ROTHAMSTED RESEARCH

The Soil at Rothamsted

Full Table of Content


THE
SOIL AT
ROTHAMSTED
B.W. AVERY
and
J.A. CATT
1995

Organic Matter Content and pH

Rothamsted Research

Rothamsted Research (1995) *Organic Matter Content and pH ;* The Soil At Rothamsted, pp 11 - 12 **- DOI: https://doi.org/10.23637/ERADOC-1-143**

per cent quartz, small amounts of flint and feldspar, and heavy fractions dominated by iron oxides, zircon, tourmaline, rutile, staurolite and kyanite. In samples from the superficial layer, however, the coarse silts contain up to 17 per cent feldspar and heavy fractions yielding chlorite, epidote, garnet and amphiboles in addition to the more resistant mineral assemblage typical of the lower deposit. As well as flint, the fine sand fractions contain small amounts of chalcedony derived ultimately from shells of partially silicified fossil lamellibranchs, brachiopods and echinoids in the Chalk (Brown *et al.* 1969). The data also support the conclusion that upper horizons of the soils in the lowest parts of both fields (profiles 23 and 27) are developed in recent colluvium (Notley series).

The clay (< 2 μm) fractions of the soils examined are composed mainly of interstratified expanding-layer silicates containing smectite and other layers, with subsidiary mica and kaolinite and small amounts of feldspar (in coarser clay fractions), chlorite and crystalline (goethite) or amorphous ferric oxides. In general, the clay fractions of loess-rich horizons differ from those consisting mainly or entirely of Clay-with-flints in containing vermiculite, chlorite and feldspar; they also contain more mica, kaolinite and quartz, but less smectite. Data on soils elsewhere in the Chilterns (Avery *et al.* 1959; Loveday 1962; Avery 1964) show that clay fractions of the Clay-with-flints *sensu stricto* immediately overlying the Chalk in Winchester and Carstens soils are normally richer in smectite than those of overlying horizons. As this layer also contains more clay, amounting in places to more than 80 per cent of the fine earth (e.g. in profile 5), it has a correspondingly larger shrink-swell capacity.

Organic matter content and pH

Under semi-natural conditions, as in woodland or old grassland, the calcareous soils on Chalk or chalky drift contain significantly more organic matter, and hence more nitrogen, than the moderately to strongly acid soils on Clay-with-flints and associated deposits. This trend is well exemplified in profiles 6-9 in Knott Wood (Fig. 3). Still larger amounts, ranging up to 7-8 per cent organic carbon in the upper 20 cm, occur under old grass in the Ver valley (profiles 17, 37-39), where humus accumulation has been favoured by the former prevalence of high water table levels as well as by high base status.

Broadbalk and Geescroft Wildernesses (Fig. 1), uncultivated since 1882 and 1885 respectively and both on Batcombe soils, provide further evidence of the effect of calcium carbonate in promoting accumulation of organic matter under semi-natural conditions. In Broadbalk Wilderness (profiles 10 and 11), the topsoil of which still contains $CaCO_3$ remaining from heavy applications of chalk before the 1880s, there was a rapid increase in organic matter content such that by 1964 it was greater than in the nearby arable plot that had received 35 t/ha of farmyard manure annually since 1843 (Jenkinson 1971). On Geescroft Wilderness, now bearing deciduous woodland dominated by oak, previous chalking had been less generous; the topsoil pH (in water) declined from 7.1 in 1883 to 4.2 in 1990 (Johnston *et al.* 1986), and the accumulation rates of organic carbon and nitrogen were slower, less than one half that for carbon and less than one third that for nitrogen in Broadbalk Wilderness.

On the farmed land, both pH and organic matter content are primarily dependent on management history, including experimental treatments. As already indicated, Broadbalk, Hoosfield and other land regularly cropped during and before the 19th century traditionally received heavy dressings of chalk, each amounting to as much as

https://doi.org/10.23637/ERADOC-1-143

150-250 t/ha, which was dug from infield 'bell-pits' or from 'dell-holes' on bordering slopes and spread by hand to improve the fertility and workability of the originally acid Batcombe and related soils; this eventually rendered them base-saturated and near-neutral in reaction to depths of 1.5 m or more. Grassland used for pasture or hay, as in Highfield and Park Grass (Fig. 1), was seldom chalked and hence remained at least moderately acid. By the 1950s, reserves of $CaCO_3$ remaining from earlier dressings had in places become exhausted by leaching and the soil had become acid, particularly in plots on Broadbalk and elsewhere receiving annual applications of ammonium sulphate. Except for areas deliberately kept acid, pH (H_2O) values on the cultivated land have since been maintained at around 7.0 by regular liming.

On Broadbalk, continuously cultivated since 1843 or earlier, organic carbon contents in the upper 23 cm of soil vary from around 0.8 per cent in the unmanured plot to around 2.2 per cent in the plot that has received farmyard manure annually. Profiles 19-27 in Broadbalk and Barnfield were located in inter-plot pathways and hence contain less topsoil organic C than adjacent plots. Corresponding values in profiles 18, 28-35, 41 and 42, all in fields not used for long-term experiments but cropped for varying periods before sampling, range from 1.4 to 2.8 per cent. Organic-carbon and pH data on a field-to-field basis, derived from a systematic survey in 1978-79, are given by Johnston *et al.* (1981).

Soil structure

Under woodland or old grassland, the structure of the topsoils is clearly influenced by organic matter content and base status. Thus the very dark coloured surface horizons of the soils that remain calcareous, either naturally or through the retention of added chalk as in Broadbalk Wilderness, are characterized by strongly developed granular or fine subangular blocky peds. In contrast those that are acid are more weakly structured and in extreme cases, typified by the unlimed Park Grass plots that have received regular applications of ammonium sulphate, organic matter has accumulated at the surface to form a discrete *mor* layer and the immediately underlying mineral soil is massive and structureless.

Despite the presence of $CaCO_3$ in varying amounts, structure is markedly weaker in the arable land than in the uncultivated calcareous soils. As a consequence the relatively impermanent aggregates produced by cultivation are apt to slake under the impact of rain, so reducing permeability and promoting the formation of a cap which can set hard and so delay the emergence of seedlings if dry weather follows. These effects are most evident in lighter soils, however, and are mitigated in the silty clay loam topsoils which predominate at Rothamsted by subsequent cultivation under favourable conditions, aided by the restorative action of periodic wetting, drying and freezing. There is accordingly no clear evidence that structural deterioration under continuous arable cultivation has influenced crop yields significantly (Boyd *et al.* 1962), though spring-sown crops may be adversely affected in unfavourable seasons as a result of failure to obtain a satisfactory seedbed.

Soil water regime

The Clay-with-flint subsoils of the Batcombe and Hornbeam series which underlie some 60 per cent of the estate are slowly permeable and hence are periodically saturated with

https://doi.org/10.23637/ERADOC-1-143