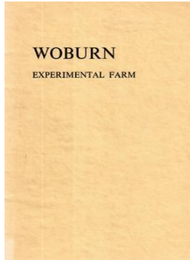
ROTHAMSTED RESEARCH

Woburn Experimental Farm

Full Table of Content



Geology, Soils and Land Use Capability

Rothamsted Research

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Geology, Soils and Land Use Capability

Geology

Not all the farm's fields have sandy soils on the Lower Greensand (Woburn Sands), some are on clay formations, in particular the Oxford Clay and Chalky Boulder Clay. The junction between the Lower Greensand and the underlying Oxford Clay occurs immediately south of the farm building where it is marked by springs at a height of 84 m O.D. in Mill Dam Close. It then rises north-eastwards to approximately 94 m O.D. on the northern side of Great Hill. Fields to the south and west of the junction are underlain by Lower Greensand, but their soils are not entirely sandy. A superficial cover of Chalky Boulder Clay extends from the south-western side of School Field towards Woburn, and is found on most of the fields west of the Husborne Crawley–Woburn Road, including a small part of Stackyard. This stony clay was deposited by a glacier which invaded eastern England through what is now The Wash during the Anglian glaciation about half a million years ago. Originally thicker and more extensive than it is today, the boulder clay has been eroded from much of the farm by both streams and mass movement of soil. The streams were probably precursors of the Crawley Brook, which now runs roughly parallel with the north west boundary of the Farm. Mass movement of partly frozen soil material occurred in very cold (tundra) conditions, which have prevailed in Britain several times since the Anglian glaciation. The most recent of these cold periods ended about 10 000 years ago and, in most of the soils, development processes, such as weathering, have only occurred since then.

However, even where the boulder clay has been removed and the Lower Greensand is close to the surface, thin slope deposits formed in temperate climatic conditions are widespread; these colluvial deposits are derived partly from the boulder clay and consequently contain more clay and silt than the Greensand. The deposits started to accumulate as a result of downslope movement of soil when the forests were cleared and the soils were first cultivated in the Middle or Late Bronze Age (about 3000 years ago). Much erosion continues today whenever heavy rain falls on soil which has little or no vegetation.

In School Field and others to the south-west, the Chalky Boulder Clay is separated in places from the Lower Greensand by a thin bed of glacial gravel, which has been quarried in several places. The boulder clay is also overlain extensively by a hard, weakly stratified deposit of stony loam or sandy clay, which probably originated as a slope deposit formed from the boulder clay during an intensely cold period.

Small natural lakes previously existed in Mill Dam Close (immediately west of the laboratory) and across the north-western ends of School and White Horse Fields. The silty clays and peats deposited in these lakes overlie the Lower Greensand, and provide further small patches of fine textured soil. However, the areas of both patches have been diminished by encroachment of colluvium washed from adjacent slopes since the lakes were drained and reclaimed.

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Fields to the north of the farm buildings and west of Great Hill are underlain by Oxford Clay, but soils formed directly on this occur only in small areas in Honey Pot Field and Great Hill Bottom II at the foot of Great Hill. This is because in Broad Mead, Long Mead and Warren Fields the clay is overlain by thick deposits of river alluvium, which range in composition from sand or slightly stony sand to silty clay. Also much of the Oxford Clay slope leading down through Great Hill Bottom I towards Broad Mead was buried by a mixture of clay and gravelly sand which issued from the junction of the Lower Greensand and Oxford Clay, just below the summit of Great Hill (in Great Hill I), probably during one of the very cold periods since the Anglian glaciation.

Soils

This complex sequence of deposits gives rise to a greater range of soil types than was recognised previously (Crowther, 1936). Well-drained brown sandy soils with Lower Greensand, often colour-banded, at depths of 25–60 cm (Cottenham series) occur only on the summit of Great Hill, the small hill on the south-western side of Lansome, and parts of Butt Close, Butt Furlong and Stackyard Fields. Elsewhere, especially in the shallow valleys, the Greensand is covered by a variable thickness of colluvium, in which slightly finer textured brown earths (Stackyard series) or imperfectly drained gleyic brown earths (Flitwick series) occur. Table 1 gives the main features of profiles representing these three soils. The colluvium in which all but the lowest horizons of the Stackyard and Flitwick series are developed, contains more clay and silt than the Lower Greensand beneath, and the mineralogical composition of these fractions shows that they are derived mainly from weathered boulder clay (Catt *et al.*, 1975). For example, the main clay minerals in the colluvial horizons are kaolinite, illite and interstratified illite-smectite, an assemblage similar to that in the Chalky Boulder Clay, whereas the clay fractions of the Lower Greensand and of all horizons in the Cottenham profile contain illite and illite-smectite, but no kaolinite. The colluvial subsoil horizons also contain more organic matter than the Lower Greensand, probably because they are largely accumulations of old eroded topsoil.

Because of the larger amounts of silt and clay in the colluvium, Stackyard and Flitwick soils have a larger available water capacity than Cottenham soils. The difference (approximately 30%) can be a critical factor in crop production, especially in very dry summers such as 1976 (Catt *et al.*, 1977). However, the boundaries between the three series are merging and are difficult to map precisely. Lateral movement of finer soil constituents during heavy rain tends to eliminate minor surface irregularities and hollows, such as old ditch or hedge lines, become filled with colluvium to form small areas of Stackyard soils. In some years these differences can be seen as the surface soil dries out in spring and later they become visible as patterns of irregular crop growth. Flitwick series occurs mainly in the lowest, central parts of the valley floors, where the water-table is nearest to the surface; mottling generally occurs within 90 cm of the ground surface, but may be found as close as 40–45 cm where abnormally fine textured subsoil horizons within the colluvium also impede vertical water movement (e.g. the Flitwick profile cited from Lansome Field).

Where the Oxford Clay is not covered by alluvium or other superficial deposits, the soils (Evesham series) are calcareous almost to the surface. Fine

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TABLE 1

Profile data for the three main sandy soil types at Woburn

Profile	Cottenham series, Lansome Field			Stackyard series, Stackyard Field				Flitwick series, Lansome Field				
Horizon depth (cm)	0–22	22–44	44–80	0–24	24–42	42–96	96–180	0–21	21–40	40–119	119–126	172–180
Texture class	Loamy sand	Loamy sand	Sand	Sandy loam	Sandy loam	Sandy loam	Sand	Sandy loam	Sandy loam	Sandy loam	Clay loam	Sand
Clay % (<2 μm)	10	8	5	11	10	8	6	12	17	12	21	10
Silt % (2–60 μm)	9	8	5	18	20	19	4	15	21	24	33	3
Fine sand % (60–250 μm)	66	72	82	50	48	52	80	50	43	48	34	74
Coarse sand % (250–2000 μm)	15	12	8	21	22	21	10	23	19	16	12	13
Colour	Dark brown	Brown	Olive and yellowish red bands	Dark brown	Brown	Yellowish brown	Olive, yellowish brown and yellowish red bands	Dark brown	Reddish brown	Reddish brown and grey mottles	Very dark grey	Grey and brown mottles
Organic carbon %	2·05	0·58	0·15	1·85[1]	0·47	0·30	0·06	2·07	0·75	0·57	0·62	0·07
pH	7·2	7·3	7·1	7·1	7·2	6·9	6·9	7·0	7·4	7·0	6·9	6·8

[1] % C is much larger than in many soils on Stackyard probably because the sample was taken from a track long under grass.

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rusty mottles in the well-structured surface horizon together with predominantly grey or olive subsoil colours indicate imperfect to poor drainage. The soils on alluvium (Woburn series) and lacustrine deposits (Ridgmont series) are also poorly drained, but are non-calcareous, weakly structured and often coarser in texture than the Evesham series. The soils associated with Chalky Boulder Clay *in situ* are more stony than others on the farm; most are imperfectly drained (Husborne series), with upper horizons formed in the periglacial slope deposit overlying the boulder clay, but there are small patches of slightly better drained profiles (Pightle series). The calcareous boulder clay is usually more than 1 m below the surface, and never closer than 40 cm.

Potassium in the soils

The Lower Greensand is so named on account of the local occurrence in the deposit of the green mineral glauconite. This contains approximately 7% K, and is often considered an important potassium supplying mineral in greensand soils. Crowther (1936) suggested that potassium supplied by glauconite explained the lack of crop response to applied potassium at Woburn.

Most of the glauconite in the Lower Greensand of Bedfordshire and in the farm soils occurs as sand-sized pellets. These pellets are only a minor constituent, about 1%, of the total sand and are too few to give it a green colour. However, large blocks of bright green sandstone found on White Horse Field suggest that originally the sand may have been green. In these blocks a thin glauconite coating on other sand grains (mainly quartz) has been preserved by intergranular deposition of silica, probably soon after the sands were laid down under the seas of the early Cretaceous period. The glauconite coatings in unsilicified parts of the sands have been oxidised to a mixture of iron oxides, illite and illite-smectite. In the Cottenham series, the illite in these coatings is the main natural source of potassium, but in other soils illite derived from the Chalky Boulder Clay, which does not occur in grain coatings, is more important. The relatively rare glauconite pellets in the soils supply little or no potassium to crops. The lack of response to applied K noted by Crowther was probably due to the fact that the clay illite could supply enough potassium for the small crops grown at the time. Since nitrogen dressings have been increased, yields have been larger, and responses to applied potassium are now common.

Land use capability

A system of classifying soils based on their capability and adaptability for agricultural crops has been described by Bibby and Mackney (1969). The classification aims to indicate the potential of land under reasonably good management, and when published in map form is usually related to a detailed Soil Survey map. The system is not based on current land use, and limitations which can be removed or decreased at an acceptable cost are not allowed for. Capability subclasses are based on limitations affecting land use, such as wetness, texture, slope and climate.

Seven classes, numbered 1 to 7, are used. The following abbreviated descriptions of the first three are taken from Bibby and Mackney. Class 1 is land with very minor or no physical limitation to use; amongst other things it is land with good reserves of moisture or with suitable access for roots to

https://doi.org/10.23637/ERADOC-1-153

moisture. Class 2 is land with minor limitations that decrease the choice of crops or interfere with cultivations; limitations include slightly unfavourable climate and soil texture and structure. Class 3 is land with moderate limitations that restrict the choice of crops and/or demand careful management.

D. J. Eagle of ADAS (Eastern Region, Cambridge) recently surveyed a number of fields and experiments, and classified them according to this system. The results can be related to the soil series described above, which have been mapped over part of the farm by Catt *et al.* (1975, 1977). The Cottenham series, as examined on block 1 of the Ley Arable experiment (Stackyard), part of the Organic Manuring experiment (Stackyard), Series 1 of the Market Garden experiment (Lansome), the Irrigation experiment (Butt Close) and on parts of Butt Furlong, is poor class 2. However, in eroded sites, such as the summit of Great Hill, where the Lower Greensand is immediately beneath the plough layer and the soils are slightly more susceptible to drought, the Cottenham series is class 3. The Stackyard and Flitwick series are both good class 2 soils, mainly because they have a greater available water capacity and suffer less from drought than any of the Cottenham soils. Stackyard series occurs on the Long Term Liming experiment and part of the Organic Manuring experiment (Stackyard), and on Series 2 of the Market Garden experiment (Lansome). Flitwick series was examined on lower blocks of the Ley Arable experiment (Stackyard). Finally, two of the heavier soils on the farm, the Ridgmont series in Mill Dam Close and the Woburn series on Warren Field, were grouped as class 3, because their large clay content and poor drainage make the timing of cultivations more critical than on the lighter soils.

As many of the experiments were laid out before the differences between soil types were recognised, they often straddle soil boundaries and include two or more soil series with different capabilities. This has often complicated the interpretation of experimental results. However, careful examination of past results from plots on different soil series does offer the opportunity of studying yield differences in relation to soil type and should make it possible to define the capabilities of the different series in greater detail. Also, it is important that new experiments should be sited in relation to the soil boundaries, so that each block is on one soil series only.

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