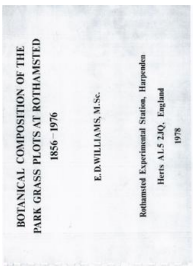
# Botanical Composition of the Park Grass Plots at Rothamsted 1856-1976

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## B. Plots Receiving Nitrogen As Ammonium Sulphate

### Rothamsted Research

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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-

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phate. All the unlimed sub-plots of plots given ammonium sulphate are now dominated by acid-tolerant grasses.

Three plots in this group were omitted from the main experiment in 1964. One of them (original Plot 6) received $N_2$ and sawdust until 1868 and the other two (Plots $5^1$ and $5^2$) received $N_2$ alone until 1897. The nitrogen dressings, which were very damaging to the herbage, were replaced by PKNaMg on Plot 6 from 1869, PK on Plot $5^2$ from 1898 but not replaced by anything on $5^1$ from 1898, which remained an unmanured plot until 1964. Details of the botanical composition of these plots are given by Brenchley & Warington (1958).

1. $N_1$ (Plot 1)

Plot 1 received farmyard manure during the first eight years; thus comparisons of its botanical composition in 1862 with that of Plot 2 (farmyard manure alone 1856-63) show the effect of a small amount of N in the presence of FYM: the main effect of the additional nitrogen was to increase *Dactylis* but slightly decrease *Lathyrus*.

This plot consisted of about 80% grass in the second year and grasses ranged from 78 to 95% during the next 60 years or so [Table 7(b)]. Legumes, which ranged seasonally from 0.2 to 3%, were absent from c. 1910 onwards although traces were present in the early 1940's. Most of the variation in % grasses was therefore counterbalanced by variations in other species. Nowadays, % grasses is about 98% and other species have seldom exceeded 5% during the last thirty years. During the first 20 years *Dactylis* and *Poa trivialis* declined and *Agrostis* and *Anthoxanthum* increased (Table 18). *Holcus*, after apparently declining between the second and sixth year, also increased. During the 1920's and 1930's *Anthoxanthum* and *Holcus* were reduced to very small amounts but *Agrostis* continued to increase as also did *Festuca*. The last two species were co-dominant in 1939 and in 1940 72% of the herbage consisted of *Festuca*. By the late 1940's, however, *Agrostis* was dominant and has remained so ever since. The recent analysis in 1973 showed a further decrease in *Festuca* but a substantial increase in *Anthoxanthum*.

Liming this plot increased *Helictotrichon* and *Dactylis*, and allowed a small amount of legume to flourish and also many other species, especially *Plantago* (Table 18).

2. $N_2$ **KNaMg** (Plot 18)

This treatment has been applied to Plot 18 since 1905 following PKNaMgSi and an amount of N (16 kg) equal to that contained in 1.02 t hay. In the absence of P and with acid soil conditions *Agrostis* became dominant on this plot and possibly sooner than on Plot 1 although treatment on that plot started in 1863. *Dactylis* rapidly decreased and *Festuca* more slowly so that there was none of the former and little of the latter present in 1973 (Table 19). Both light and heavy liming greatly encouraged *Dactylis* and continue to do so, and *Alopecurus* was also increased initially but it declined during the 30's and early 40's. As *Alopecurus* declined *Arrhenatherum* increased with both light and heavy liming (Table 20).

3. $N_2$**P** (Plot $4^2$)

*Festuca rubra* has been the most abundant grass on this plot for most of the duration of the experiment and it was co-dominant with *Agrostis* in 1949 (Table 21). *Agrostis* was abundant from the start and has maintained its contribution. *Anthoxanthum* became prominent from the beginning of the century and greatly increased during the 1950's and 1960's; it is now dominant (76%) on the unlimed quarter-plot but *Festuca*



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is infrequent. *Alopecurus* was the most plentiful grass for about 20 years following liming; it then decreased and *Festuca*, which now makes up about half the herbage, increased. *Poa pratensis* was also plentiful in 1974.

4. **$N_2$PNaMg** (Plot 10)

Like the other plots given nitrogen, this plot has also been dominated by grasses [Table 7(b)] except in the early years and during 1915-1920, when *Rumex* was abundant. *Dactylis, Helictotrichon, Poa pratensis* and *Poa trivialis* all declined during or shortly after the first twenty years. *Festuca rubra* increased during the same time, but except in 1948, did not make a very large contribution after 1920. The most important grasses on this plot during the last 40-50 years have been *Agrostis, Anthoxanthum* and *Holcus* and these have competed for dominance. *Holcus* became dominant probably sometime during the 1920's and remained so until 1938 but afterwards it declined greatly; *Anthoxanthum* and *Agrostis* together with *Holcus* made up 90% of the herbage in roughly equal proportions in 1940. Afterwards *Holcus* decreased, *Agrostis* remained plentiful and *Anthoxanthum* has been dominant for ten to fifteen years (Table 22).

Lime not only prevented *Alopecurus* declining but increased it so that it was dominant until c. 1940; afterwards its contribution was halved but *Festuca rubra* previously 20-30% increased to about 50% during the 1940's. Recently, *Alopecurus* has decreased further and *Arrhenatherum* and *Anthoxanthum* have increased (Table 23).

5. **$N_2$PKNaMg** (Plot 9)

This plot has been analysed more frequently than any other. By the third year *Holcus* and *Lolium* had doubled their contribution to a total of 69% (Table 24). Both subsequently decreased, *Holcus* temporarily, but *Lolium* was absent after 1903. *Dactylis* also declined from about 13% in the 1870's to less than 1% in the mid-20's and *Festuca rubra* which made a significant contribution until the mid-20's also later declined. *Arrhenatherum*, prominent between 1870 and the mid-20's was afterwards much reduced. Between 1900 and 1930 a struggle for dominance occurred between *Agrostis, Anthoxanthum* and *Holcus*; by 1921 they contributed 80% of the herbage in approximately equal proportions. However, by the mid-20's *Holcus* became increasingly ascendant and was dominant from 1930 probably until about 1962. Since then *Anthoxanthum* has been dominant on the unlimed sub-plot. Legumes have always been absent and after the first 60 years other species have rarely contributed much to the yield of this plot.

*Alopecurus* and *Arrhenatherum* have usually dominated the limed half of this plot, although several other grasses particularly *Dactylis, Festuca, Holcus* and *Poa pratensis* have also made significant contributions (Table 25). *Arrhenatherum* became prominent sooner and was twice as abundant as *Alopecurus* during the first four cycles of the liming scheme. From the late 1920's until 1940, except in 1932 and 1933 *Alopecurus* contributed about 50% of the hay yield and was usually much more abundant than *Arrhenatherum*; it continued to be so during 1947 and 1948 although both species were much reduced in those years. The evidence available in 1974 and 1976 suggests that whereas *Alopecurus* declined further, *Arrhenatherum* increased and there is now at least three times as much *Arrhenatherum* as *Alopecurus* on this plot. Recently, *Festuca* and *Poa pratensis* have decreased but *Holcus* increased.

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Small amounts of *Lathyrus* were present on this plot in most years in the past and the amount increased during the late 1930's and 1940's; it is now abundant (Table 25). As on the limed half of Plot 7 (PKNaMg) the species was unusually abundant during 1976. Before 1940 other species rarely contributed more than 4% to the yield but since then they have ranged from 4 to 14%, the increase being mainly in *Heracleum* and *Taraxacum*.

6. **$N_3$PKNaMg** (Plot $11^1$) **and $N_3$PKNaMgSi** (Plot $11^2$)

On Plot $11^1$ (with the largest amount of ammonium sulphate) *Alopecurus* and *Arrhenatherum* increased slowly to reach about 30% in 1903 and 1919 respectively. Both species then declined to very small amounts. Percentage *Dactylis* doubled during the first ten years, then decreased to its original level between 15 and 20 years and then virtually disappeared. Neither *Poa* species, both about 10% at the start, persisted. Neither *Lolium* nor *Holcus* were as much encouraged in the early years as on Plot 9, with a smaller amount of N. In fact, *Holcus* declined during the early years, but then increased greatly as *Alopecurus* and *Arrhenatherum* declined. It has been dominant on this plot since c. 1910 (Table 26). *Agrostis*, encouraged during the early years, has not persisted on this plot to the same extent as on the plots receiving $N_2$. *Anthoxanthum* has been present in only small amounts; in 1973 it made up 5% of the herbage and appears to be increasing. Except during the early years, or in exceptional seasons, only small amounts of other species have occurred on this plot. The botanical composition of Plot $11^2$, which receives Si as well, has been similar to $11^1$ except that *Holcus* probably became completely dominant later. *Alopecurus* contributed 30% to the yield of this plot in 1919 whereas it had declined to 1% on $11^1$ by 1914. *Arrhenatherum* also persisted for longer on $11^2$ than on $11^1$ (Table 27).

As on the plot receiving $N_2$ (96 kg N $ha^{-1}$) and PKNaMg, *Alopecurus* and *Arrhenatherum* are the most abundant grasses on the limed end of these plots. Without silica (Plot $11^1$) *Alopecurus* and *Arrhenatherum* were equally abundant in 1914, 11 years after the start of liming. *Alopecurus* then increased and *Arrhenatherum* decreased markedly. Afterwards *Alopecurus* decreased and *Arrhenatherum* increased so that they were again present in roughly equal proportions in 1974. On $11^2$ *Alopecurus* was twice as abundant as *Arrhenatherum* in 1914 and a similar sequence of events occurred but on a different scale so that in 1964 there was almost twice as much *Arrhenatherum* as *Alopecurus*. There has, for most of the time, been more *Dactylis* on $11^2$ than on $11^1$. Although *Poa pratensis* has declined *Poa trivialis* has increased. A large increase in *Holcus* has occurred on both plots since the 1947 and 1949 analyses. *Taraxacum* established on these plots during the 1940's and since then *Anthriscus*, *Heracleum* and *Rumex* have increased slightly.

## C. PLOTS RECEIVING NITROGEN AS SODIUM NITRATE

These plots were started in 1858. Plot 15 (already discussed) which has received PKNaMg since 1876, received 96 kg N $ha^{-1}$ as sodium nitrate annually between 1858 and 1875.

1. $N_1$ (Plot 17)

The botanical composition of this plot contrasts strongly with that of Plot 1, which receives the same amount of nitrogen, but as ammonium sulphate. Grasses have usually contributed about 70% and other species 30% to the yield of plot 17 but legumes only

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