Rothamsted- the Classical Experiments

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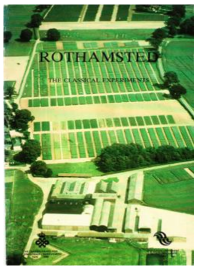

Park Grass

Rothamsted Research

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1975, together with an increase in nitrogen rate considerably increased yields on plots with residues but gave no improvement on plots without. Since then, despite the inclusion of larger nitrogen rates and probably as a result of continued depletion of P and K, yields have generally declined on all plots. The decline has been less on plots with FYM residues, supporting the view that the prolonged residual effects in this experiment are primarily those of P.

During the 40 years, 1901–40, when no N was applied, crops made little use of the P and K residues in the soil. However, these residues must have remained in available forms because for the next 40 years they increased yields to twice those on unmanured plots and these larger yields equalled the national average for spring barley.

PARK GRASS

The Park Grass experiment, laid down in 1856, is much the oldest on grassland in Great Britain. The field had been in grass for at least a century when the experiment began. It demonstrates in a unique way how continued manuring with different fertilizers affects both the botanical composition and the yield of a mixed population of grasses, clovers and weeds. After more than 100 years, the boundaries of the plots are still clearly defined; the transition between adjacent treatments occupies 30 cm or less, showing that there is little sideways movement of nutrients in undisturbed soil.

The plots have been cut each year for hay, all at the same time, although no single date can be suitable for all plots. For a few years the aftermath was grazed by sheep, penned on each plot and their weight increases recorded but from 1873 the second cut has been weighed and carted green. Since 1960 yields, corrected to dry matter, have been calculated from the weights of produce from sample strips cut with a forage harvester (two per plot). At the first cutting the produce of the remainder of each plot is made into hay; this allows the return of

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Park Grass (see plan on opposite page)

Treatments (every year except as indicated)

Nitrogen (applied in spring)

N1, N2, N3	sulphate of ammonia supplying 48, 96, 144 kg N ha^{-1} (about 0·4, 0·8, 1·2 cwt N $acre^{-1}$)
N1*, N2*	nitrate of soda supplying 48, 96 kg N ha^{-1} (about 0·4, 0·8 cwt N $acre^{-1}$)

Minerals (applied in winter)

P	35 kg P ha^{-1} as granular superphosphate (19% P_2O_5) (0·6 cwt P_2O_5 $acre^{-1}$)
K	225 kg K ha^{-1} as sulphate of potash (50% K_2O) (2·2 cwt K_2O $acre^{-1}$)
Na	15 kg Na ha^{-1} as sulphate of soda (14% Na)
Mg	10 kg Mg ha^{-1} as sulphate of magnesia (10% Mg)
	Silicate of soda at 450 kg ha^{-1} of water soluble powder (plot 11/2)

Plot 20. Rates of manuring in years when FYM not applied:

30 kg N, 15 kg P, 45 kg K ha^{-1}

Organics (each applied every fourth year)

FYM	35 t ha^{-1} farmyard manure (bullocks) (1985, 1989) (14 tons $acre^{-1}$)
Fish meal	(about 6·5% N) to supply 63 kg N ha^{-1} (1983, 1987) (about 950 kg ha^{-1} meal or 850 lb $acre^{-1}$)

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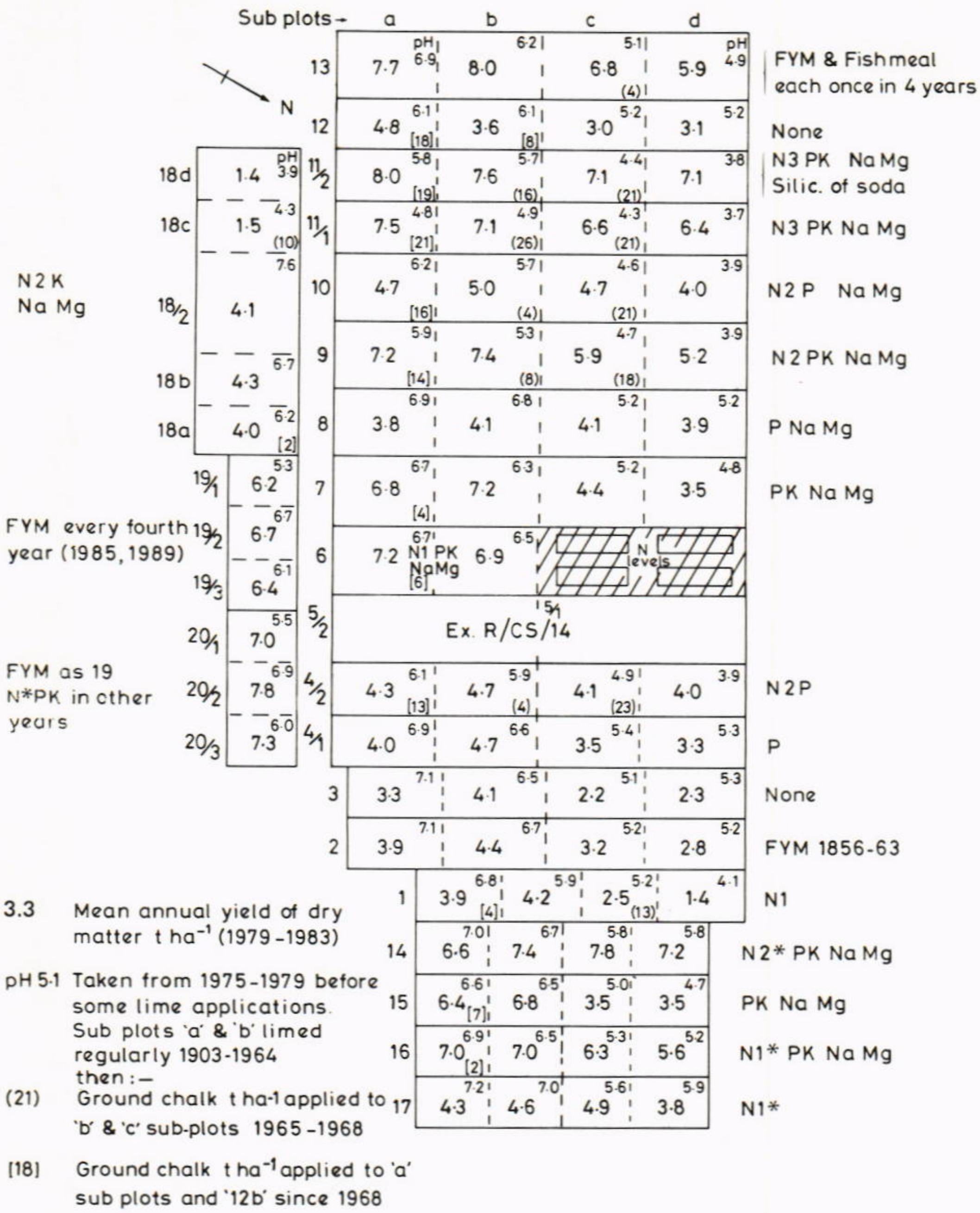
PARK GRASS
Hay since 1856



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seeds to the soil as in the past. At the second cutting the whole produce is carted green. The position of the sample strips differs from year to year.

The soil of Park Grass, in contrast to that of the nearby arable fields, contained little or no calcium carbonate when the experiment began; on plots treated with sulphate of ammonia increasing acidity caused a gradual deterioration in the species composition, although not the yield, of the sward. Lawes recognized this and made two tests of lime in 1883 and 1887, but these were without immediate effect. Regular liming was not begun until 1903. Then, and every fourth year until 1964, lime (originally burnt lime, more recently calcium carbonate) was applied to the southern halves of most of the plots (see plan). Except for plots 18, 19 and 20, a fixed amount was applied on each occasion. From 1965 each half-plot on plots 1 to 18 was further subdivided. (At this stage the old plots 5/1, 5/2 and 6, whose treatments had not been constant throughout were used for new experiments.) From 1965 only sub-plots 'd' remain unlimed. On the more acid plots, sub-plots 'c' (previously unlimed) now receive chalk calculated to give pH 5. Sub-plots 'b' (already limed) are chalked to give pH 6 and (from 1976) sub-plots 'a' to give pH 7.

The unmanured plots (3, 12) have the richest flora, about 60 species, with many red clover plants and broad-leaved weeds, but none grows vigorously, and yields are small. These swards are probably the nearest approximation to the state of the whole field in 1856. Lime alone or P alone (Plot 4/1) has little effect. Giving PKNaMg (Plot 7) produces a much stronger growth of legumes, including red clover (*Trifolium pratense*) and white clover (*Trifolium repens*), and meadow vetchling (*Lathyrus pratensis*); on this plot lime greatly increases the vigour and yield of the legumes. Omitting K and giving PNaMg (Plot 8) results in much less meadow vetchling, and on this plot lime depresses yields.

With nitrogen, either as sulphate of ammonia or as nitrate of soda, yields are above average except on some of the unlimed ends. Plots 11/1 and 11/2 show the extreme effects of sulphate of ammonia. The unlimed ends are dominated by Yorkshire fog (*Holcus lanatus*) and the mineral soil is covered by a peaty layer of only partly decomposed plant residues; earthworms are absent. The limed ends have tall coarse species, false oat (*Arrhenatherum avenaceum*) and meadow foxtail (*Alopecurus pratensis*), which makes a poor hay, although yielding well. Nitrate of soda (Plots 14, 16, 17) supplies nitrogen without acidifying the soil; lime has little effect on these plots. The organic manures are applied on a four-year cycle of farmyard manure, none, fish meal, none to Plot 13 which has a well-mixed herbage, but yield is much less than from the best fertilizer treatments.

The most interesting feature of the experiment since 1965 has been the change in the botanical composition of the swards of the sub-plots where lime has been applied to very acid soils. Red clover has occurred on most of these and is now well established on sub-plots 1c and 9c. Fescues (*Festuca* spp.) have increased on plots given 48 and 96 kg N ha^{-1} with incomplete minerals (sub-plots 1c, 4/2c, 10c and 18c); tall oat grass (*Arrhenatherum elatius*) and cocksfoot (*Dactylis glomerata*) are now common on plots receiving 96 and 144 kg N ha^{-1} and complete minerals (sub-plots 9c, 11/1c and 11/2c) and also meadow foxtail and rough-stalked meadow grass (*Poa trivialis*) on 144 kg N plots (sub-plots 11/1c and 11/2c). Smooth-stalked meadow grass (*Poa pratensis*) is now plentiful on all these. Much mouse-ear chickweed (*Cerastium holosteoides*) and pignut (*Conopodium majus*) occur on sub-plots 1c and 18c and cow parsley (*Anthriscus sylvestris*) and hogweed (*Heracleum sphondylium*) on sub-plots 9c and 11/2c. Dandelions (*Taraxacum officinale*) are now present on all the recently-limed

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previously acid plots and occasional plants of many other broad-leaved weeds also occur. Increasing the pH to 6 on sub-plots 9b, 11/1b and 11/2b has halved the amount of meadow foxtail but increased tall oat grass, especially on 11/1b.

(The botanical notes above were written in 1976 by Joan Thurston who has since retired.)

The distributions in the soil of nodule bacteria (*Rhizobium* spp.) for clover, *Lathyrus* and *Lotus* correspond closely to the distributions of their hosts in the different plots; neither medicks nor their nodule bacteria occur. Acid sub-plots contain no nodule bacteria and liming increases numbers. On limed sub-plots, N fertilizer has neither diminished the numbers nor altered the symbiotic effectiveness of the clover nodule bacteria.

BARNFIELD

Although less well-known than the other Classicals this was the first, having treatments applied in spring 1843 for a crop of turnips several months before the start of Broadbalk. However, the treatments and the cropping, although mainly roots, varied until 1876 when a period of continuous cropping with mangolds was started which lasted until 1959 (sugar beet were also grown from 1946).

As on Hoosfield Barley the treatments were applied in strips crossing at right angles. North–south strips tested minerals and FYM, including a test of FYM + PK, and these were crossed by strips comparing no nitrogen fertilizer with forms of nitrogen supplying 96 kg N ha^{-1}. Before 1968 this was the only Classical in which N was applied with both FYM and FYM + PK fertilizer.

Because yields of the continuous roots were declining, perhaps because of increasing amounts of cyst nematodes (*Heterodera schachtii*), the cropping has been progressively modified since 1959 and has included a range of arable crops with an increased range of N dressings and grass. Since 1977 the strip which had never received nitrogen fertilizer has been kept in fallow and since 1975 the remainder has been in grass.

A feature of the continuous roots and of recent arable crops has been the superiority of yields from plots given FYM even when a wide range of N dressings has been tested with the minerals. This may be because the extra organic matter has improved soil structure with greater effect on this field which is one of the most difficult to cultivate well. Yields of grass have also been larger on FYM-treated soils although FYM has not been applied since sowing the grass. This may be because more of the N applied to grass on fertilizer-treated soils is being used to increase soil organic matter. Accordingly a range of nitrogen dressings (75, 100, 125, 150 kg N per cut) has been tested on the grass since 1983.

AGDELL

This was the only Classical in which crops were grown in rotation. From 1848 to 1951 three different manurial combinations (none, PKNaMg and NPKNaMg plus rape cake/castor meal) were applied to the root crops of two four-course rotations. The rotations differed only in their third course – roots, barley, fallow or legume, wheat. There were only six plots and only one course of the rotation was present each year. The roots were turnips or swedes, the legume

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