A comparison between conventional and organic farming practices 1: Soil physical properties

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Abstract
Soil samples were collected from sixteen pairs of farms, throughout England, having both arable and grass fields within each pair on similar soil type. The farms were divided into clusters which are used as replicates in this paper. Chemical (nutrients, pesticides) and physical (aggregate stability, field capacity, shear strength, soil organic matter) soil properties were measured over four main soil textures classes (clayey, coarse, medium, silty) and two land uses (arable and grassland) in organic and conventional fields. The physical soil properties varied significantly between the different texture and land use. However, there are no significant differences between organic and conventional management for any of the soil chemical and physical properties measured.

Key Words
Aggregate stability, field capacity, infiltration rates, plasticity, soil texture, SOM.

Introduction
Changing UK policy relating to farming practices, due to both consumer and governmental pressures, have fuelled the debate over the merits of organic and conventional management methods especially regarding the issues of sustainability, leaching and agricultural pollution. Conventional farming (non organic) is a more input intensive system with higher inputs such as fertilisers, pesticides and high outputs in terms of yield (Byrne, 1997). Whereas, organic farming is governed by strict legislation controlling the production of organic food within the UK; this generally reduces reliance on external inputs such as chemical fertilisers, and promotes good soil management techniques (Lampkin 1999).

Sustainable management is crucial to the maintenance of soil structure and organic matter (SOM) levels are important if the continued availability of water and nutrients and standards of soil workability are to be sustained (Pulleman *et al*. 2003). There is an abundance of recent literature comparing organic and conventional farms with respect to soil properties, microbiology and nutrient analysis (Armstrong Brown *et al.* 2000; Marinari *et al*. 2006; Mulumba and Lal 2008; Pulleman *et al*. 2003; Parfitt *et al*. 2005). Pulleman *et al*. (2003) compared soil structure and organic matter dynamics on conventional (non-organic) and organic arable farms. It is well understood that the key to long-term success in organic farming is good soil management. There is at present a lack of comparative research into soil physical properties between organic and conventional management and Stolze *et al*. (2000) emphasised the need for new consistent collection of data on soil properties when comparing organic and conventional fields.

The aim of this paper is to provide a baseline data set; which assesses the effects on soil physical properties and leachate potential of soil management practices, under organic and conventional farming systems within England. The results will help provide a platform for future research into the impacts of organic farming on soil physical characteristics. This study forms part of an ongoing Rural Economy and Land Use (RELU) project which will explore the environmental and socio-economic impacts of ‘clusters’ of organic farms and to assess whether these clusters are beneficial to wildlife and soil and water quality.

Materials and methods
Site location
This study investigates sixteen pairs of organic and conventional farms, in England, with both arable (winter wheat) and grass fields (grass/clover composition) with each pair on the same or similar soil type. The paired farms were chosen in two groups (see Figure 1).

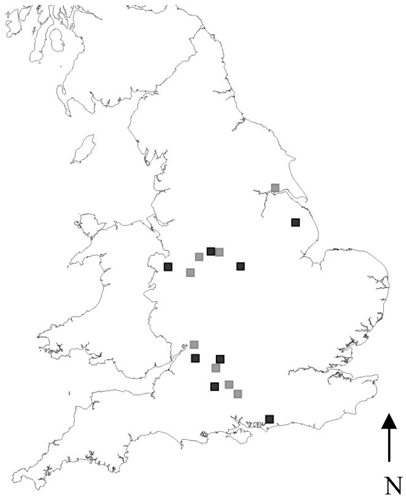

Figure 1. Site locations (RELU 2007). The dark squares represent cold spots (less than 2% organic land use) and the lighter squares represent hotspots (more than 12% organic land use). These were used as replicates.

Field sampling and analysis

Soil sampling and within field assessment was carried out in March and April 2007, when soils were at or near to field capacity moisture content as soil structural condition is most clearly assessed at this time. The seasonal effects of variations in soil moisture content were minimised. At each site soil assessment was conducted and samples were collected to measure a suite of physical and chemical parameters. To obtain a representative sample of soil, a 'W' shaped path sampling strategy was observed, avoiding untypical areas, taking 10 samples; which were bulked (MAFF 2000). Samples were obtained from 0- 200 mm depth. One or more small pits were excavated at each site to determine the soil structure and physical conditions of the soil. A shear vane was used to measure shear strength *in situ* based on a grid sampling technique using 30 samples to cover the field.

Laboratory and statistical analysis

The soil samples were prepared through air drying and homogenisation by grinding and sieving (Allen 1989). The samples were sieved to either 2mm diameter (SOM and texture) or passed through a 5 mm sieve and retained on 3.35 mm sieve (aggregate stability). Soil texture was determined using the pipette method (BS 7755). SOM was established by dichromate digestion (BS 1377-3). Aggregate stability was determined through the wet sieving method outlined in Haynes and Swift (1990). Gravimetric moisture content was measured through oven drying at 105^{o}C. Soil water sub-samples were sent to NRM laboratory to be analysed for a suite of pesticides and nutrients using centrifugation. Data analyses were calculated using Statistica (8.0), under the assumption that data was normally distributed. Factorial analysis was used to determine whether there was a significant difference in soil properties between the two management regimes (organic and conventional); two land uses (arable and grass) and the four textural classes.

Results and discussion

Soil water nutrients and pesticides

Soil water samples were tested for a range of pesticides. Pesticides were only discovered within five of the clusters. There were only two organic fields which tested positive for pesticides, but these were only trace levels. There were fifteen conventional fields which showed traced of pesticides. The pesticides detected in the organic fields were compounds of organochlorine (DDE) and organonitrogen (pendimethaline) with concentration of 0.3 and 0.02 mg/kg respectively. The pesticides are degraded by the microbial community to form metabolites and its half life determines its persistence (Andreu and Pico 2004). Both are fairly persistent as DDE has dt50 of thirteen years whereas pendimethaline has dt50 of 90 days however it bio accumulates within the soil due subsequent applications prior to the farm converting in 2000 (Andreu and Pico 2004). The low concentrations of pesticides detected can be associated with historical application and does not pose a threat of leaching. In addition no differences in pesticide levels were found between organic and conventional management. There were no significant differences ($p<0.05$) in levels of total phosphorous and total potassium according to management, land use or soil texture. However, there was a significant difference in Total Nitrogen (ammonium and nitrate) where the conventional arable was two to three times

(32 mg/kg) greater than the other land uses and managements. This is not surprising and is due to the timings of fertiliser or manure applications on the arable land and not the grassland.

Soil organic matter (SOM)
There was no significant difference ($p<0.05$) between organic and conventional management for SOM content as was reported by Gosling and Shepherd (2005). This can be explained by the fact that to have a significant effect on SOM Bhogal *et al.* (2008) suggests that at least 65 tha/y of organic matter should be applied and currently organic farmers add 40 tha/y and in arable farming typical wheat yields are 4 and 6.75 t/ha from organic and conventional practices respectively (Nix 2007) where generally the straw yield is positively accumulated with the grain yield. There were significant differences related to land use, where grass had a significantly higher level of SOM compared to arable ($p<0.05$); and soil textural class where the clayey and silty soils had an improved level of SOM in relation to coarse and medium soils ($p<0.05$). This is due to the protective nature of the clayey soils which reduces the amount of decomposition (Loveland and Webb 2003). Schjønning *et al.* (2007) have recently shown that different land management will influence SOM level after 5-6 years; however, this research does not support this.

Aggregate stability
There was no significant difference ($p<0.05$) between organic and conventional management for aggregate stability. There were significant differences related to land use, where grass had a significantly higher proportion of stable aggregates compared to arable; and soil textural class where the clayey and silty soils were more stable in relation to coarse and medium soils. Clayey texture soil had the highest amount of SOM and the clay content helps to bind the soil improving the stability of the aggregates. The management style of grassland such as the removal of grass as silage can remove roots, SOM and binding ingredients (such as calcium ions) which reduces aggregate stability. Over all the fields, a mixture of practices were occurring which could be masking any overall effect of organic or conventional management.

Shear strength and field capacity
There was no significant difference between organic and conventional management for shear strength or field capacity. There were significant differences related to land use, where grass had a significantly higher shear strength compared to arable; and soil textural class where the clayey soils had greater shear strength in relation to the other textures. The amount of SOM present and the moisture content affect the shear strength of the soil. The soils were all sampled at field capacity and the higher amounts of SOM shown in the clayey soils mean that these have higher shear strength. It is important to note that the fields with the higher field capacity (higher moisture content) had lower shear strength as this decreases with moisture content (Smith and Mullins 1991). The grass fields generally have higher shear strength due to the formation of a strong root mat binding the soil together. The arable fields were more affected by the date of primary tillage, with a few fields having just been tilled and hence the shear strength was much lower than the untilled fields.

Atterberg Limits and workability
There was no significant difference ($p<0.05$) between organic and conventional management for plasticity index, plastic or liquid limits. Soil texture and the amount of SOM are very important for governing changes in Atterberg Limits; higher levels of SOM can cause a shift in plasticity index extending the friability zone to fairly high moisture contents (Baver *et al.* 1972). Plasticity limit can be used as a guide to determine the water content at which a soil can be handled without causing damage, if the field capacity moisture content is below the plastic limit there is a lower risk of soil damage. From the data, there is no overriding management (organic or conventional) which actually makes a positive difference on soil working conditions; it is more dependent upon the soil texture.

Conclusion
The main conclusions for this paper are as follows:
1. There are no significant differences between organic and conventional management for any of the soil physical properties measured. For the fields sampled, it can be concluded that there is little direct benefit on soil physical condition for organic farming practices but equally there is no detrimental effect.
2. There are significant differences between grass and arable land use in the following:
   - Aggregate stability, field capacity, shear strength, and SOM are all higher in grass land use.

These differences are related to the complex interactions between previous land use, current cropping cycle and tillage regime.

3. There are significant differences between the four soil textural groups for all of the soil properties measured. Soil texture plays a key role in determining physical properties which is greater than the current and past land use or management.
4. There were fewer traces of indentified pesticides and herbicides in organic fields compared to conventional fields.

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