

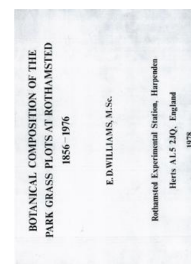
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Botanical Composition of the Park Grass Plots at Rothamsted 1856-1976

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D. Plots Receiving Organic Manures

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in general *Dactylis* and *Arrhenatherum* were less but *Festuca rubra* much more abundant in the shade than in the sun.

D. PLOTS RECEIVING ORGANIC MANURES

None of the plots now receiving farmyard manure (FYM) have the treatment dating back beyond 1905. Plot 13 which has received FYM and fish meal alternately once every four years since 1905 received N_2 (as ammonium sulphate) and PKNaMg between 1856 and 1904 and straw until 1897. Plot 19 which has FYM once every four years received N_1 (as sodium nitrate) and PK between 1872 and 1904. Plot 20 which also received N_1 (N as potassium nitrate and PK) during the same period also now receives FYM every fourth year but also N (30 kg ha⁻¹ as nitrate of soda), P (15 kg ha⁻¹ as superphosphate) and K (45 kg ha⁻¹ as sulphate of potash) in intervening years.

Plot 13 was included in the liming scheme of 1903 and is now in the new one. Plots 19 and 20 (like 18) were divided in 1920 into lightly, heavily and unlimed thirds to test two laboratory methods for measuring the lime requirement of soils. (Warren & Johnston, 1964). They are not included in the new liming scheme and were not analysed during 1973-76. They were, however, unlike the plots in the main liming scheme, analysed in the years immediately after liming and so provide evidence of the rate of change in different constituents after liming, not available from any other plots. For this reason past results for these two plots are also included (see also Brenchley, 1925 and 1930).

1. FYM and fish meal (Plot 13)

The main species on the unlimed end of this plot has for most of the time been *Alopecurus*. It increased until the mid-40's to c. 50%, then declined to 16% in 1974. *Agrostis* increased in the mid-40's and was twice as abundant as *Alopecurus* in 1973 and *Holcus* has increased markedly since 1949 (Table 33).

Alopecurus was increased by lime in 1919 but then declined to less than on the unlimed half. *Arrhenatherum* was also increased by lime in 1914 but then declined before increasing to become the most plentiful grass in 1948. Although lime had only small effects on *Dactylis* in the early years it greatly increased it during 1946-48 so that it contributed more than 20% in those years. With lime *Agrostis*, *Anthoxanthum* and *Festuca* are infrequent and *Holcus* now much reduced. Legumes, although variable between seasons were plentiful on the limed half. *Plantago* has been the main other species, although it was much reduced on the unlimed half in 1974 (Table 33).

2. FYM every fourth year (Plot 19)

Although *Alopecurus* was slightly more prominent than most other species it declined during the 30's and for most of the time there has been no single dominant. Legumes have been plentiful but variable, and although *Plantago* was the main other species during 1946-48 there was also much *Ranunculus* and *Achillea* (Table 34).

Lime had little effect on *Alopecurus* until the ninth year when low lime increased but high lime decreased it (Table 35). Afterwards during 1946-48 both amounts of lime increased *Alopecurus*. The effects of lime on *Dactylis* depended upon the season: in many years there was little effect but in others there were large (and similar) increases with both amounts of lime. *Festuca rubra*, little affected at the start, was usually decreased by lime although high lime increased it during the eighth and ninth years. High lime decreased *Agrostis* from the fifth year onwards but low lime had little

effect during the first 20 years.

Liming, especially the larger amount, decreased *Anthoxanthum* and *Holcus* but increased *Helictotrichon* and *Trisetum*. The amount of legume, although somewhat increased by lime, has been more dependent upon season than upon the liming treatment. The main other species have been *Plantago*, *Ranunculus* and *Achillea*. Neither % *Plantago* nor the time of its increase have been affected by lime, *Achillea* was little affected by low lime and decreased by high lime whereas *Ranunculus* was increased by low lime but decreased by high lime.

3. FYM once every four years with NPK in other years (Plot 20)

As on Plot 19 (FYM alone), *Alopecurus* has tended to be the main grass species on this plot but *Dactylis* and *Arrhenatherum* have also been prominent (Table 36). In contrast to Plot 19, where it declined during the 1940's *Alopecurus* remained at a high level on this plot. Although lime, especially the larger amount, increased % *Alopecurus* until 1925, it afterwards decreased it. In contrast, *Arrhenatherum* was decreased by both amounts of lime during the first three years; afterwards the smaller amount increased it but there was no increase with the larger amount until 1946-48. The effect of lime on *Dactylis* was small and somewhat erratic, and the larger amount tended to decrease it. *Poa pratensis* was decreased by the smaller but increased by the larger amount of lime though *Poa trivialis* was increased by both amounts. *Helictotrichon* has declined on all sub-plots of Plot 20; it was decreased by low lime at the start but then increased though high lime increased it throughout. In contrast *Trisetum*, decreased by both rates of lime at the start, was afterwards little affected. Both rates of lime decreased *Agrostis* but not *Holcus*. *Lathyrus* has varied greatly with season and has been increased by high lime throughout (Table 37).

Plantago, prominent in the late 40's was increased by both amounts of lime but *Achillea* little affected by low lime was increased by high lime. *Taraxacum* was also increased by lime.

2. CHANGES INDUCED BY THE NEW LIMING SCHEME

A. EFFECTS OF APPLICATIONS OF LIME BETWEEN 1965 AND 1968 ON THE BOTANICAL COMPOSITION OF PREVIOUSLY UNLIMED SUB-PLOTS *c* COMPARED WITH THAT OF SUB-PLOTS *d* (CONTINUOUSLY UNLIMED) OF PLOTS GIVEN AMMONIUM SULPHATE i.e. 1, 4², 9, 10, 11¹, 11² AND 18 AND OF 13 (FYM AND FISH MEAL)

To assess the effects of fresh applications of lime to previously unlimed sub-plots *c*, samples of herbage were taken for botanical analyses in 1973 from the relevant sub-plots and also from the corresponding permanently unlimed sub-plots *d* of the same plots. Although the plots were not sampled for botanical composition prior to the introduction of the new scheme in 1965, visual survey showed no changes in the flora of sub-plots *d* between 1965 and 1973. Since these sub-plots are dominated by single species, the botanical compositions of sub-plots *d* in 1973 may be taken as a measure of the composition of both *d* and *c* (i.e. the unlimed half-plot) at the start of the new liming scheme.

Since liming affected total dry matter yield at hay making as well as botanical composition, results are expressed not only qualitatively as % composition of hay but also quantitatively as amounts ha⁻¹ as explained in the Introduction.

1. Plots 1 (N_1) and 18 (N_2KNaMg)

The unlimed sub-plots of both plots 1 and 18 were dominated by *Agrostis* at the start of the new liming scheme and sub-plot *d* of both plots had more than 80% *Agrostis* in 1973. By 1973, 12.5 and 10 t ha⁻¹ of calcium carbonate had decreased this species from 84 to 20% on 1c and from 83 to 52% on 18c (Table 38). *Anthoxanthum*, which contributed c.10% on 1 and 20% on 18, was less affected. The most obvious changes were extremely large increases in % *Festuca rubra* on both plots (from 3 to 50% on 1 and from 0.1 to 14% on 18) and the introduction or increase of a large number of other species including *Cerastium*, *Plantago*, *Rumex* and *Taraxacum* on both plots. *Lathyrus* and *Trifolium* also established on both plots but in greater amount on 1 than on 18, *Lathyrus* having spread inwards from adjacent Plot 14.

Since liming increased the yield of *c* relative to *d* approximately threefold on both plots in 1973, the effects on the amount of species per unit area of land (Table 39) differed from those on percentage composition (Table 38). For example, the large reduction in % *Agrostis* on 1c compared to 1d was largely offset by the increase in yield and on 18c the relatively smaller decrease in % *Agrostis* was more than counterbalanced by the increased yield so that there was almost twice as much *Agrostis* on 18c as on 18d. On the other hand, increases in % composition of particular species e.g. *Festuca* were greatly accentuated by the yield increases.

2. Plots 4² (N_2P), 10 (N_2PNaMg) and 9 ($N_2PKNaMg$)

The unlimed half-plots of these three plots were dominated by *Anthoxanthum* at the start of the new liming scheme in 1965 and the unlimed sub-plots *d* continue to be so (Table 38). About 20 t ha⁻¹ of chalk, applied to these sub-plots between 1965 and 1968, decreased % *Anthoxanthum* from more than 70% to between 5 and 11%. The yield of hay was at the same time increased by at least 50% but the reduction in the amount of *Anthoxanthum* was nevertheless at least 80% (Table 39). In contrast to *Anthoxanthum* and to *Agrostis* in the previously discussed plots, % *Agrostis* on these plots was less affected by liming. However, on Plot 10c the combined effect of a small increase in % *Agrostis* and the 50% increase in total yield resulted in a large increase in the amount of this species. Liming allowed a range of grasses to increase or to establish. On Plots 4²c and 10c, in the absence of potash, *Festuca rubra* increased greatly to form about half and a quarter of the total yield respectively; on 9c which receives potash, *Festuca* increased much less and formed only 3% of the total yield. *Holcus* increased greatly on 9c and 10c and *Poa pratensis* increased on all three sub-plots.

There was some evidence that *Holcus* increased further between 1973 and 1976 on 9c as also did *Arrhenatherum* (Tables 44 and 45). Only on 9c did legumes and appreciable amounts of other species establish.

3. Plots 11¹ ($N_3PKNaMg$) and 11² ($N_3PKNaMgSi$)

The unlimed half plots of 11¹ and 11² were dominated by *Holcus* in 1965 and sub-plots *d*, permanently unlimed, continue to be so. Twenty t ha⁻¹ of chalk, applied between 1965 and 1968 have resulted in very similar changes in the botanical composition of both sub-plots. Percentage *Holcus* was decreased from 96 to 34% (Table 38) and the weight was, on average, halved (Table 39).

In 1973 *Arrhenatherum* contributed about 30%, *Poa pratensis* 12%, *Alopecurus* 8%

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