently cultivated; the population which lives on and works this area is about 1/80th of the total population.

The growth of fruit trees represents a secondary item of income and the garden is more or less the result of the particular soil conditions and the social needs of the Kabyles and has become a factor of equilibrium and security against the sudden fluctuations of cereal and pastoral production.

There is some land which might well be irrigated, a total of 810 ha. forming a basis for the future increase in value of the zone.

There are too other lands which may be considered as subsidiary to the irrigable lands, and another 10 000 ha. of good land, with good depth and quality of soil, on gentle slopes, part of it benefited by winter floods.

No progress from the present form of misuse of the soil can be expectted from the indigenous population. Admitting the possibility of cultivating garden crops, part for local consumption and part susceptible of foreign and industrial trade, the establishment of a nucleus of a white population of about 2500 persons, to the extent of 5 per hectare, inclusive of white labour is considered possible.

Other groups might be established elsewhere with a total of 3500 for the land made fit for irrigable cultivation and about 7000 for ordinary dry cultivation, of whom not more than 3000 would be in Tocra and the others in rural villages scattered along the water places of Sabal.

The realization of this scheme, modest as it is, requires however shrewdness in the acquisition of land and in the investment of capital for irrigation and in general for economic reclamation. A. F.

On the meadows of the Tessin River. Study on the Connection of Soil Formation and the Succession of Plant Associations.

SIEGRIST R. and GESSNER H. Festschrift Carl Schöder. *Veroffentlichung des geobotanischen Institutes Rübel* in Zürich. Part 3. Rascher & Co. Zürich, 1925.

We heartily welcome this collaboration of botanists and soil experts. The present work shows very plainly how very closely soil formation and vegetation are connected with each other.

The investigation extends over the bottom of the valley of the Tessin from Airolo to Lake Maggiore. In the upper valley of the river the alluvial areas are only about 200 m. wide, whereas in the lower valley plains 10 km. long and 800 m. wide are quite covered with fertile woods and undergrowth. The following are the most interesting points for soil science.

All the soils examined belong to the brown earth type; the appearances of disintegration point to podsol soils, but these could nowhere be establised definitely. The unitary nature of the original deposits is shown by microscopic examination of the mineral composition of the sand. The new soils are bright grey, the more disintegrated older terraces showing pronounced chocolate-brown colouring, caused by humus and hydrate of iron. Analyses in muriatic acid extracts determined lime, humus and pH, ratio and suspension analyses gave the following picture of the soils: carbonate contents up to 12 %, humus contents up to 28 %. The very coarse sandy passage soils become very much richer in humus with progressive vegetation. Pronounced lime (and distinct magnesium) washing out is characteristic. The soils are found to be suitable for cropping, and quick cultivation of the meadows is recommended, to prevent the climatic washing away of its nutrient matter. H. J.

Sketch of Agricultural Geology of the Jura.

SIMONOT, F. *Le Jura Agricole*, 320 pages. Lons-le-Saunier, 1925.

We will confine ourselves here to the nature of the soils furnished by the different geological features of the Department of the Jura.

The generally marly soils of the Lias contain 4 to 15 % of lime, 2 to 3 % of phosphoric acid, and as much potash or nitrogen. They are very fertile.

The ferruginous limestone of Bajocien only yields on the surface soils containing traces of carbonate of lime, 2 to 3 per thousand of potash, and less of phosphoric acid and nitrogen.

The soils derived from the oolitic Bathonian limestones are chemically poorer. Carbonate of lime re-appeared on the analysis of the marly features. All soils of the middle and upper Jurassic are poor in phosphoric acid and contain less than 8 per cent of lime.

Lime content falls until there are only traces in the soils derived from yellow limestones, sands or the jagged face of the lower Cretaceus without the content in phosphoric acid being increased. The Pliocene soils of La Bresse do not contain any carbonate of lime and little phosphoric acid (0.5 to 1). The same is the case with ancient and glacial alluvial soils. The latter however are moderately rich in phosphorus, potash and nitrogen.

The richness of modern alluvial soils is very variable. In them the content in lime varies from zero to 20 per cent. The characteristic of Jura districts, where calcareous rocks predominate, is therefore the decalcification of the agricultural soils.

In view of the altitude of the mountainous part and the heavy rainfall, these lands are naturally suited for grass if they are marly and for forest if they are rocky.

Differing from dried regions showing the same features, Burgundy on the one hand and Provence on the other, which breed sheep, the Jura watered by 150 cm. of water goes in for the breeding of milch cows and manufacture of cheese.

The marls of the Trias and Lias exposed to the sun on the slope of the mountain are rich in phosphoric acid and potash and carry vineyards. Their content of carbonate of lime being less than 20 per cent., Riparia and Rupestris hybrids are used as grafting stock. The altitude of the vineyards is from 250 to 500 metres.

DR. PIERRE LARUE.

On the Exchange and Active Reaction Figures of Some Moravian Soils.

SMOLIK L. O výměnných a aktivních reakčních číslech některých Moravských půd.

1. The following limits of exchange reaction figures in the Moravian soils were determined in pH :

(*a*) With cultivated soils 4.4 - 7.4 ;
(*b*) With forest soils 4.1 - 6.3.

Limits of active pH concentration :

(*a*) Cultivated soils 6. 3- 7.3 ;
(*b*) Forest and meadow soils 5.9 - 7.1.

The alkalinity of the soils fluctuates within limits not so wide as the acidity.

2. The greatest acidity (of smallest exchange and active pH concentration and at the same time the greatest titration acidity) was found in forest soils and in those cultivated soils only which came from the more humid climate (from 700 mm. upwards).

The profiles of the arid cultivated soils show neutral or weak alkaline reaction up to pH 7.3.

3. The profiles of the degraded black soil (e. g. Hulín) showed an approximately constant pH exchange reaction in the vertical direction. The argillaceous earth capable of exchange could not be established here (as with the majority of the arid soils) ; on the other hand lime capable of exchange occurred in the whole profile in considerable and constant quantity. The active pH concentration has a maximum in loose vegetable mould, a second in the deepest subsoil.

4. In all acid soils the presence of exchangeable argillaceous soil was established.

5. The titration acidity (n KCl) reached the following amounts (calculated to 100 g. dry soil):

(*a*) with cultivated soils, highest 3.927 mg H ;

(*b*) with forest soils, highest 5.841 mg H ; in water extraction 0.451 mg H.

6. There was no connection established between the weight of humus present and the pH concentration, though the soil samples whose humus was unsaturated (soils of more humid climate) showed everywhere a lower pH concentration.

7. In the laboratory test, the germinating capacity and average growth of barley showed no correlation with the different pH concentration (exchange and active) of the different soils on which the grains were grown.

8. The relation between the hydrogen-peroxide-catalysis of the soils and the exchange reaction figure in pH is only a partial one.

AUTHOR.

The Reaction Profile of some Old Valley filling Soils.

STEPHENSON, R. E. Soil Department Oregon Agricultural Experiment Station. Cornwallis.

Eight soils are studied to determine changes in hydrogen ion concentration, lime requirement, and replaceable calcium and magnesium with the development of a soil profile. Textural observations noted a marked concentration of colloidal clay material in the second major horizon in some of the soil studied. Replaceable calcium is usually much greater in amount in the heavy horizon than in either the surface soil or the parent material. In these cases acidity is greatest in the surface leached soil.

The development of a normal mature profile in the valley soils therefore appears to be accompanied by the formation of base poor, acid suface soil. The material from which the soil was formed, however, is usually somewhat acid in reaction. The most fertile soils appear to carry the largest amount of replaceable calcium. Some of the soils which carry a fair amount of calcium in replaceable form are not productive however, apparently because of the physical conditions. X.

Relation of Replaceable Bases to Oregon Soil Problems.

STEPHENSON. R. E. Soils Department Oregon Agricultural Experiment Station. Cornwallis.

Replaceable bases are studied in eleven different Oregon soils taken from three types of climatic conditions. Six soils are taken from the humid valley section, two from the dry farm section and three from the arid section.

The soils from the humid area are heavy soil types acid in reaction, and much lower in total replaceable bases than soils from the dry farm section. One acid soil which responds abundantly to lime treatments in the field is very low in total replaceable bases, but especially low in replaceable calcium and high in replaceable hydrogen. The soils from the dry farm area are neutral in reaction, also rather heavy types, and very high in total replaceable bases and especially high in replaceable calcium. The soils from the arid section are neutral or only slightly alkaline light textured types. These soils are relatively low in replaceable bases, but show a high ratio of calcium to other bases.

There appears to be some correlation between total replaceable base and soil texture, as the heavier soils contain larger amounts when of similar reaction.

Calcium appears to be the most important replaceable base in both amount and function. Under humid conditions replacement of calcium by hydrogen produces base poor, acid soils. Under conditions of insufficient rainfall, calcium may be replaced by sodium, which results ultimately in alkali soils that are non-productive. In both cases prevention is decidedly better than cure. Proper soil management supplemented if necessary by treatment with special substances for its improvement may largely prevent either seriously acid or alkaline soils. At present there is no practical method known for reclaiming bad alkali soil. X

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General News.

Kispatic. — On the 17th May 1926, at Zagreb, the death occurred after long suffering of Dr. phil. MIJO KISPATIC, Professor in ordinary of mineralogy and petrography at the University of Zagreb, member of the Southern Slav Academy of Science, who had been living in retirement since 1918.

In addition to numerous scientific works which appeared in the " Rad der Südslawischen Akademie der Wissenschaft ", in the " Verhandlungen der K. K. geologischen Reichsanstalt ", in the " Centralblatt für Mineralogie ", etc., KISPATÍC was also the author, in the Croatian language, of a series of scientific nature instruction books, of which " Zemljoznanstvo, Zagreb 1877 " may be specially mentioned, as it represents the first technical instruction book on soil written in one of the Southern Slav languages. A. S.

Christensen. — On the 27th. August 1926 the death occurred of Dr. HARALD R. CHRISTENSEN, Director of the Statens Planteavls Laboratorium at Lyngby, Denmark.

Proceedings of the IV International Soil Science Conference.

The Proceedings of IV International Soil Science Conference — articles in original languages — edited conjointly by the International Institute of Agriculture and the Italian organizing Committee of the Conference, was published in book form last June and at once put in circulation.

The whole consists of 3 volumes containing 1758 pages, — tables and 183 figures and is a standard reference book on Soil Science. The general secretary — and acting president — of the International Society of Soil Science Dr. D. J. HISSINK has sent the following letter of thanks to the President of the International Institute of Agriculture, S. E. G. DE MICHELIS :—

" C'est mon devoir d'exprimer à votre Institut la reconnaissance de l'Association Internationale de la Science du Sol pour la participation qu'il a eu dans l'achèvement de cette grande œuvre, ce qui est une grande acquisition pour la Pédologie ".

A most careful index forming a valuable aid for its use has also been published.

Price of the three volumes	250	Lires It.
" " " index	30	" "
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Formation of the Italian Section of the International Society of Soil Science 19 July 1926.

At the last session of the Italian organizing Committee of the IV Conference of Soil Science, the President, Prof. G. de ANGELIS D'OSSAT presented the three volumes of the Proceedings of the Conference and expressed his thanks and those of the Committee to all who had collaborated in the interesting work. He drew special attention to the work of Prof. R. PEROTTI, secretary of the organizing Committee and of the Conference. A financial Statement was then made by Prof. PEROTTI and was approved.

On completion of the business and before declaring the meeting at an end the President, DE ANGELIS D'OSSAT, proposed the formation of an Italian Section of the International Society of Soil Science. The proposal was carried unanimously.

A provisional Committee of management was appointed to act until the meeting of a General Assembly. Its members were :—

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The above mentioned members are requested to send their subscriptions for the years 1925 and 1926 as soon as they see this notice.

In countries where there are national sections the subscriptions may be paid to the secretariat of these sections.

Dr. D. J. HISSINK
Acting President and General Secretary.

Erratum. — In the article by A. v. NOSTITZ, vol. II, 1 page 10, illus. 2, it should read " Increase of water-draining power " instead of " water capacity ".