

Thank you for using eradoc, a platform to publish electronic copies of the Rothamsted Documents. Your requested document has been scanned from original documents. If you find this document is not readable, or you suspect there are some problems, please let us know and we will correct that.



# Rothamsted Experimental Station Report for 1977 Part 2



[Full Table of Content](#)

---

## Botanical Composition of the Park Grass Plots

**E. D. Williams**

E. D. Williams (1978) *Botanical Composition of the Park Grass Plots* ; Rothamsted Experimental Station Report For 1977 Part 2, pp 31 - 36 - DOI: <https://doi.org/10.23637/ERADOC-1-36540>

## Botanical Composition of the Park Grass Plots

E. D. WILLIAMS

During 1973–76 botanical analyses were made of hay samples from selected plots of the Park Grass experiment. These were initiated primarily to assess changes in the botanical composition of sub-plots which had received lime for the first time or increased rates of lime under a new scheme of liming; the analyses were then extended to include plots with unchanged treatment. Recent changes are considered not only in relation to those since the last analyses in 1948–49 but also to the main changes on the plots throughout the duration of the experiment. To enable this to be done all previous data were collated and condensed. A full report of this work has been prepared;\* the present paper is a summary of that account.

### Introduction

The Park Grass experiment at Rothamsted was laid down by Lawes and Gilbert in 1856 to assess what were the optimum amounts and combinations of different fertilisers needed to obtain maximum yields of hay. It was sited on land which had been under grass for at least a century; there is no record of any seeds being sown and so the species present at the outset represented indigenous strains of plants. Details of initial treatments were given by Lawes and Gilbert (1880), changes during the experiment by Warren and Johnston (1964) and present-day treatments by Thurston, Williams and Johnston (1976). Briefly, the treatments can be considered in three main groups: (1) no nitrogen; (2) nitrogen applied at three amounts (N1, N2 and N3) as ammonium sulphate supplying 48, 96 or 144 kg N ha<sup>-1</sup>; (3) nitrogen applied at two amounts (N1 and N2) as sodium nitrate supplying 48 or 96 kg N ha<sup>-1</sup>. Within the three groups there are comparisons of O and P (applied as superphosphate) with and without K, Na and Mg for some of the amounts of N.

Starting in 1903 and subsequently every fourth year until 1964 the southern halves of most plots were limed at the equivalent of 2.24 t CaO ha<sup>-1</sup>. In 1965 a new liming scheme (Warren, Johnston & Cooke, 1965) was introduced. In this scheme each half plot is further divided into two, giving four sub-plots (*a*, *b*, *c* and *d*) for each fertiliser treatment and it is intended that eventually sub-plots of all plots should have soils with pHs, measured in water, of approximately 7, 6, 5 and 4. A start was made during 1965–68 on the first phase of this scheme when lime was applied to previously unlimed sub-plots *c* to increase their pH to 5 and also increased rates of lime were given to previously limed sub-plots *b* to increase their pH to 6. Only plots given ammonium sulphate were sufficiently acid then to require lime. In 1976 a start was made on raising the pH of sub-plots *a* to 7, where they are less than this.

The management of the plots has remained fairly constant throughout: the plots have been cut for hay every year, usually in June. During most of the years until 1877 the aftermath was grazed by sheep but since then it has been cut and carted green and yield given as hay or since 1960 as herbage dry matter.

\* 'Botanical Composition of the Park Grass Plots at Rothamsted 1856–1976' obtainable from the Librarian, price £1.

## ROTHAMSTED REPORT FOR 1977, PART 2

**Past and present analyses.** The experiment soon showed how yield could be increased by fertilisers. The treatments quickly changed the botanical composition of the swards as shown by analyses of selected plots made in the third year (Lawes & Gilbert, 1859) and more detailed ones during the seventh to twenty-second year (Lawes, Gilbert & Masters, 1882). Some plots were analysed in 1903 and all plots were analysed in 1914, 1919 and during 1948–49 (Brenchley & Warington, 1958); many plots were also completely analysed in certain years between 1920 and 1946. Partial separations of the species into three main groups of plants—grasses, legumes and ‘other species’—have also frequently been done. Every year since 1920 the presence and abundance of species in inflorescence on the plots in June and in the autumn have been recorded.

Analyses of samples of hay from the plots were discontinued in 1949 because of doubts about the relevance of the experiment to modern agriculture; the plots then appeared to be relatively stable. Analyses were resumed in 1973 to quantify some of the large differences in botanical composition brought about by addition of lime to previously unlimed sub-plots *c* of plots receiving ammonium sulphate. In 1974 the botanical compositions of sub-plots *b*, which received increased rates of lime, were compared with those of sub-plots *a*, which at that time had continued to receive lime under the old scheme. In 1975 and 1976 the unlimed and limed half plots of some of the plots with unchanged treatment were analysed to assess changes since the last botanical analyses in 1948/49. Additionally, comparisons of the botanical compositions of sub-plots *a* and *d* in 1974 and 1973 respectively with the corresponding limed and unlimed half plots in 1948/49 also provided a measure of change during a quarter of a century on the parts of the ammonium sulphate plots which had received unchanged treatments. The results are presented briefly in two parts; in the first section the results for plots with unchanged treatments are given in relation to the main changes in the past and in the second the effects of lime under the new scheme are reported.

### Results

#### 1. Changes in botanical composition with time (1856–1976)

**A. Plots not given nitrogen fertiliser.** There were about 50 species of higher plants on the unmanured plots at the start of the experiment but afterwards the number declined to an average of 37. Grasses initially contributed 76% to the yield, legumes about 7% and other species less than 20%. Afterwards grasses declined and the contribution of other species increased to about 40%. The most significant change within the other species has been a tendency for three species *Leontodon hispidus*, *Plantago lanceolata* and *Poterium sanguisorba* to become dominant. Legumes have averaged 7% of the yield and have not changed systematically with time. The most plentiful grasses at the start were *Lolium perenne* and *Holcus lanatus* which together made up about a third of the herbage but after the first ten years *Agrostis tenuis* and *Festuca rubra* soon became the main grass species. The largest recent change (i.e. since the previous analyses in 1948–49) on the unmanured plot 3 has been an increase in *Festuca rubra* which now constitutes a third of the herbage.

The main effect of PKNaMg in the past was to increase % legumes; *Dactylis glomerata* has also been more prominent than on the unmanured plot and *Leontodon* and *Poterium* have been infrequent. Recently, as on the unmanured plot, % grasses have increased; % legumes, especially *Lathyrus pratensis*, and other species have decreased. During the last 30 years *Agrostis* and *Festuca* have increased tremendously and half the herbage on this plot consists of these two species. With lime, legumes have usually been very vigorous but have varied seasonally; *Alopecurus pratensis* and *Dactylis*, both prominent

## BOTANICAL COMPOSITION OF THE PARK GRASS PLOTS

throughout, have recently decreased but *Arrhenatherum elatius* has increased greatly and now makes up 30% of the herbage.

Where K is not added (PNaMg), legumes, especially *Lathyrus*, have usually been less abundant but other dicotyledons more plentiful. *Agrostis* has been less frequent than on the unmanured and PKNaMg plots but *Festuca* has been plentiful. Liming this plot had little effect, except to increase *Helictotrichon pubescens*. On both limed and unlimed halves *Arrhenatherum* and *Dactylis* have recently decreased but *Anthoxanthum odoratum* and *Festuca* increased.

**B. Plots receiving nitrogen as ammonium sulphate.** Some of the most spectacular effects on Park Grass and some of the largest changes with time have been due to the acidifying effect of ammonium sulphate. All the unlimed sub-plots of plots receiving ammonium sulphate are now dominated by acid-tolerant grasses. Dicotyledonous species were discouraged early and plots soon consisted of more than 90% grass. During the early years a decline occurred in *Dactylis*, *Lolium* and *Poa trivialis* and on most of the plots *Agrostis*, *Anthoxanthum* and *Holcus* have competed for dominance. With the smallest amount of ammonium sulphate without P and K, *Agrostis* became dominant about 1940 and has remained so ever since. With the intermediate amount of N and where P was also given *Festuca rubra* was dominant for much of the duration of the experiment but *Anthoxanthum* increased during the 1950s and is now dominant. With Na and Mg as well, *Agrostis*, *Anthoxanthum* and *Holcus* have all been prominent during the last 50 years but *Anthoxanthum* has been dominant for the last 15 years or so. Inclusion of K as well (N2PKNaMg) resulted in *Holcus* being dominant between 1930 and 1960 but since then the herbage on this plot has also consisted mostly of *Anthoxanthum*. With the largest amount of nitrogen (N3PKNaMg) *Holcus* became dominant about 70 years ago and has remained so ever since.

When lime was given and potassium was not supplied *Alopecurus* was the main grass for the first 30 years or so after the start of liming but *Festuca* has been the main grass since the 1940s. Where K is included (N2PKNaMg and N3PKNaMg) the main grasses have been *Alopecurus* and *Arrhenatherum* but their relative contributions have fluctuated widely. In general, the 1975 and 1976 analyses showed increases in the amount of *Arrhenatherum* and decreases in *Alopecurus* on the limed halves of most of the plots given N as ammonium sulphate.

**C. Plots receiving nitrogen as sodium nitrate.** The botanical composition of the plot given 48 kg N ha<sup>-1</sup> as sodium nitrate contrasts strongly with that where the same amount of nitrogen is given as ammonium sulphate. About 30 species of plants occur on this plot and the vegetation has been relatively stable. Where PKNaMg is given, either with the same amount or twice as much nitrogen, *Alopecurus* increased greatly during the first 60 years to make up 50% of the herbage. It then declined and *Arrhenatherum* increased at the same time so that the two species are now co-dominant. Liming decreased *Alopecurus* on both plots and the amount further decreased with time so that with lime *Arrhenatherum* is dominant.

## 2. Changes induced by the new liming scheme

**A. Effects on botanical composition of increasing to 5 the pH of sub-plots c compared with that of sub-plots d, permanently unlimed.** On plots receiving N1 and N2KNaMg, which lack P, and where *Agrostis* is dominant, liming between 1965 and 1968 decreased *Agrostis* from more than 80% to 20 and 50% respectively, and *Festuca* was increased from 3 to 50% and from 0.1 to 14% in 1973. Since dry weight yield per plot was approximately trebled

## ROTHAMSTED REPORT FOR 1977, PART 2

the increases in *Festuca* were much larger and decreases in *Agrostis* much smaller than the percentage figures suggest. A large number of other species also established on both plots but in greater amount on the plot receiving N1 than on the plot receiving N2KNaMg.

The unlimed halves of the three plots receiving the intermediate amount of nitrogen and P were dominated by *Anthoxanthum* at the start of the new liming scheme in 1965 and the unlimed sub-plots *d* continue to be so. Lime decreased *Anthoxanthum* from about 70% to about 8% and the weight per plot by at least 75%. On the two plots lacking potash, *Festuca* increased greatly to form about a half (N2P) and a quarter (N2PNaMg) of the total yield but with K (N2PKNaMg) the species formed only 3% of the total yield. *Holcus* increased greatly on the N2PNaMg and N2PKNaMg plots and *Poa pratensis* increased on all three sub-plots.

The unlimed halves of plots receiving N3PKNaMg were dominated by *Holcus* in 1965 and the permanently unlimed sub-plots *d* continue to be so. Lime decreased *Holcus* from 96 to 34% and halved the weight. In 1973 *Arrhenatherum* contributed 30% and *Poa pratensis*, *Alopecurus* and *Dactylis* were also plentiful on sub-plots *c* but remained absent on sub-plots *d*. Liming allowed small amounts of a few other species to establish.

**B. Effects of increased applications of lime between 1965 and 1968 on the botanical composition of sub-plots *b* (whose pH is being raised to 6) compared with that of sub-plots *a* (limed under old scheme).** On plots receiving N2P and N2PNaMg only small amounts of lime were needed to raise the pH to 6; as a result few changes in botanical composition occurred. Where increased lime was given to the N2PKNaMg plot the main effect was to halve both the percentage and weight per plot of *Alopecurus* and to increase the legumes, particularly *Lathyrus*. The pHs of sub-plots *b* of plots receiving N3PKNaMg were more acid and so more lime was required to increase their pH to 6. The increased amounts of lime on these plots almost halved *Alopecurus* but increased *Arrhenatherum*, especially on the plot lacking silica. *Holcus*, which had been plentiful in recent years, was greatly decreased and *Anthriscus* and *Heracleum* were increased by increased rates of liming.

## Discussion

The effects of the treatments on the botanical composition of the plots have been reported in many previous publications (e.g. Lawes, Gilbert & Masters, 1882; Brenchley & Warington, 1958). In the present analyses most emphasis was placed on an examination of whether and in what way the botanical compositions of the plots change with time, and of how they have been affected by lime under the new scheme. Although differences between the plots were established early and many of the major differences have persisted, the dynamic nature of the grass sward—the variation in the contribution of different constituents between and within seasons even with constant management and unchanging fertiliser treatment—has long been recognised. The present analyses have shown that over and above these short-term variations systematic changes in the botanical composition of the plots continue to occur. On most of the plots not receiving nitrogen there has been a large increase in *Festuca rubra* during the last 30 years and *Agrostis* has also increased greatly on the plot receiving PKNaMg. On plots receiving the intermediate amount of nitrogen as ammonium sulphate *Anthoxanthum* has become dominant during the last 15–20 years. On the limed halves of plots given N2 and N3 *Arrhenatherum* and *Alopecurus* percentages have fluctuated so that their relative proportion now more closely resembles that of 60 rather than 30 years ago. However, some plots, for example the one receiving nitrogen (N2) as sodium nitrate plus PKNaMg, and the unlimed part of the N3PKNaMg plot, have remained fairly stable during the last 60 years or so.

## BOTANICAL COMPOSITION OF THE PARK GRASS PLOTS

Except on the plots given sodium nitrate the effects of lime under the old scheme are now very pronounced but the difference between limed and unlimed half plots are for many plots not much greater than that which has occurred with time on the unlimed half plots as they have gradually acidified. In so far as comparison is possible, the effects of lime under the new scheme, where it has been applied to previously unlimed sub-plots, have appeared larger than the initial effects of lime under the old scheme. The reason for this is that in the interval between the start of the two schemes (1903–65) the unlimed halves became progressively more acid so that whereas a range of grasses was present in 1903, in 1965 the unlimed sub-plots were dominated by acid-tolerant grasses. Whereas the initial effect of lime applied in 1903 was to change differentially the proportion of species already present, the new liming caused species, which were absent at the time or present in extremely small amounts, to be introduced or to increase on the newly-limed sub-plots. Small changes in the pH in the uppermost soil layers on sub-plots *c* have brought about large changes in botanical composition. These changes, which include the reduction of acid-tolerant grasses, were accompanied by large increases in yield but in general the effect of recent lime on the botanical composition has been more consistent than on yield since it has been less subject to seasonal variations. The fact that the three sub-plots dominated by *Anthoxanthum* were to a certain extent affected differently by lime serves to emphasise that the effect of lime will depend not only on the original vegetation and extent of pH change but also on the supply and availability of other nutrients, the proximity of other species and the ease with which they can be introduced.

Although the experiment started as an agricultural investigation, the contrasted processes of depletion and enrichment of nutrients on the different plots now limit the applicability of much of the data to present-day agriculture. However, the fact that old permanent pastures may often yield as much as sown leys and that bred varieties are not necessarily superior to locally-adapted indigenous species under all conditions has resulted in renewed interest and a reappraisal of the agricultural value and ecological requirements of native species. The species present on the plots are mainly those adapted to the specific conditions and this information can now be used to predict what species would be most appropriate in particular ecological niches and at what levels of fertility and pH. Most of the major changes on the plots occurred in the early years and changes in the first phase of the new liming scheme are likely to be greater than in phases that ensue. Nevertheless, as far as can be predicted, steady changes are likely to continue to occur on most plots during the next 20–30 years. It is clear, however, that, whereas monitoring the changes in the vegetation during the early years gave information of general application, it may now serve as background to more detailed autecological studies and to the comparative biology of species. The usefulness of any future data will be enhanced if they enable the information to be used to predict successions at other sites and attempt to describe the mechanisms of distribution and change within plant associations and the nature and significance of differentiation within species.

### Acknowledgements

I thank Miss Hilary Gogay and Miss Heather Pellant for much help throughout the course of these investigations.

### REFERENCES

- BRENCHEY, W. E. & WARINGTON, K. (1958) *The Park Grass plots at Rothamsted, 1856–1949*. Revised 1969. Rothamsted Experimental Station, Harpenden, Herts.  
LAWES, J. B. & GILBERT, J. H. (1859) Results of experiments with different manures on permanent meadow land. *Journal of the Royal Agricultural Society of England*. 1st Series. **19**, 552–573, 20, Part II, 228–246, Part III, 246–272, Part IV, 398–441.

## ROTHAMSTED REPORT FOR 1977, PART 2

- LAWES, J. B. & GILBERT, J. H. (1880) Agricultural, botanical and chemical results of experiments on the mixed herbage of permanent meadow, conducted for more than twenty years in succession on the same land. Part I. The agricultural results. *Philosophical Transactions of the Royal Society*, (A and B), **171**, 289–415.
- LAWES, J. B., GILBERT, J. H. & MASTERS, M. T. (1882) Agricultural, botanical and chemical results of experiments on the mixed herbage of permanent meadow, conducted for more than twenty years in succession on the same land. Part II. The botanical results. *Philosophical Transactions of the Royal Society*, (A and B), **173**, 1181–1413.
- THURSTON, J. M., WILLIAMS, E. D. & JOHNSTON, A. E. (1976) Modern developments in an experiment on permanent grassland started in 1856: effects of fertilisers and lime on botanical composition and crop and soil analyses. *Annales Agronomique* **27**, 1043–1083.
- WARREN, R. G. & JOHNSTON, A. E. (1964) The Park Grass experiment. *Rothamsted Experimental Station. Report for 1963*, 240–262.
- WARREN, R. G., JOHNSTON, A. E. & COOKE, G. W. (1965) Changes in the Park Grass experiment. *Rothamsted Experimental Station. Report for 1964*, 224–228.