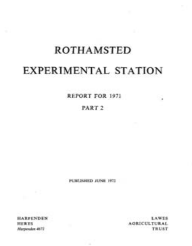
Rothamsted Experimental Station Report for 1971 Part 2



Full Table of Content

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Changes in Soil Properties Caused by the New Liming Scheme on Park Grass

A. E. JOHNSTON

In reviewing the Park Grass experiment, Warren and Johnston (1964) suggested it would be improved by additional treatments with lime; Warren, Johnston and Cooke (1965) detailed the proposed changes. The Park, for long in grass, never received the large dressings of chalk given to arable land on Rothamsted Farm and the soil was already slightly acid when Lawes and Gilbert started the experiment in 1856. The acidifying action of the manurial treatments differed greatly and, together with the effects of two tests of liming started in 1903 and 1920, with dressings applied every four years, had caused large differences in soil pH by 1959. Because botanical composition of the sward was affected both by soil reaction and manuring, yield and chemical composition were also affected and the comparisons between the nutrient effects of the treatments were of limited value.

The new liming scheme

The new liming scheme begun in 1965 was proposed to establish and maintain soils with pH values near to 7, 6, 5 and 4 on sub-plots (now called *a*, *b*, *c* and *d*) of most of the treatments. Where the scheme required greater acidity on sub-plots this was intended to be achieved by the present manuring, relatively quickly where ammonium sulphate was applied, more slowly with the other treatments. On sub-plots where acidity was to be lessened, chalk dressings were to be given but not incorporated by mechanical cultivations. Because we did not know how the very large dressings of chalk to be given on some sub-plots would affect the various plant species, we decided to delay increasing the soil reaction of the *a* sub-plots to pH 7. Instead, we planned to maintain continuity with the old liming scheme by keeping the soils of the *a* sub-plots at the pH values they had in 1959. The future of the *a* sub-plots will be decided when we know the effects of increasing the pH of the *b* sub-plots to 6. The amount of chalk needed was determined by titrating the soils with saturated calcium hydroxide in 2% sucrose solution at a soil : solution ratio of 1 : 2·5 (Smith & Coull, 1932). This method was also used to determine the lime requirement of the 'mats' of partially decomposed vegetation on the ammonium sulphate plots, except that a soil : solution ratio of 1 : 5 was used. In calculating the dressings no 'field factor' was used; (most advisers use a factor to convert laboratory estimates of the $CaCO_3$ needed to field dressings likely to have the same effect on soil pH). The amount of chalk was rounded to the nearest 10 cwt/acre, here converted to the nearest 0·1 t/ha.

The first dressings of ground chalk were given during January 1965. More were given to sub-plots with 'mats' in January 1967 and to all sub-plots in January 1968, both sets of dressings were half the amounts given initially in 1965. Soil samples were taken in January and November 1967, January 1970 and November 1971. Where there was a 'mat', this was removed and soil samples taken from all sub-plots at 0 to 7·5, 7·5 to 15 and 15 to 22·5 cm deep in the mineral soil.

Results

Table 1 shows pH values of the 'mats' and of the mineral soil in autumn 1959, 1967 and 1971, together with amounts of each chalk dressing applied. The sub-plots can be

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Table 1

Amounts of chalk applied in the new liming scheme on Park Grass and the pH (in water) of successive horizons of the soil profile sampled in November 1959, 1967 and 1971

Plot number	pH, November 1959				Chalk applied t/ha		pH, November 1967				Chalk applied t/ha	pH, November 1971			
	'mat'	horizon* 1	2	3	1965	1967	'mat'	horizon* 1	2	3	1968	'mat'	horizon* 1	2	3
Sub-plots without a 'mat' and soil pH intended to be 6															
4/2*b*	—†	6·0	5·7	5·3	2·5	0	—	6·1	5·5	5·4	1·2	—	6·5	6·3	5·8
9*b*	—	5·5	5·2	5·1	5·0	0	—	5·9	5·2	5·0	2·5	—	6·5	5·7	5·2
10*b*	—	5·8	5·5	5·4	2·5	0	—	6·2	5·4	5·1	1·2	—	6·3	6·2	5·7
mean	—	5·8	5·5	5·3			—	6·1	5·4	5·2		—	6·4	6·1	5·6
Sub-plots with a 'mat' and soil pH intended to be 6															
11/1*b*	5·5	4·2	4·1	4·4	12·5	6·2	6·3	5·4	4·3	4·4	6·2	6·4	4·9	4·6	4·6
11/2*b*	5·2	4·7	4·5	4·6	7·5	3·8	6·4	5·8	4·9	4·6	3·8	—	6·5	6·2	5·6
Sub-plots without a 'mat' and soil pH intended to be 5															
13*c*	—	4·7	4·6	4·9	2·5	0	—	5·2	4·8	4·8	1·2	—	5·8	5·2	5·2
Sub-plots with a 'mat' and soil pH intended to be 5															
1*c*	3·8	3·7	3·9	4·4	6·2	3·1	5·8	4·0	3·9	4·2	3·1	6·7	4·7	4·3	4·5
4/2*c*	3·7	3·6	3·7	3·9	11·2	5·6	5·3	3·8	3·7	4·0	5·6	6·3	4·7	4·2	4·3
9*c*	3·7	3·4	3·8	4·0	8·8	4·4	5·6	4·0	3·9	4·1	4·4	6·2	4·4	4·1	4·2
10*c*	3·9	3·4	3·7	4·1	10·0	5·0	5·2	3·9	3·9	4·0	5·0	6·4	5·0	4·2	4·2
11/1*c*	3·7	3·6	3·6	3·8	10·0	5·0	5·9	3·8	3·8	3·8	5·0	6·3	4·2	4·0	4·1
11/2*c*	3·7	3·5	3·7	4·0	10·0	5·0	5·7	3·8	4·2	3·5	5·0	6·5	4·2	4·0	4·2
18*c*	3·9	4·2	4·0	4·1	5·0	2·5	4·8	3·9	4·0	4·1	2·5	6·3	4·4	4·2	4·4
mean	3·8	3·6	3·8	4·0			5·5	3·9	3·9	4·0		6·4	4·5	4·1	4·3

* Horizons 1, 2 and 3 = 0 to 7·5, 7·5 to 15 and 15 to 22·5 cm depth of soil.
† — shows there was no 'mat'.

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divided into four groups, depending on whether or not there were 'mats', and the pH values required.

Sub-plots without a 'mat' and soil pH intended to be 6. There were three sub-plots in this group. Table 1 shows that the first dressing of chalk, 2·5 or 5·0 t/ha, had changed the soil reaction little by autumn 1967 and further dressings, 1·2 or 2·5 t/ha, were applied in January 1968. By autumn 1971 the top 7·5 cm of soil was more alkaline than intended, whereas the third depth was slightly more acid. No more chalk will be applied to these sub-plots until the soil 15–22·5 cm deep has pH 6.

Sub-plots with a 'mat' and soil pH intended to be 6. There were only two sub-plots, 11/1*b* and 11/2*b*, in this group. The first dressing of chalk, 12·5 t/ha on sub-plot 11/1*b* and 7·5 t/ha on 11/2 *b* had raised the pH of the 'mat' by about 1 unit by early January 1967, but the pH of the mineral soil had changed little. A further dressing of chalk, half as much as the first, was given in January 1967. By autumn 1967, the pH of the 'mat' showed little further change, but the pH of the soil 0 to 7·5 cm deep had increased by about 1 unit. The pH of the next two depths had changed little. A third chalk dressing, equal to the second, was applied in January 1968. Table 1 shows that, on both sub-plots 11/1*b* and 11/2*b*, soil pH at the various depths had changed similarly up to 1967. In January 1970, the 'mat' had disappeared from sub-plot 11/2*b* and pH of the 0 to 7·5 and 7·5 to 15 cm depths of soil had increased to 6·6 and 5·5 respectively. Sub-plot 11/1*b* still had a 'mat' and the pH at each depth of mineral soil had not changed, the 0 to 7·5 and 7·5 to 15 cm depths were pH 4·7 and 4·2 respectively. A possible explanation of these results, confirmed by the 1971 sampling (Table 1), is discussed later.

Sub-plots without a 'mat' and soil pH intended to be 5. Sub-plot 13*c* was the only one in this group where acidity had to be lessened. The initial dressing of chalk, 2·5 t/ha, increased the pH of the 0 to 7·5 cm depth of soil to just over 5. There was little change in pH of the other two depths at either sampling in 1967. A further dressing of 1·2 t/ha chalk in January 1968 increased pH of all three depths, to 5·8, 5·2 and 5·2 respectively. The 0 to 7·5 cm depth of soil is now a little less acid than was intended, and no more chalk will be applied until pH is below 5.

Sub-plots with a 'mat' and soil pH intended to be 5. This was the largest sub-group because so many plots in the main experiment received ammonium sulphate, and many of the half plots that were unlimed between 1856 and 1959 were more acid than 4·2; they also had 'mats'. Sub-plots at pH 5 were to be established on these half plots and the estimated lime requirements (without a 'field factor') were from 6·2 to 11·2 t/ha of chalk. By January 1967 these large dressings had increased the pH of the 'mats', but only on sub-plots 9*c* and 10*c* had the 0 to 7·5 cm depth of mineral soil become less acid. A second dressing of chalk, half as much as the first, was applied in January 1967; by November 1967 the pH of the 'mats' had increased by between 1 and 2 units. A third dressing of chalk, equal to the second, was applied in January 1968. By 1971 the 'mats' all had pH above 6 and the 0 to 7·5 cm depth of mineral soil was more than 0·5 unit less acid than in 1959. Because the 'mats' are now too alkaline, whereas the mineral soils are still too acid, no more chalk will be given for the present.

Discussion

This new liming scheme, started in 1965, has already shown how slowly soil pH changes, even in the 7·5 to 15 cm depth, when grassland is undisturbed and percolating water has

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to take calcium down the profile. All sub-plots have so far received more chalk than the laboratory determination of the lime requirement showed was necessary for the soil to reach the required pH. Only on one sub-plot, 13*c*, is the soil at all three depths, 0 to 7·5, 7·5 to 15 and 15 to 22·5 cm, now at the intended pH or is more alkaline. The dressing used was 50% more than lime requirement estimated in the laboratory, suggesting that a 50% 'field factor' is too much. Results from those sub-plots without 'mats', which are intended to achieve pH 6, will give more relevant information. Results on those sub-plots with 'mats', where so far the chalk dressings have been twice the lime requirement, are especially interesting. Changes in soil pH have been almost entirely confined to the 'mats', with the single exception of sub-plot 11/2*b* where the mineral soil rapidly became less acid as soon as the 'mat disappeared'. Pratt and Grover (1964) established that divalent cations are absorbed much more strongly by exchange sites in organic matter than in clay. Possibly the added calcium has been absorbed on exchange sites in the 'mats' on Park Grass and held there against leaching. When the 'mat' has been oxidised, the calcium, no longer retained at the surface, will be leached down the profile and make the mineral soil less acid. No more chalk will be applied to plots with 'mats' until we know what changes will occur in the pH of the mineral soil after the 'mat' disappears.

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