

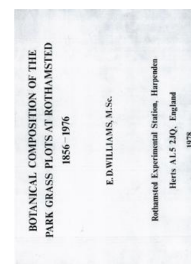
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Botanical Composition of the Park Grass Plots at Rothamsted 1856-1976

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A. Plots Not Receiving Nitrogen

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analysed from each sub- or half-plot.

The plots sampled in the four years were as follows:-

- (1) 1973 – sub-plots *c* and *d* of plots 1 (N_1), 4² (N_2P), 9 ($N_2PKNaMg$), 10 (N_2PNaMg), 11¹ ($N_3PKNaMg$), 11² ($N_3PKNaMgSi$) and 18 (N_2KNaMg), i.e. plots receiving N as ammonium sulphate.
- (2) 1974 – sub-plots *a* and *b* of plots 4², 9, 10, 11¹ and 11² and also sub-plots 13*c* and 13*d* (FYM and fish meal).
- (3) 1975 – unlimed (U) and limed (L) half-plots of plots 3 (unmanured), 7 ($PKNaMg$), 8 ($PNaMG$), 14 ($N_2^*PKNaMg$), 16 ($N_1^*PKNaMg$) and 17 (N_1^*).
- (4) 1976 – unlimed (U) and limed (L) half-plots of 3, 7, 14 and sub-plots *a*, *b* and *c* of plot 9.

The dates of sampling in 1973, 1974, 1975 and 1976 were respectively 12, 20, 9 and 9 June.

As in 1948 and 1949 about 1-2% of the samples consisted of small detached fragments which were not sorted into species. Although it would have been technically possible to do so it would have taken too much time. To maintain continuity with past records the contribution of each species was expressed as a percentage of the total hay (air dry) weight of the sample. However, yields since 1960 have been based on dry weight before hay-making and it is possible that the contribution to dry weight may differ slightly from that to hay weight. Since yields of many plots differ greatly the % figures have nevertheless been used to calculate the weights of the different species per unit area to provide a measure of quantitative as well as qualitative difference between plots (see Tables 39, 41, 43 and 45).

The two main aims of this paper – to present recent data on the botanical composition of some of the main plots and at the same time to trace the major changes that have occurred on them with time and to report on the effects of the new liming scheme – are considered separately.

RESULTS

1. CHANGES WITH TIME

A. PLOTS NOT RECEIVING NITROGEN

1. Unmanured plots [3, 12 (since 1856) and 2 (since 1863)]

Although most treatments are neither randomised nor replicated two plots, 3 and 12, at different ends of the field have received no fertiliser from the start. However, Lawes, Gilbert & Masters (1882) considered plot 3 to be the true 'control' plot since they deduced that soil had in the past been brought in to plot 12 to level this part of the field. The soil of plot 12 has differed in chemical composition from plot 3 and yielded more hay for most of the duration of the experiment (Warren & Johnston, 1964). Plot 2 has received no manure since 1863 and so can now also be considered an unmanured plot.

The botanical composition of Plot 3 in 1858 (Lawes & Gilbert, 1859), is a reasonable indication of the flora of the whole field at the start of the experiment. About twenty species of higher plants were identified on the plot in 1858 but during 1862 about fifty species were found "a result no doubt due to the much greater amount of attention and labour bestowed upon the more recent separations" (Lawes & Gilbert, 1863). During 1877-1903 a decline in the number of species then occurred and between 1910 and 1948 the number of species identified averaged about 37. Thirty species were found in 1975 and 35 in the 1976 samples, but since the range of variation for

previous years was from 25 to 41 there is no evidence of any change in the number of species during the last 30 years.

The relative contributions of grasses, legumes and other species have changed during the duration of the experiment [Table 7(a)] as well as the composition of the three main groups themselves (Table 8). Grasses contributed 76% of the yield on plot 3 at the start and other species less than 20% and these proportions remained unchanged for about thirty years. Afterwards % grasses decreased, averaging 53%, and other species increased to about 40%, but seasonal variations have been large. At the same time yields declined by about 50% so that the net amount of grass greatly decreased but other species remained much the same. Legumes have ranged from 2 to 19% but usually 5 to 12% and averaged 7%; they have not changed systematically with time. The most plentiful grasses at the start were *Lolium* and *Holcus* which together contributed about a third of the herbage. *Arrhenatherum*, *Anthoxanthum*, *Agrostis* and *Festuca* all contributed at least 5%. *Lolium* and *Arrhenatherum* then declined and since 1877 have not made a significant contribution to yield. *Anthoxanthum* remained much the same but *Agrostis* increased as also did *Festuca rubra* and these have been the two main grass species throughout. *Festuca rubra* has increased markedly since the last hay analysis in 1949 and grasses now contribute more than 60% to the yield. Amongst the legumes, *Lotus* has usually been the main constituent; *Lathyrus* was not prevalent during 1975 and 1976 but similar results were obtained in 1938 and 1939. (Table 8). Although a large number of other species still persists the most significant change has been a tendency of three species to be dominant within this group. *Poterium*, present in small amount, and *Leontodon*, absent at the start, have been abundant from the beginning of the century. *Plantago* has also been plentiful throughout but has fluctuated systematically from only 3% between 1872 and 1914 to about 13% from then until 1939 and afterwards about 6%. *Ranunculus* species, 2-5% in the early years have been less conspicuous since then, but *Centaurea* increased from a small amount to 2-10% between 1903 and 1939 but afterwards declined. It is of interest to note that, although the weather preceding the 1976 harvest was much drier than that preceding the 1975 harvest, *Plantago* and *Poterium* were no more abundant in 1976 than in 1975. This contrasts with results in 1937 and 1938, with similar sequences of weather, when the % of both species was two-three times greater in 1938 than in 1937.

Plots 2 and 12, not analysed during 1973-76, have also been analysed much less frequently than plot 3 in the past; in general their botanical composition has been very similar to that of plot 3 (Tables 9 and 10). One of the main differences is that both have little *Poterium*.

Liming on plot 3 initially increased % grasses and decreased % other species, compared with the unlimed half-plot [Table 7(a)]. However, % grasses have declined and % other species increased with time so that there is now a greater percentage of grass but a smaller percentage of other species on the unlimed than on the limed half-plot. Percentage legumes was increased by lime and appeared to increase until about the mid-40's. The number of species has been little affected by lime; there has possibly been a slight increase. Lime soon increased *Helictotrichon* and *Briza* and decreased *Agrostis* (Table 11). Percentage *Briza*, although usually greater on the limed than on the unlimed half-plot, declined from about the mid-20's onwards and *Helictotrichon* has also declined more recently. *Festuca*, almost as plentiful on the limed as on the unlimed half-plot until about the mid-20's, declined more on the limed than on the unlimed half-plot and it has usually been more plentiful on the unlimed half-plot.

Recently *Festuca* has also increased on the limed end. *Trifolium pratense* has increased since the mid-1930's. Amongst the other species the same three species have been abundant as on the unlimed end. However, lime decreased the percentage of all of them until around 1940. Afterwards % *Poterium* and *Plantago* have been greater on the limed than on the unlimed half-plot and during 1975 and 1976 % *Leontodon* was also larger on the limed than on the unlimed half.

Plot 4¹ (Table 12) which has received P alone since 1859 and has been only infrequently analysed was not included in these analyses. It has usually had a smaller % *Agrostis* and *Poterium*, but a larger % legumes and *Rumex* than the unmanured plots.

2. PKNaMg (Plot 7)

As on plot 3 (unmanured) % grass declined on this plot after the first 25 years or so and % other species increased slowly from the outset to reach about 30% by the mid-1940's [Table 7(a)]. The main difference between this and the unmanured plots in the three main groups of plants has been a much larger % legumes in most seasons. Even in the third year legumes, mainly *Trifolium pratense*, were 23%, but afterwards *Lathyrus* has been the main component of this group (Table 13). The 1975 and 1976 analyses show that, as on plot 3, % grasses have recently increased, % legumes and other species have decreased. This conclusion, although based on results from two contrasting seasons, must, nevertheless, remain a tentative one since the recent values are within the range of variation recorded in the past. Visual surveys, however, during the past ten years have also suggested a decline in the legumes on this plot.

Dactylis increased on this plot during the beginning of this century (Table 13), and made a much larger contribution to the yield of this than of the unmanured plot. The 1975 and 1976 analyses showed that it declined between 1948 and these dates but was still twice as plentiful as on plot 3. Percentage *Agrostis* and *Festuca* have usually been less on this plot than on plot 3 but both have increased tremendously since 1948 so that about half the herbage here, as on the unmanured plot, now consists of these two species. In contrast to the unmanured plot, where it has recently decreased, *Holcus* has increased on this plot.

The recent decline in legumes has been mainly in *Lathyrus*; *Trifolium pratense* has remained at the same level as in 1947-48. *Achillea* and *Heracleum* have usually been more prominent here than on the unmanured plot but both now contribute only 1% or less of the herbage. The large amount of *Achillea* recorded during 1947 and 1948 did not persist. *Poterium* and *Leontodon*, important constituents of the unmanured plot, are absent or infrequent on this plot but since 1947 *Plantago* has increased and it is now as abundant as on the unmanured plot 3. *Rumex* has been more conspicuous on this plot than on the unmanured plot, although it has declined greatly on both plots.

On the limed half of this plot grasses have contributed about 60% of the yield but have ranged from less than 40 to more than 80%, and during 1975 and 1976 were respectively 48 and 40% [Table 7(a)]. Legumes have also ranged widely, averaging about 25% and other species, about 12%. There have been no definite trends with time within the three main groups. However, within the grasses, *Arrhenatherum* has increased with time, especially during the last 30 years, and now makes up 30% of the herbage, but *Alopecurus* and *Dactylis* both prominent throughout have decreased during the same interval as also have *Helictotrichon* and *Trisetum* (Table 14). *Festuca rubra*, much decreased by lime, further decreased with time so that it now contributes less than 1% of the herbage. Both *Poa* species have maintained their contribution. *Lathyrus*

although variable between seasons has also probably maintained its contribution and was abundant in 1976. *Trifolium pratense* increased from the mid-30's but *T. repens*, which was then conspicuous, is now infrequent. The most abundant other species are now *Taraxacum*, *Heracleum* and *Ranunculus* but their % contribution was much larger in 1975 than in 1976. *Heracleum* increased about fifteen years after liming but the increase in *Taraxacum* has been more recent. *Centaurea* and *Knautia* are now less abundant than in the past.

Plot 15 (Table 15) received 96 kg N ha⁻¹ as sodium nitrate until 1875 but since then it has received the same treatment as Plot 7. Legumes, which were present in only small amounts when only nitrogen was given, quickly reappeared and were 10% by 1880, almost 20% during the next ten years and about 40% between 1891 and 1900. The level then decreased somewhat but with large seasonal variations. The reappearance of legumes on this plot was faster than where the same amount of nitrogen as ammonium sulphate was replaced by PKNaMg (original Plot 6). Plot 15 has had more *Alopecurus* and *Dactylis* than Plot 7 throughout most of the experiment. However, strict comparisons between the limed halves of the two plots cannot be made for particular years since liming started 17 years later on Plot 15 than on Plot 7. As on Plot 7 liming encouraged *Arrhenatherum* but *Dactylis* has usually been less plentiful on 15 than on 7. *Trifolium repens* has been more abundant on the limed half of 15 than on 7.

3. PNaMg (Plot 8)

This plot also received K and sawdust during 1856-61 and 1856-62 respectively. Omitting K had large effects on % legumes and on yield; in most years there has been 20-25% less legume on this plot than on Plot 7 (PKNaMg); the reduction was even larger in the early years. Recently, because of the decline on Plot 7, % legumes have been similar on the two plots. Percentage grass has usually been less and other species much more than on the PKNaMg plot [Table 7(a)]; there have been more species on this than on the PK plot but slightly fewer than on the unmanured.

This plot has a smaller percentage of *Agrostis* than the unmanured and PKNaMg plot since c. 1930; as on those plots *Festuca rubra* has been plentiful throughout and although there was some evidence of decline in the late 40's it had also increased by the time of the recent analyses (Table 16). *Arrhenatherum*, although recently declined has been more prominent than on the unmanured or PK plot, but *Dactylis* has, except in 1947 and 1948, been less abundant than on the PK plot. A marked permanent decline in *Lathyrus* occurred during the 1920's and the legumes now consist mainly of *Trifolium* and *Lotus*. *Plantago* has contributed 10-30% since the beginning of the century and *Leontodon* is also prominent and possibly increasing, but *Achillea* was much less prominent in 1975 than in 1948.

The botanical composition of the limed half is qualitatively similar to that of the unlimed half (Table 17). The main difference is that *Helictotrichon* is much more abundant with than without lime. As on the unlimed half *Arrhenatherum* and *Dactylis* have recently decreased but *Anthoxanthum* and *Festuca rubra* increased and *Plantago* and *Leontodon* are the main other species.

B. PLOTS RECEIVING NITROGEN AS AMMONIUM SULPHATE

Some of the most spectacular treatment effects on Park Grass and some of the largest changes with time have been due to the acidifying effect of ammonium sul-