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The effects of soil management on subsoil organic matter

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Soil management has a clear effect on the organic matter (OM) content of soils in agricultural systems. For instance, grassland soils tend to have a greater OM content than arable soils due to the difference in the management of the surface vegetation between the two systems. Our knowledge of this is largely restricted to the topsoil however, as this is the part of the profile that is most obviously influenced by the inputs and losses of OM. How agricultural management at the surface affects OM contents in the subsoil is rarely considered, let alone understood. We present the state of our current knowledge of the effect of soil management on subsoil OM based on measurements made on soils from some of the established field experiments at Rothamsted Research, UK.

We have examined subsoil OM data collected by us and other scientists at Rothamsted representing different timescales: long-term (Broadbalk wilderness and arable, Geescroft wilderness, and Park Grass: 130 years), medium-term (Highfield ley-arable: 40-60 years), and short-term (Highfield and Geescroft reversion: 2 years). Samples to depths of up to 96 cm in the profile were collected from the field experiments periodically between 1870 and 2009 and analysed for C and N.

Both C and N increased in soils converted from arable to long-term woodland and grassland throughout the profile. The C:N ratio also increased in comparison to long-term arable soils which suggested either the preferential accumulation of C or the preferential decomposition of N at depth in grassland and woodland soils, or the converse at depth in the arable soils. Small increases in C and N in both long-term grassland and arable soils were also apparent.

In the medium-term, differences in the pattern of soil C and N with depth were found, with homogenisation in the cultivated layer in arable and fallow soils and a more gradual decrease with depth in the grassland soil. In general, differences between soils subjected to different management for 60 years were restricted to the upper 45 cm, where both C and N were greater in grassland soils than arable and fallow soils. The C:N ratio was greater for the medium-term grassland soil than arable and fallow soils, and decreased with depth in all soils.

The short-term management practices have generally not had sufficient time to affect the pattern of OM in the soil profile. Notwithstanding this, the sowing of grass on fallow soil was associated with a small increase in subsoil OM content, and the cultivation treatments for the new fallow and arable treatments on the old grassland soil have homogenised OM contents in the upper 30 cm.

We speculate that some of the greater OM in the surface of grassland and woodland soils is transported down the profile in dissolved and particulate forms through the better-developed (compared to arable soil) soil pore network to form the subsoil OM content. Another possible mechanism is direct precipitation at depth from the roots of trees and grasses. Following transportation, accumulation of subsoil OM is probably very slow and dependent on stabilisation processes. Indeed, the OM contents in the long-term woodland soils cannot be said to be in equilibrium some 130 years after establishment. To this extent, monitoring the effect of short-term changes in soil management on subsoil OM will be invaluable to capture the initial stages of the process. Our data will also help to test and develop the Rothamsted C model presented elsewhere at this symposium.