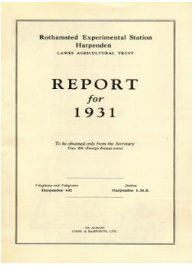
ROTHAMSTED RESEARCH

Report for 1931

Full Table of Content



Fertilisers on Grassland

Rothamsted Research

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REPORT ON THE WORK OF THE ROTHAMSTED EXPERIMENTAL STATION DURING THE SEASON 1931

The purpose of the work is to obtain information about the soil and the growing plant, and to put this information in a form in which agricultural experts and good farmers can use it. The work is done partly in the laboratory, partly in the pot culture house, and partly on the two experimental farms, the heavy land at Rothamsted and the light land farm at Woburn.

Broadly speaking, the laboratory work is concerned with the acquiring of information, while the field work aims at testing the applicability of this information on the farm and also at finding solutions for important practical problems of present-day agriculture.

THE FIELD EXPERIMENTS

The Conferences held at Rothamsted, and the visits made by members of the Staff to farms in different parts of the country, show that certain general problems are of great importance to large numbers of farmers : these are studied in the field.

(1) The most efficient use of artificial fertilisers on grass and arable land.

(2) The provision of keep for animals when grass supplies fall short.

(3) The maintenance of soil fertility in regions where mechanization is advancing and live stock is being reduced.

THE EFFICIENT USE OF FERTILIZERS

I. Grassland

Our earlier investigations have shown that the full value of fertilizers on grass land is obtained only when the grass is properly used. Seeding, manuring and management are closely connected ; we shall therefore describe all the grassland work in this section.

The older Rothamsted experiments dealt only with the manuring of grass for hay ; in 1921, however, experiments were begun on the phosphatic manuring of grazing land in Great Field, the results being expressed as live weight increase of the sheep in accordance with the method of the late Sir William Somerville. These experiments* showed that the method, while giving striking results on poor land such as that of Cockle Park, was quite unsuited to land in better condition. It is liable to serious errors arising from differences in the sheep themselves and differences in rate of stocking, and in our

* Report 1923-4, p. 21 ; Report 1925-6, p. 25 ; Report 1927-8, p. 33.

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experience it can work only on poor land capable of considerable improvement: land, for example, which without manure will produce only about 50 lb. live weight increase of the sheep per acre during the season while after manuring it will produce 75 or even 100 lb. per acre. On more normal grass land, producing some 150-200 lb. live weight increase during the season, the method fails; we accordingly gave it up in 1929.

In later experiments we have used instead the method designed by the late T. B. Wood of Cambridge. The grass is cut repeatedly during the growing season and the separate cuttings are weighed and analysed. This reproduces part of the effect of the animal, but not all; it removes the grass but returns no manure. In spite of this weakness, however, the method has been found to give useful results.

The more recent experiments on grass land fall into three groups, dealing respectively with the laying down to grass, the manuring and treatment of the grass, and the utilisation of the grass.

1. *The laying down to grass.* Up to 1925 there was only one grass field on the farm, Great Field, which had been laid down in the 1870's, a small grass field, New Zealand (7½ acres) laid down in 1907 having been broken up during the war, in 1915*. In 1925 we sowed down Little Knott (10½ acres), and in 1928 other fields also, thereby considerably altering the distribution of the land on the farm.

The areas are:

	Before 1925.	1928 to present time.
Arable	225	122½
Grass	27½	130
Roads, buildings and enclosures . .	27½	27½
Total	280	280

In the sowing down various mixtures were used, some with indigenous and some with commercial strains; various previous treatments were also given. By reason of our heavy head of stock —220 breeding ewes (half-bred, Cheviot ewe by Border Leicester ram), producing 340 lambs; some 60 head of cattle (mostly young), and some 25 breeding sows (mostly Wessex Saddleback)—it is possible to graze the land thoroughly, and the management has been consistently good. At first the herbage on each of the different areas had its characteristic appearance, but under similar treatment these differences began to lessen, and now, 4 years after sowing, the general type of herbage is much the same on all the grassland whatever the original seeding. On Sawyer's field six widely different mixtures were tested, yet the herbage is now fairly similar on all the plots. Rye grass and wild white clover form about 70 to 80 per cent. of the whole; the rest is chiefly cocksfoot, now 15 to 20 per cent. on all plots, though the original seeding of 5 to 10 lb. per acre had corresponded to a variation from 15 to 40 per cent. of the numbers of seed sown. Timothy forms about 5 per cent. of the herbage. The actual figures vary from spring to autumn and from season to season, but the order is the same. Of the other plants sown little survives beyond some red clover. (Table I.)

* See Report for 1915-17, p. 9.

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TABLE I.—Comparison of weights of seed sown with percentage area now occupied by the various groups of plants.

†*Composition of Mixtures Sown* 1928. *lb. per acre.*†

Mixtures.	I.	IV.	V.	VI.	VII.	VIII.
Grasses	24	30.5	40	29	29	27
Clovers	4	5	1	5	7	5
Miscellaneous ..	2	—	—	2	—	—

Percentage area now occupied by the various groups.

	1931—*Spring.*					
Mixtures.	I.	IV.	V	VI.	VII.	VIII.
Grasses	55.4	49.4	50.7	51.6	46.1	54.0
Clovers	40.1	45.0	40.9	41.9	48.5	39.6
Weeds	0.1	0.2	0.1	0.2	—	0.2
Chicory	—	—	—	0.7	—	—
Bare Space ..	4.4	5.4	8.3	5.6	5.4	6.2

	1931—*Autumn.*					
Mixtures	I.	IV.	V.	VI.	VII.	VIII.
Grasses	35.15	31.6	16.3	40.2	44.5	35.7
Clovers	64.05	67.5	82.3	55.1	54.95	64.0
Weeds	0.1	0.3	0.3	0.05	0.1	—
Chicory	0.2	—	—	4.6	—	—
Bare Space ..	0.5	0.6	1.0	0.05	0.45	0.3

	1932—*Spring.*					
	I.	IV.	V.	VI.	VII.	VIII.
Grasses	62.6	40.65	37.45	60.2	43.6	48.3
Clovers	35.5	57.05	58.73	37.5	54.6	49.7
Weeds	0.2	—	—	0.05	0.3	—
Chicory	0.1	—	—	0.35	—	—
Bare Space ..	1.6	2.3	3.62	1.9	1.5	2.0

† For percentage numbers of seeds of the different plants see Report for 1929, p. 24.

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in the next. The gain in protein may be considerable, much greater than the gain in dry matter; superphosphate gave the following increases in the first year in grass laid in for hay:

Percentage gain in—

	Dry Matter.	Protein.	Phosphoric Oxide P_2O_5.
Braintree (1930)	42	102	97
Northallerton (1931) ..	47	78	195

These results depend entirely on the solubility of the phosphate. In the first year after application water soluble phosphate is most effective, so that superphosphate comes out best. Citric soluble phosphate comes next, hence high soluble basic slag is second. Mineral phosphate and low soluble basic slag are less effective. The value of mineral phosphate as compared with the others changes a good deal according to soil and season. In the drier conditions of Hertfordshire and the Eastern counties it came a long way behind high soluble slag and was very similar to low soluble slag; in the moister, warmer conditions of Devonshire it acted more like high soluble slag and was much superior to the low soluble slag.

In the second year the high soluble basic slag did better than superphosphate at several of the centres, both on the hay land and on the grass repeatedly mown, though it has not yet caught up with superphosphate. At the Devonshire centre mineral phosphate acted as well as high soluble slag, though it is still behind on the two years' programme, but the low soluble slag showed no sign of improvement.

The experiment is being continued to see what happens in the third and fourth years.

Soluble phosphates (both water soluble and citric soluble) increase the amount of phosphoric oxide (P_2O_5) in the herbage by some 50 or 60 per cent.; sometimes as at Northallerton, by much more; and of course this improves its value for forming bone and building up the animal's frame. The amounts involved are, however, only small, and in none of these experiments has much of the added phosphate been recovered in the herbage; at two of the centres the results have been:

Percentage of added P_2O_5 recovered in repeatedly mown herbage.

	Mineral Phosphate.	Low soluble Slag.	High soluble Slag.	Super
Dartington, 1st year ..	4	1	8	11
,, 2nd ,, ..	12	—1	11	10
,, both years	16	0	19	21
Much Hadham, 1st year	3	4	14	17

Here, again, the difference between low soluble and high soluble slags is well shown.

Low soluble slag has given poor results in practically all of our

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of nitrogenous manure so far studied, and also for mixtures of cereals with leguminous plants such as are used for fodder mixtures. On the grass land the increased growth is obtained chiefly in spring ; in summer and autumn the increase is less, or it may even vanish.* The effect of reducing the leguminous plants is to cut down the protein content of the whole herbage so that the net gain of nitrogen by the whole crop is only small. Non-leguminous crops usually recover 50 per cent. or more of the nitrogen added in the manure, and the recovery is increased by giving a complete fertiliser ; grass land herbage, on the other hand, shows a much smaller recovery—on the Park grass hay plots our highest figure is 37 per cent., when sulphate of ammonia only was given—and the recovery is decreased by using complete fertilisers, it may then fall as low as 14 per cent.

Recovery of added nitrogen in the hay.
Park grass first 18 years.†

Source of nitrogen.	*Other manures.* None.	Phosphate and Potash.
Sulphate of Ammonia ..	37	20
Nitrate of Soda	35	14

For fodder mixtures the recovery was even less ; in some experiments‡ it was even nil.

As against these, the figures for the recovery of nitrogen by non-leguminous crops grown singly are :

Cereals 40—50
Mangolds 60—70
Potatoes 50—70‖

In contradistinction to mixed grass and leguminous herbage the recovery of nitrogen is increased by adding potassic and phosphatic fertilisers. When nitrogenous fertilisers are dear they are not very suitable for grazing land unless special precautions are taken to keep the grass young and leafy by frequent and intense rotational grazing. Otherwise the small amount of nitrogen recovered and the depressing effect on the clover are serious disadvantages.

The increase in amount of early growth brought about by nitrogenous fertilisers has the great advantage that it enables the spring grazing to start earlier than would otherwise be possible, and this may often be a great convenience, especially if supplies of roots, silage or other succulent foods have given out—as not infrequently happens. When nitrogenous fertilisers are as cheap as at present they may advantageously be used for accelerating the early grazing whenever this is needed.

Effects of Phosphatic Manures. Phosphates, unlike the nitrogenous fertilisers, increase the proportion of clover in the herbage, and so add greatly to its protein content. This increase is not confined to the spring months, as happens with nitrogenous fertilisers ; it is maintained throughout the season, and is continued

* Summer manuring has not yet been studied.
† In this period complications due to change in reaction were not serious.
‡ Report for 1930, p. 36 ; the results were confirmed in 1931.
‖ For details see Artificial Fertilisers Bull. 28, Ministry of Agriculture, pp. 15-18.

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This tendency towards uniformity of herbage comes about for two reasons : species which are unsuited to the conditions soon die ; and those which, while well enough suited, cannot stand up against competition, are soon crowded out. In order to obtain further information on this important subject, experiments were started by A. R. Clapham and F. J. Richards, in 1928, and developed later by D. J. Watson. These experiments show that Italian rye grass reduces the growth of perennial rye grass mixed with it, perennial rye grass reduces the growth of cocksfoot, cocksfoot reduces the growth of timothy, and timothy reduces the growth of rough stalked meadow grass ; in Clapham's phrase the grasses acted as " aggressors " in this order. The order varied somewhat with season ; in another year timothy was more " aggressive " than cocksfoot. Watson has extended the observations by introducing clover (late flowering red) and varying the manurial treatments. He finds that the heaviest yield per unit area is obtained by seeding with rye grass and giving a complete manure ; if, however, alternate plants of rye grass are replaced by cocksfoot or by clover, the remaining rye grass plants grow much bigger, though the other plants grow much smaller than if they were alone and the total weight of all the herbage per unit area is reduced. In other words, a plant of rye grass suffers less from the competition of a plant of cocksfoot or clover (Montgomery late flowering red) than it does from the competition of another plant of rye grass. The effect of omitting phosphate from the manuring, however, is to cut down the aggressiveness of the grasses considerably, leaving the clover freer to develop ; the omission of potash from the manuring proved a greater handicap to the clover. (Table II.)

TABLE II.—Mean yield of dry matter in grms. per square foot.

Seedings.	*Manurial treatments.*				
	Complete Manure.	No N.	No P.	No K.	No Manure.
Ryegrass	68.8	40.3	46.4	45.1	39.2
Cocksfoot	46.4	46.9	33.4	39.0	23.7
Clover..	38.6	34.1	30.3	25.6	24.6
Ryegrass and Cocksfoot ..	52.7	62.8	45.5	65.1	37.0
Ryegrass and Clover ..	62.2	43.3	31.1	43.6	37.7
Cocksfoot and Clover ..	41.3	36.9	29.8	48.2	30.8

In the experiments just described the plants were allowed to complete their growth ; they were neither grazed nor mown. This same order of aggressiveness, however, is indicated by the final state of the herbage in the different fields : rye grass, the most aggressive, dominates the rest ; among the grasses cocksfoot comes next ; then timothy and the others come a long way after or not at all. In other circumstances other grasses, Yorkshire fog, agrostis, sheeps' fescue, become more " aggressive " and may dominate the herbage.

2. *Manuring of Grass Land.*

The experiments on the manuring of grass land have led to some important results. Nitrogenous manuring has increased the growth of grass but depressed the growth of clover. This holds for all forms

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TABLE I (continued)—Percentage Botanical Composition.

1930—*Spring.*

	I.	IV.	V.	VI.	VII.	VIII.
Perennial Rye ..	77.5	57.4	61.7	—	—	} 53.7
Italian Rye ..	—	—	—	49.2	57.5	
Cocksfoot ..	3.3	13.4	17.3	15.5	12.6	18.7
Timothy	4.9	8.8	0.7	4.8	9.4	5.1
Fescue	0.3	—	—	3.2	1.4	2.7
Agrostis	0.2	—	—	—	—	—
Red Clover ..	2.1	6.6	0.2	5.2	6.4	6.6
Wild White Clover	6.6	5.6	2.9	11.2	5.5	5.4
Trefoil	—	—	—	—	0.7	—
Chicory	1.4	—	—	5.3	—	—
Weeds	1.4	3.5	2.2	1.7	1.0	2.7
Bare Space ..	2.4	4.7	15.0	3.9	5.5	5.1

1930—*Autumn.*

	I.	IV.	V.	VI.	VII.	VIII.
Perennial Rye ..	44.6	35.3	43.4	—	—	} 30.1
Italian Rye ..	—	—	—	23.8	25.9	
Cocksfoot ..	8.4	21.1	18.6	19.9	16.2	21.7
Timothy	2.1	4.2	0.5	1.5	7.5	4.7
Fescue	0.2	—	0.1	8.6	—	0.9
Agrostis	1.3	—	—	0.1	0.1	—
Red Clover ..	8.1	12.2	0.7	8.9	7.7	14.1
Wild White Clover	28.6	22.0	29.5	31.1	35.5	22.6
Trefoil	—	—	—	—	—	0.7
Chicory	3.4	—	—	2.6	—	—
Weeds	1.2	0.1	0.4	0.6	0.2	0.3
Bare Space ..	2.1	5.1	6.8	2.9	6.9	4.9

For previous measurements see Report for 1930, p. 44 and for 1929, p. 24.
For particulars of seeding see Report for 1928, p. 101.

The most obvious difference between one mixture and another has been that Italian rye grass has persisted as the dominant grass where it was sown without perennial rye grass; otherwise little difference between cheap mixtures and dearer mixtures persisted by the end of four years. It seems clear that, if the farmer is to recover the extra money spent on costly mixtures he must do it within the first few years, or he may never do it at all.

In the intervening years there were differences in yield and composition of the herbage, and in the density of the plants on the ground. The mixtures were sown on April 25th, 1928; in July, 1929, only about 70 per cent. of the land was covered with vegetation, the remaining 30 per cent. being bare; by the spring of 1930 the bare space was reduced to about 5 per cent. The figures were much the same for all the mixtures. Variations in previous treatment, however, caused considerable differences. West Barn, sown on August 29th, 1928, and therefore very late, and Great Knott (A) (S.E. part), sown on May 29th, 1928, on weedy land and without a cover crop, have both been slower in filling up.

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experiments, especially in the South Eastern Counties. It is said to be more effective in acid soils in Scotland and in the North of England, and if this be so it might be attributed as much to the lime as to the phosphate. Precise comparisons are difficult to make, but the lime value of slag approaches that of an equal amount of ground limestone. There may also be an advantage in supplying lime and phosphate together ; at any rate, on some acid soils phosphates rapidly lose their availability as the result of chemical reactions in the soil.

HOME-GROWN FOOD FOR ANIMALS

Several methods are studied for providing *keep for animals* when grain supplies fall short.

Fodder Mixtures. Mixtures of leguminous and cereal crops are grown (e.g. vetches, barley, beans), cut green, converted into hay or silage, or allowed to ripen for use as straw and crushed grain. These crops are cheap and easy to grow ; they keep down weeds, and they have proved of great value as food stuffs because of this elasticity in use ; no other crops can be consumed in such a variety of ways. The manuring of a mixture, however, differs from that of a single crop because the element of competition comes in. The crops grown without manure, or with potash or phosphate only, are rich in protein and starch equivalent ; they make excellent feeds. Nitrogenous manures, such as sulphate of ammonia and nitrate of soda, increase the growth of the cereal considerably, but reduce the vetches and peas ; the total weight of crop per acre is greater, but the feeding value is entirely changed. The new crop contains no more protein, but more starch equivalent per acre ; it resembles hay of moderate quality.

Several different mixtures are being sown at different times of the year to see how far it is possible to arrange for a sequence of these crops suitable for the needs of a flock master, a dairy farmer, or a crop-drying apparatus.

Lucerne. The work on inoculation of lucerne is continuing, and search is being made for new strains of organisms more efficient than the one at present being distributed to farmers. These experiments have revealed great differences in effectiveness between different strains occurring in different soils ; none, so far, is as good as the one we use. But the smallness of the number so far studied gives us grounds for hoping that our search may be rewarded by the discovery of one that is far better.

Nitrogenous manuring proved ineffective in pot experiments to raise the yield of lucerne grown by itself, and it lowered the yield of lucerne grown with grass, besides depressing the formation of nodules, apparently by reducing the root development. The protein content of the mixed herbage was decreased by the nitrogenous manure.

Sales of cultures to farmers have again exceeded all records, amounting to over 9,000 during the season, enough to inoculate over 4,500 acres.

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