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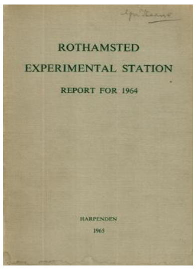

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Changes in the Park Grass Experiment

BY R. G. WARREN, A. E. JOHNSTON and G. W. COOKE

Our Classical Experiments, which have had known treatments for over a century, provide unique opportunities for work on soil chemistry and crop nutrition. Simply continuing the past treatments and recording crop yields, however, cannot contribute much new information relevant to present farming practices. It is our policy therefore, when possible, to modify the experiments to help in solving current problems, while retaining features that are still of value. For example, the sites of the Exhaustion Land and Agdell experiments at Rothamsted and the Permanent Wheat and Barley at Woburn have been used for new experiments with micro-plots, and the Barnfield mangold experiment has been modified. The review of the Park Grass Experiment in last year's Report (pp. 240–262) suggested how it might be modified to give more information about the manuring of grass and provide a further range of soils for laboratory work, without detracting from its value as a unique demonstration of the effects of manuring on the composition of herbage.

At present Park Grass is cut twice a year, first at the hay stage and then the aftermath is cut for silage. The most nitrogen applied is 129 lb/acre as a single dressing in spring, and the largest yields are less than 3 tons dry matter/acre. The management and manuring is not relevant to present grassland farming, and the yields are much less than from grass on other fields at Rothamsted. The whole experiment is a valuable source of material for study in several departments, and it vividly illustrates how manuring and liming affect soil reaction, nutrient reserves and the composition of the herbage. These functions will be better fulfilled by the proposed new liming scheme. The new fertiliser tests on three of the plots will show how increasing amounts of nitrogen affect the yield and composition of permanent grass that is cut often. The nitrogen contributed by legumes will also be assessed. As there is little information from long-term experiments on the phosphorus and potassium requirements of intensively managed grass, some of the new treatments will assess these on both rich and poor soils.

New fertiliser tests. The histories of the Park Grass plots place them in two categories. In the first, which comprises most of the experiment, the manuring of the plots has been unchanged (no nitrogen, ammonium-N or nitrate-N, with various combinations of P and K and tests of sodium, magnesium and silicates). Herbage yields and analyses of the soils of these plots were given in the Report for 1963, but not of the other category consisting of plots where treatments have changed in the past. Plots in this second category can now be used for new treatments, however, comparing different N levels and cutting systems to those used on Park Grass, assessing the value of P and K residues accumulated in the soil, because analyses of the soils, given in Table 1, show they are *now* very similar to those of plot 3 (unmanured) or plot 7 (P K Na Mg), both plots with unchanged manuring.

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TABLE 1

Analyses of soils of some plots of the Park Grass Experiment

Plot No.	3		5/1	18/1	18/3	7		5/2	6	15	
Unlimed (U) or limed (L)	U	L	U	U	L	U	L	U	U	U	L
pH	5·2	7·2	4·6	4·1	7·1	4·9	7·0	4·6	4·9	4·9	6·8
Organic carbon, (% C)	3·3	4·0	3·3	3·2	3·8	2·8	3·4	3·7	2·7	3·0	3·5
Nitrogen (% N)	0·27	0·33	0·25	0·27	0·31	0·23	0·30	0·27	0·22	0·25	0·30
Phosphorus											
Total (mg P/100 g of soil)	50	57	51	54	53	140	134	123	122	127	127
$NaHCO_3$-soluble* (mg P/100 g of soil)	0·5	1	0·5	0·5	0·5	17	10	17	14	11	9
HCl-soluble* (mg P/100 g of soil)	0·2	0·3	0·5	0·5	0·5	17	22	16	15	15	20
$CaCl_2$-soluble,* g mol. P/l × 10^{-6}	2	2	1	0·3	0·5	23	24	36	29	24	20
Potassium, soluble in											
Ammonium acetate* (mg K/100 g)	8	7	8	32	55	61	61	67	62	70	62
Water (mg K/100 g)	1	0·5	2	9	12	12	10	14	11	12	10
$CaCl_2$* (mg K/100 g)	2	1	2	15	21	26	20	29	26	28	24
HCl* (mg K/100 g)	5	4	6	24	40	48	49	51	47	51	47

* The solutions used were 0·5*M*-$NaHCO_3$, 0·3*N*-HCl, *N*-ammonium acetate and 0·01*M*-$CaCl_2$.

New work planned to begin in 1965 involves three of these plots:

		Yield, cwt dry matter/acre (average of 1920–59)
Plot 5/1	86 lb N/acre (as ammonium salts), from 1856 to 1897; unmanured from 1898 to 1964	10·5
Plot 5/2	86 lb N/acre (as ammonium salts) from 1856 to 1897 and then superphosphate and potassium sulphate from 1898 to 1964	20·4
Plot 6	86 lb N/acre (as ammonium salts) from 1856 to 1868 (with sawdust from 1856 to 1862); then a mixture of superphosphate and potassium, sodium and magnesium sulphates from 1869 to 1964	28·8

All three are acid (pH 4·6–4·9) and will be limed. One (5/1) has very little soluble P and K, the others (5/2 and 6) have much of both; plot 6 has had small dressings of sodium and magnesium salts.

New treatments with nitrogen fertilisers will establish the full shape of the response curve to N and will measure the maximum yield possible from this site. As yield of grass depends on frequency of cutting, some subplots will be cut three times and others six times each year.

At present the legumes which appear to grow well on plot 6 can contribute little nitrogen, as the herbage contains only about 60–70 lb N/acre/year, some of which must come from non-symbiotic sources. The present cutting system discourages legumes, but the more frequent cuttings proposed should encourage clovers; the nitrogen they contribute will be measured on plots that receive no nitrogen fertilisers, by eliminating legumes from half of the plots with selective weedkillers.

New phosphorus and potassium dressings will test how much must be given to achieve maximum response to nitrogen on the poor soil of plot 5/1; parallel tests on the other two plots will show whether herbage responds to fresh fertilisers on soils already rich in P and K. The effects of fertilisers on both yield and composition of herbage, and on the soluble P and K in soils, will be measured.

Sodium and magnesium fertilisers are unlikely to increase yields, but their amounts in herbage are thought to be important in animal nutrition. Very small dressings of Na and Mg are given at present; the amounts given will be increased and their effects on herbage composition measured.

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New liming scheme. In the review of the Park Grass experiment in the Report for 1963 it was suggested that the experiment could be improved by adding new lime treatments. At present there are two liming schemes:

(1) a test since 1903 of 2,000 lb CaO/acre (or equivalent $CaCO_3$) applied every fourth year to the south halves of plots in the main block of the experiment (except plots 5/1, 5/2, 6, 12);

(2) a test started in 1920 of two laboratory methods for measuring the lime requirement of soils on three plots (18, 19, 20) to the south of the main block of plots.

Neither of these now gives new information. The first scheme produced soils with very different pH values, because the acidifying actions of the manurial treatments differed greatly. Soil reaction affects the yield, botanical and chemical composition of the herbage, and so limits comparisons of the nutrient effects of the manurial treatments. The soils of the ammonium sulphate plots, limed and unlimed, have a greater range of pH values than the sodium nitrate plots, and as most of them are also more acid, there is but little overlap of the pH ranges of the two groups of soils. The smallest difference in soil reaction between plots receiving these two forms of fertiliser N, but otherwise similarly manured, is 0·7 pH unit (pH 5·3 and 6·0) and is too large to compare ammonium and nitrate fertilisers satisfactorily. Comparisons of the different amounts of ammonium sulphate are also restricted to very acid soils.

The present liming scheme fails to indicate the best pH for grass or grass–legume herbage; nor does it give a good estimate of the lime needed to maintain a given pH for any of the manurial régimes in the experiment. Further, the acidification of neutral grassland soil by ammonium sulphate is expected to be less than with a neutral arable soil, because the fertiliser is applied close to the grass roots, and the ammonium is rapidly taken up by the crop, giving little opportunity for nitrification. On very acid grassland the acidification might be still less without nitrification. None of these expectations can be tested by the experiment in its present form. In addition to the large differences in the existing pH values between many of the plots, some of the plots are gradually becoming more acid (nearly 1 pH unit during 1923–59), others less acid by nearly the same amount. Long-term averages for yield therefore include the undetermined effects of these changes. Even averages for periods of 10 years may partly depend on the change in soil reaction if there are critical pH values for growth and botanical composition of the herbage or for reactions between plant nutrients and soil.

In the second current liming scheme on plots 18, 19, 20 neither of the laboratory methods succeeded in predicting lime requirement. The amounts needed were underestimated and some of the lime dressings were much too small. Even after repeating the prescribed dressings 10 times (every fourth year during 1920–59) two of the soils were slightly acid (pH 6). Success or failure of such laboratory methods is determined by the results from one application, and no further useful information can therefore be expected by continuing the test.

To provide new and more precise information on the effect of lime, the

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new liming scheme will replace the fixed rate of lime on the main block of plots. The test of laboratory methods for lime requirement on plots 18, 19, 20 will be stopped and plot 18 will be included in the new scheme. The pH of plots 19 and 20 will be maintained at their present values.

The new liming scheme will apply to all plots from plot 1 to plot 18 except 5/1, 5/2, 6, 12 and 15. Plot 15 is omitted because it received different manuring in the very early years (1858–75) and because its present treatment is represented in the new scheme by plot 7 (P K Na Mg), where the manuring has not changed since the experiment started. The other exceptions were never in the current liming scheme, and there seems no need to bring them into the new one. They will be more gainfully used for other problems arising from the recent review of the experiment, problems that are likely to need special treatments incompatible with the new liming scheme or with the management of the main block of the experiment. Plot 18, one of the plots in the second current liming scheme, is included in the new scheme because it will add a useful manurial treatment (N_2 K Na Mg). This plot was omitted from the main discussion of results in the Report for 1963, because the lime treatments differed from the main block and major changes in manuring were made in 1905. Before then, the plot received a small dressing of superphosphate (8–9 lb P_2O_5/acre) each year but none since. Sub-standard amounts of N and K fertilisers were also given. A large proportion of the added P was removed in the crops during the early period and judged by recent soil analysis the remainder was taken up in later crops. The plot can now therefore be used as a no P plot but receiving the other nutrients (N_2 K Na Mg) at standard rates. It is important to remember that although the N and K dressings are now standard, they were much smaller before 1905. The small amount of K given for 40 years (32 lb K/acre but now 200 lb K) is particularly relevant in comparisons of the soil K in this plot with plots that received the standard amounts since the beginning of the experiment.

The new liming scheme is designed to establish and maintain the same set of soil reaction values for all manurial treatments. It also provides for continuity of the existing experiment. The present fixed rate of liming will be replaced by differential liming, and it will then be possible to compare at several pH values the yield, botanical and chemical composition of the herbage for all manurial treatments. The change in liming will also provide estimates of the lime needed to maintain a given pH value. It will produce a better series of soils under permanent grass for studying reactions between plant nutrients and soil and the contributions made by organic matter and clay to soil acidity.

The objectives of the new scheme require more liming treatments than in the present experiment, and to accommodate them the existing limed and unlimed sections will be halved to give subplots *a* and *b* on the limed section and subplots *c* and *d* on the unlimed. Although further division would give more pH values, some of the main plots (limed + unlimed) are only 0·16 acre, and the subplots would be too small to study changes in botanical composition of the herbage, unless appropriate replication could also be introduced. Where the scheme requires greater acidity on subplots it will be achieved relatively quickly where ammonium sulphate is applied,

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but for other manurial treatments the extra acidity will develop slowly by allowing the present drift to continue. Increases in pH on other subplots will come quickly after liming, but there will be an unavoidable pH gradient down the profile, probably for several years in the top 9 in. of soil, and the subsoil will only slowly become less acid.

Subplots *b* and *c* are to be limed to give pH values of 6 and 5 respectively. Subplots *a*, which are to be maintained at present pH values, are half-way through the current 4-year liming cycle, and maintenance dressings will therefore be deferred for 2 years. Subplots *d* will be allowed to develop "maximum acidity", which for the Park Grass surface 0–9 in. is pH 3·7–3·8, the current value now on most of the ammonium sulphate plots. Subplots *a* and *d* provide the continuity of the present Park Grass experiment. The liming treatments are an initial dressing of ground chalk to bring the surface soil (0–9 in.) to the required pH, followed by maintenance dressings applied every second year. The initial dressings were determined from titration curves with $Ca(OH)_2$ solution. In the calculation of the dressings a "field factor" was not used, but the acidity of the mats on the ammonium sulphate plots was allowed for. Table 2 shows the initial dressings of ground chalk to be applied in January 1965.

TABLE 2

Initial chalk dressings, Park Grass, January 1965

Tons $CaCO_3$/acre

	Subplot			
Plot	*a*	*b*	*c*	*d*
1	—	—	2½	—
2	—	—	—	—
3	—	—	—	—
4/1	—	—	—	—
4/2	—	1	4½	—
7	—	—	—	—
8	—	—	—	—
9	—	2	3½	—
10	—	1	4	—
11/1	—	5	4	—
11/2	—	3	4	—
13	—	—	1	—
14	—	—	—	—
16	—	—	—	—
17	—	—	—	—
18/1 + 3	—	—	2	—

If after two years these amounts were not enough to establish the correct pH values supplementary dressings will be applied. The maintenance dressings will be based on subsequent changes in soil reaction.

The Saxmundham Experiments

By G. W. Cooke

Long-term experiments began in 1899 on land sited a mile west of Saxmundham in East Suffolk. They were controlled by a sub-committee of the Education Committee of the East Suffolk County Council and supervised

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