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Report for 1933

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The Field Work

Rothamsted Research

Rothamsted Research (1934) *The Field Work* ; Report For 1933, pp 20 - 30 - DOI:
<https://doi.org/10.23637/ERADOC-1-3>

generously installed at Dr. Mann's expense, has greatly facilitated experimental work. To an increasing extent investigations involving costly and highly specialised apparatus are made not at Rothamsted, but at the Institution best equipped for the purpose, it being found easier and altogether more effective and economical to move the worker or the work than to set up and learn how to use the very costly appliances modern science now demands. Investigations involving X-ray photography are done in association with the Royal Institution and the Textile Physics Department of the Leeds University; vitamin examinations are made at the Sir William Dunn Field Laboratories, Cambridge; dough studies at the Milling Research Institute, St. Albans. One of the staff of the Physics Department is temporarily working at the Johns Hopkins University, Baltimore, using the elaborate high vacuum methods evolved by Professor Patrick. The help afforded by the Directors and Staffs of these various laboratories is exceedingly valuable, ensuring us the maximum of information for the minimum expenditure of time and money.

THE FIELD WORK

As usual during the past few years, the field work has centred round three main problems:

1. The value of organic manures as compared with artificial fertilisers;
2. The effects of artificial fertilisers on the yield and quality of crops; the modifications brought about by soil and seasonal conditions;
3. The processes of soil cultivation.

Organic Manures. So many farmers are now abandoning strict four- or five-course rotations, the feeding of sheep on arable land, and the winter-fattening of cattle in yards, that the supply of organic manure on the farm is much less than it used to be. The purpose of this work is to find out:

1. How the fertility of the soil is likely to be affected in consequence of these changes;
2. Whether the lack of organic manure can be made up in any other way;
3. What value can be put upon farmyard manure as a means of maintaining soil fertility over a long period.

Two rotation experiments have in recent years been started in which organic manure supplied in various ways is compared with artificial manures alone without any organic manure. The treatments include:

1. Straw made into farmyard manure in the old way;
2. Straw ploughed direct into the soil, along with artificial fertilisers;
3. Straw rotted artificially by the "Adco" process;
4. Artificial only, without addition of straw or of any organic matter.

The experiments are intended to run for a number of years, and are designed to bring out both the immediate and the long term effects. The first five-year period is now completed and the results are set out in the Yield Tables, but we prefer to await a longer time before discussing them.

Green manuring receives considerable attention as a practicable method of supplying organic matter to the soil. Our earlier experiments and those at Woburn show that it is very liable to prove ineffective on the light soils that it was especially intended to benefit, and the present experiments are designed to discover the causes of the failure and the best ways of overcoming them. On heavy soils more definite results have been obtained; mustard ploughed in at Rothamsted has proved an excellent preparation for wheat. But we do not know sufficient about it to be able to advise with certainty.

The ploughing-in of leys affords a simple method of increasing the supply of organic matter in the soil. Its effect is not easily assessed, because the simplest comparison in practice is against a fallow which is itself known to benefit considerably the succeeding crop. In 1933 the yield of wheat following fallow was greater than after any ley, the yield following clover came next, then came the yield following rye grass and clover, while that following rye grass alone was the poorest, being no less than 14 cwt. of grain and 23 cwt. of straw below that following the fallow. The wheat yields after leys cut twice were less than those after leys cut once and then bastard fallowed; the loss due to the second cutting of the rye grass leys amounted to 2.7 cwt. of grain and 6 cwt. of straw, though on the pure clover ley only the straw suffered, and not the grain, the straw being depressed 3.7 cwt. per acre.

The fallow was so beneficial that dressings of sulphate of ammonia gave no further increase in yield. After the once-cut leys sulphate of ammonia gave a small increase in straw (2 cwt. per acre) but none in grain. After the twice-cut leys sulphate of ammonia added 2.6 cwt. of straw and 0.9 cwt. of grain. Some of the barley in which the leys had been seeded down had received nitrogenous manuring; this increased the barley and affected the seeds ley, but had no effect on the following wheat.

There was an interesting difference between the effects of the fallow and the clover ley on the wheat crop. Both increased the yield of wheat as compared with rye grass, but in different ways: the fallow by increasing the number of ears per acre, and the clover by increasing the number of grains per ear. This difference may be associated with the time when the nitrogenous nutrients become available; the fallow acts like an early nitrogenous dressing in promoting tillering; the clover acts like a nitrogenous dressing that comes too late to increase the number of tillers, but not too late to increase the number of grains per ear.

Poultry Manure. The great increase in the number of poultry has caused a marked increase in the output of poultry manure and has led to many enquiries as to how best it can be used. Under the aegis of the Ministry of Agriculture an investigation into its manurial value has been started; the field experiments are being made not only at Rothamsted and Woburn, but on various other farms and market gardens. For ordinary agricultural crops it was last year usually inferior to artificials. For the market garden crops, onions and brussels sprouts, it was distinctly superior at some of the centres. More work is needed before any explanation can be given, but the results show that the manuring of market garden crops should not necessarily follow the same lines as that of farm crops.

A proper investigation, planned on modern lines, is clearly needed to find how best to deal with them.

THE EFFECTS OF ARTIFICIAL FERTILISERS ON THE YIELD AND QUALITY OF CROPS

The key experiments in this investigation are those on the classical plots at Rothamsted and Woburn and on the six-course rotation more recently established at both centres and intended to run for a long period of years. As, however, the effects of fertilisers are known to be modified by soil and season, numerous experiments are made also on good commercial farms in different parts of the country.

Barley. This work has hitherto been done in association with the Institute of Brewing. The Report of the ten years' experiments has now been published and is obtainable either from Rothamsted or from the Institute.

Sugar Beet. The sugar beet investigations are now made in association with the factory organisation and staffs. Owing to the slender resources hitherto available, the scale of operations has till recently been small. Last year, however, thanks to the co-operation of the factories, a much better scheme was put into operation. The first year's results were discussed at a Conference between the Rothamsted and the factory staffs; as the result a satisfactory experimental programme was drawn up and is now being carried out.

The general purpose is to test the effects of fertilisers at a number of centres, and to make chemical examinations of the soil as described later. Reference to the tables in the full Report shows that the response to fertilisers is less definite than that of potatoes or mangolds, and we do not yet know how to draw up proper recipes for the manuring of sugar beet. The crop, of course, requires manuring, but the ordinary methods seem often to be less effective than for other crops.

Part of the explanation may be in the fact that the sugar beet farms on which the experiments were made were above the average in productiveness. The average of yields on these plots was 11.5 tons per acre, while the average for the country was only 9.0 tons. It is possible that more definite responses would have been obtained on farms below the average in productiveness. This, however, is not the whole explanation.

The experiments at Rothamsted indicate that the subsoil plays an important part in the feeding of the sugar beet. In absence of dung, potassic and phosphatic fertilisers increased the yield of roots and the percentage of sugar, when ploughed in so as to get well down into the soil, to a greater extent than when drilled in the usual way. On the light soil at Woburn the result was reversed. This experiment is being repeated: the yields were too low and the standard errors too high for complete satisfaction.

Sugar beet differs from all other crops in the very high concentration of its root sap, and this cannot fail to modify in some way or other the translocation of sugar from the leaf. A physiological study of the growing crop is needed before the manurial problems can be fully solved.

The spacing of the rows is particularly important. So far as the experiments have gone, the closer the rows the better. At Rothamsted rows 10 inches apart gave 37 per cent. higher yield of roots than rows 20 inches apart; the sugar content was higher and the yield of sugar per acre was raised no less than 41 per cent. The yield of tops was higher also. This increase of sugar content of the root appeared only when the rows were less than 15 inches apart; between the 20-inch and the 15-inch spacing there was no difference.

At Woburn similar results were obtained: rows 10 inches apart gave 21 per cent. higher yield of roots than rows 20 inches apart and 24 per cent. more sugar per acre.

On the other hand, as shown last year, nothing was gained by giving more cultivation than is needed to keep down weeds.

There is clearly a great deal to be learned about the growth of the sugar beet crop. In our experiments the yields have varied from 6 to 16 tons per acre. The average yield over the country is too low to enable the industry to be self-supporting, and it is unreasonable to expect a subsidy to continue unless the fullest efforts are made to raise them.

Potatoes. These experiments, like those on sugar beet, are made not only at Rothamsted and Woburn, but also at a number of farms in various parts of the country. The results since the commencement of the series in 1927 up to and including 1933 were summarised by E. M. Crowther in a conference on Potato Growing at Rothamsted in February, 1934. Many of the experiments were simple 16- or 25-plot schemes, testing different amounts of superphosphate. More complex ones had 36 or 81 plots to test different amounts and combinations of nitrogen and potash, and a few had 27, 36 or even 162 plots to test all three nutrients.

The results are shown in Tables 1 and 2 for the experiments as a whole and also for a special group of highly organic fenland soils. Every experiment undertaken is included; there has been no selection or elimination.

TABLE 1.—Significant responses of potatoes to fertilisers.

Nutrient.	Soil.	Negative.	Insignificant.	Positive.
Nitrogen	Fen	—	2	11
	Others	—	3	16
	Total (32)	—	5	27
Phosphoric Acid ..	Fen	—	—	8
	Others	2	17	13
	Total (40)	2	17	21
Potash	Fen	—	5	9
	Others	—	14	8
	Total (36)	—	19	17
INTERACTIONS :				
N and P ₂ O ₅ .. ..	.. ..	1	9	6
N and K ₂ O .. ..	.. ..	—	19	4
P ₂ O ₅ and K ₂ O .. ..	.. ..	—	16	1

In 90 per cent. or more of the trials there was a definite response to sulphate of ammonia. Fenland soils, which are rich both in total and in available nitrogen, responded to sulphate of ammonia just as frequently as the mineral soils.

Each of 8 fenland soils responded to superphosphate, but only in 13 out of 32 trials did the mineral soils give significant responses to superphosphate. In two experiments superphosphate definitely reduced the yield. In three experiments on acid peat—"moss" soils in Lancashire—there was no phosphate response. It is clear, then, that fenland soils stand out quite distinctly from other soils in their need for phosphate, as is, of course, well recognised in practice.

In 36 potash trials one half gave definite responses, with some indication that fenland soils were more responsive to potash than mineral soils. In so far as the soils tested in these experiments were typical, they show that sulphate of ammonia is almost always effective and that superphosphate is effective on fenland soils. Superphosphate on mineral soils and potash on all soils are much less consistently successful in increasing yield. The experiments show that sulphate of ammonia and superphosphate quite often "interact positively," i.e. they frequently reinforce each other's effect. Thus in 6 out of 16 trials the response to either sulphate of ammonia or superphosphate in the presence of the other manure was significantly greater than in its absence. This harmonises with the striking effects of superphosphate on fenland soils, for these are known to be rich in available nitrogen. The "interactions," or reinforcements of effects of nitrogen and potash and of potash and phosphate were much less frequent. Positive significant effects were obtained 4 times out of 23 for nitrogen and potash, and only once in 17 trials for potash and phosphate.

The size of the response is shown in Table 2. In most of these experiments the standard error per plot was about 15 cwt. per acre, and a response of 1 ton per acre would be detected as significant in an experiment with 16 or 25 plots. The results are set out by showing the number of experiments in which the response in cwts. of potatoes per acre was from 0 to 10, 10 to 20, and so on.

TABLE 2.—Response of potatoes to fertilisers.

Response in cwt. per acre		Decrease		Increase.						
		20-10	10-0	0-10	10-20	20-30	30-40	40-50	50-60	Over 60
Nitrogen (0.4 cwt. Nitrogen per acre=2cwt. sulphate of ammonia)	Fen Soils	—	1	1	1	1	6	2	—	1
	All Soils	—	3	3	5	7	9	3	1	1
Phosphoric Acid (0.6 cwt. P ₂ O ₅ per acre=4.5 cwt. super)	Fen Soils	—	—	—	1	2	2	1	2	—
	All Soils	3	9	8	7	4	5	2	2	—
Potash (1.0 cwt. K ₂ O per acre =2 cwt. sulphate of potash)	Fen Soils	1	3	1	3	2	—	—	2	2
	All Soils	1	7	11	7	4	—	—	3	3

TABLE 4.—Marks for Quality of Steamed Potatoes (1929).

Cwts. K ₂ O per acre.	Woburn.	Rothamsted.	Cwts. N per acre.	Woburn.	Rothamsted.
0	32.6	28.5	0	34.4	29.2
0.5	33.6	29.5	0.3	33.3	29.3
1.0	34.5	29.6	0.6	32.9	29.1

The practical conclusion is that the quality is determined by soil and season, and yield by the fertiliser dressing. Quality is not likely to be affected one way or the other by a good scheme of complete manuring, and so the grower can aim at producing heavy crops without fear that the quality will suffer. This same result was obtained for barley.

Chemical analysis shows consistent changes in composition produced by fertilisers which, however, are small and nothing like so marked as those obtained on the same soil in different seasons. The amount of dry matter in the fresh tubers was but slightly affected by sulphate of potash but somewhat reduced by potassic fertilisers containing chlorine, *e.g.* muriate of potash and still more by 30 per cent. potash salts. (Table 5.)

Sulphate of ammonia consistently increased the nitrogen content of the dry tuber. Superphosphate reduced the nitrogen content of the dry tuber in those years in which it greatly increased the yield. Potash had no effect on the nitrogen content of the dry tuber.

Although the potato is essentially a carbohydrate food, it is an efficient crop for converting inorganic nitrogen—sulphate of ammonia—into vegetable protein. The recoveries in the potato tuber of the nitrogen added as sulphate of ammonia in the Rothamsted experiments of 1929 to 1932 were 21, 43, 29 and 36 per cent., respectively; in addition, 20 per cent. may be recovered in the haulm.

TABLE 5.—Effect of fertilisers on the quality and composition of Potatoes. Dry matter per cent.

	No Potash.	Sulphate of Potash.	Muriate of Potash.	30 p.c. Potash Salt.	Rate of Dressing cwt. K ₂ O per acre.
Woburn, 1929 ..	27.5	26.7	26.2	24.8	1.0
Rothamsted, 1929	26.1	25.9	24.9	24.2	1.0
.. 1930	23.1	23.3	22.7	22.1	0.8
.. 1931	20.9	20.5	20.2	20.2	0.8
.. 1932	22.6	22.1	—	—	0.8

Effect of Sulphate of Ammonia on Nitrogen Content of Dry Matter of Tubers

Rate of application, cwt. per acre.	0	1	1.5	2	3	4
Woburn, 1929	1.44	—	1.49	—	1.54	—
Rothamsted, 1929	1.52	—	1.58	—	1.65	—
.. 1930	1.34	1.40	—	1.47	—	—
.. 1931	1.40	1.41	—	1.46	—	—
.. 1932	1.28	—	—	1.35	—	1.43

The responses to nitrogen were as a rule much the same whether the yields were high or low. Two cwt. of sulphate of ammonia per acre added between 1 and 2 tons of potatoes to the yield in just one half of the experiments, and the other results are grouped round these values, some above and some below, in such a way as to make it possible to speak of a general nitrogen response at the rate of about 15 cwt. of potatoes per cwt. of sulphate of ammonia.

The responses to superphosphate were very variable. In over one-quarter of the trials the superphosphate plots yielded less than those without superphosphate. In one-third of the trials the response exceeded 1 ton per acre; these more responsive centres included 7 of the 8 fenland trials and 6 of the 32 trials on other soils. The responses to superphosphate had no obvious connection with the productiveness of the soil. The yields in the various experiments ranged from 3 to 17 tons per acre, yet some of the most productive soils responded while some of the low yielding soils did not. We still have a good deal to learn about the factors determining response to phosphate.

The responses to potash, on the other hand, showed some connection, though not a close one, with yield. At most of the centres where the responses had been small the yields were over 10 tons per acre, which is well above the average for the country. At half of the centres the responses were less than 10 cwt. of potatoes per acre. Thirty of the 36 trials fall into a consistent group with small responses, but the other six centres (4 on light fenland soils and 2 on light sands) show very large responses of about 3 tons per acre. In isolated soils potash fertiliser doubled the crop. Some soils have an acute potash shortage, but the majority of potato soils show only slight effects on yield.

The reinforcement of effect when superphosphate supplements sulphate of ammonia or when sulphate of potash is added—the "interaction" mentioned above—is well shown on the fen soils. The results are given in Table 3.

TABLE 3.—Yields of potatoes, tons per acre. Fen soils.

	Used alone.	Used with Sulphate of Ammonia.	Difference (interaction).
Increase due to Superphosphate—			
Little Downham, 1932 ..	2.96	4.40	1.44 ± 0.71
March, 1932	1.03	1.92	0.89 ± 0.24
Increase due to Sulphate of Potash			
Thorney, 1933 (no dung)	3.49	4.78	1.29 ± 0.52
Thorney, 1933 (dung) ..	0.74	2.19	1.45 ± 0.52

The chemical work on the composition of potatoes has continued on the lines of the quality investigations made in conjunction with Messrs. Lyons laboratories in 1929. Fertilisers had but little effect on the cooking quality of the potatoes: sulphate of ammonia slightly decreased and potassic fertilisers slightly increased the quality for steaming, but neither affected the quality for frying. The effects, however, were small and nothing like as marked as the effect of soils. By no fertiliser treatment was it possible to raise the quality of the Rothamsted potatoes to the level of those grown at Woburn. (Table 4).

The Rothamsted potato experiments of 1927 to 1932 (recorded in the Reports for those years) gave smaller responses to potash fertilisers than had been obtained on the same fields from 1921 to 1926. The explanation may be that in the earlier years little stock was kept and little dung was used on the farm. Further, in several years of the earlier period the potatoes received no dung but large dressings of fertilisers. In the later years the potatoes always had a basal dressing of dung and the dressings of fertiliser were smaller.

TABLE 6.—Yield of Potatoes, Tons per acre, Outside Centres.

Centre.	Soil.	Dung.	Sulphate of Ammonia.			Sulphate of Potash.			Superphosphate.		
			None.	In-creased yield.	Quantity used, cwt per acre.	None.	In-creased yield.	Quantity used, cwt per acre.	None.	In-creased yield.	Quantity used, cwt per acre.
Potton*(Earlies)	Sand	Added	3.16	0.05	1½	2.74	0.88	2	3.09	0.19	3
<i>Mineral Soils.</i>											
Wisbech	Silt	None	12.25	1.91	4	12.87	0.86	4	12.42	1.63	9
Sutton Bonington (Midland Coll.)	Light loam	Added	9.94	0.36	3	9.92	0.12	3	—	—	—
Owmbly Cliff, Lincs.	Limestone	None	9.5	0.42	1	—	—	—	—	—	—
Swanley (Hort. Coll.)	Gravel loam on chalk	Added	8.41	0.16	3	—	—	—	—	—	—
<i>Fenland Centres.</i>											
March†	Heavy fen	None	10.58	1.63	2	11.46	-0.12	1.5	—	—	—
"	Silty fen	Added	10.33	2.37	2	11.22	0.58	1.5	—	—	—
"	Light fen	Added	12.38	0.65	2	12.18	1.05	1.5	—	—	—
"	Light peaty fen	None	9.16	-0.17	2	7.56	3.02	1.5	—	—	—
Thorney†	Light fen	None	8.46	1.08	2	6.93	4.14	1.5	—	—	—
"	Light fen	Added	9.60	1.14	2	9.43	1.46	1.5	—	—	—
Wimblington	Light fen	None	7.49	1.98	3	7.02	2.16	1.5	—	—	—
Little Downham	Heavy fen	None	11.42	3.76	2	—	—	—	11.86	3.61	6
March ..	Peaty fen on clay	None	12.24	0.24	2	12.30	0.12	2	11.75	1.21	7
<i>Microplots.</i>											
Welshpool	Medium loam	None	7.63	1.32	3	—	—	—	—	—	—
Bakewell	Limestone	None	6.65	1.64	3	—	—	—	—	—	—
Burford	Brashy loam	None	6.81	0.44	3	—	—	—	—	—	—
Staindrop	Garden	None	10.62	1.28	3	—	—	—	—	—	—
Godalming	Sandy	None	7.83	2.32	3	—	—	—	—	—	—
Hull	Clay	None	11.57	0.52	3	—	—	—	—	—	—
Fakenham	Sandy loam	None	8.61	0.66	3	—	—	—	—	—	—
Newcastle, Staffs	Heavy loam	None	12.15	0.21	3	—	—	—	—	—	—
Kimmel	Light loam	None	5.21	0.17	3	4.98	0.63	3	4.79	1.01	4
Doncaster	Medium loam	None	—	—	—	3.58	7.60	3	—	—	—

* Nitrate of Soda given. † Muriate of Potash given. (The figures in heavy type are significant.)

In the 1933 experiments when the summer was unusually dry, nitrogen had somewhat less than its usual effect though the increases were very profitable. Potash acted well at practically all the centres, especially on the light peaty fens, but most of all on the medium

loam at Doncaster. It was the only fertiliser effective for the early potatoes. Superphosphate acted unusually well, giving four successful responses in five trials and showing up particularly well on the heavy soil at Rothamsted. (The results are given in Table 6.)

Alongside of the field work on the potatoes physiological studies of the growing plant are made by D. J. Watson to find out what the fertilisers do in the plant. Potassic fertilisers decreased the concentration of sucrose in the leaf during the hours of daylight but not during the darkness. They had no recognisable effect on the reducing sugars, however.

Grassland

The manuring of grassland alters not only the yield and composition of each of the individual species of plants but also the balance of competition between one plant and another and therefore changes the entire flora. Two groups of investigations have been made: with phosphatic fertilisers, which broadly speaking tend to give a more pronounced leguminous herbage; and with nitrogenous fertilisers, which tend to make the grasses dominant.

The work on phosphatic fertilisers has been done under the aegis of the Basic Slag Committee of the Ministry of Agriculture; it involves a large amount of analytical work for which R. G. Warren is responsible. The key experiments are made at Rothamsted, and numerous experiments are made at various centres in the country. The outstanding result is the general superiority of superphosphate and of high soluble slag over the low soluble slag and, on non-acid soils, over ground mineral phosphate. On an average the high soluble slag has been about three times as effective in supplying phosphate to the plant as the low soluble slag containing equal amounts of phosphate, while the mineral phosphate has been on certain acid soils about as good as the high soluble slag and on non-acid soils about as poor as low soluble slag. The percentage recovery of phosphoric acid over the three or four years is given in Table 7.

TABLE 7.—Percentage Recovery of Phosphoric Acid in 3 or 4 Years in Grassland Experiments.

Season.	Treatment of grass.	Centre.	Geological origin of soil.	Soil pH reaction.	Low-soluble slag.	Gafsa mineral phosphate.	High-soluble slag.	Super-phosphate.
<i>Neutral or calcareous soils—</i>								
1930-33	Hay	Braintree, Essex ..	Calcareous boulder clay	7.8, alkaline	3	3	17	17
1930-33	Hay	Badminton, Glouc.	Oolite	7.2, neutral	2	4	13	16
1931-33	Repeatedly mown, ungrazed ..	Much Hadham, Herts	Calcareous boulder clay	7.1, neutral	8	8	34	30
1931-33	Grazed, mown once annually ..	Much Hadham, Herts	Calcareous boulder clay	7.1, neutral	6	8	26	30
				Mean	5	6	22	23
<i>Acid soils—</i>								
1930-33	Hay	Chesterfield, Derby	Lower coal measures shales ..	5.1, very acid	6	13	13	16
1930-33	Hay	Lydbury, Salop	Wenlock shales ..	5.2, very acid	10	19	14	18
1930-33	Hay	Cockle Park, North Northallerton, Yorks	Boulder clay ..	4.9, very acid	3	10	7	8
1930-33	Hay	Yorks	Boulder clay on keuper marl ..	5.2, very acid	5	16	18	21
1930-33	Repeatedly mown, ungrazed ..	Dartington Hall, Devon	Devonian shales	5.2, very acid	6	29	31	32
				Mean	6	17	17	19

This superiority of the soluble phosphates shows itself not only in increased yield and larger proportion of good fodder plants, but also in the higher content of phosphorus in the herbage, whereby its feeding value per ton is almost certainly enhanced. A special feature of the work has been the chemical control of the phosphorus uptake by the crop, and this has proved of great help in showing the relative values of the different fertilisers.

So far the experiments have not shown where the line is to be drawn between the high soluble and the low soluble slags. Hitherto this problem has been unimportant, because most samples on the market were either above 75 per cent. or below 30 per cent. solubility. Now, however, there seems the probability that slags of intermediate solubility will be offered for sale and the work is being extended to cover these.

Fodder Mixtures. Further studies were made of the yield and composition of fodder mixtures containing different proportions of oats and vetches, grown with and without nitrogenous manure. The yields of dry matter per acre were highest when the seed mixture contained 3 bushels of oats to 1 bushel of vetches. Nitrogenous manure increased the yield, but not significantly more for one mixture than for another; previous work has shown that the increase is in the starch equivalent per acre and not in the quantity of protein.

Lucerne. The inoculation experiments are described later. (p. 36)

For some time past Professor W. Southworth, who is working at Rothamsted after his retirement from Canada, has been experimenting with hybrids of lucerne and black medick, and has obtained at least one promising sort considerably more vigorous in early life than the ordinary Provence variety. The percentage of plants that died during the first year were:

	The new sort.	Provence.
Rothamsted	1.7	23.4
Woburn	0	15

The new sort is at least as productive as the Provence, both of fodder per acre and of seed, and further experiments are being made.

Clover. Cultures of the nodule organism have been prepared which in preliminary experiments made in association with Professor Stapledon greatly improved the "take" of clover on newly sown upland grassland. Should any extensive resowing seem likely to occur, this work ought certainly to be expedited so as to ensure supplies of the cultures in time to meet the farmers' needs.

Marrow stem Kale. This is proving one of the most valuable fodder crops on the farm. In our numerous experiments yields of 25 or more tons per acre are frequently obtained on our poor heavy land. It responds remarkably well to nitrogenous manuring, and is one of the best crops for converting fertiliser nitrogen into valuable animal food.

The residual effect of the farmyard manure applied to the 1932 kale crop at Woburn was studied by following it with barley in 1933, and comparing the yield with that given by sulphate of ammonia. On plots that had dung in 1932 there was an increase of 12.2 cwt. of green matter over the plots receiving no dung; while 0.2 cwt. of nitrogen applied as sulphate of ammonia in 1933 gave an increase of 20.7 cwt. per acre. The residual effect of the dung was therefore

approximately that of 0.118 cwt. nitrogen per acre, or 0.6 cwt. sulphate of ammonia. No residual effect of sulphate of ammonia applied in 1932 could be detected.

Mangolds. In the Statistical Department an examination of the yields of mangolds on Barnfield for the years 1876 to 1930 has been completed by R. J. Kalamkar. The new facts brought out are that the deterioration of yield usually observed where one crop is grown continuously has not been pronounced on the plots receiving farm-yard manure or complete artificials including nitrate of soda, but it becomes more marked when either nitrogen or potash and phosphate are omitted. Slow changes in yield other than deterioration are unimportant except on the dunged plots. The annual variance is increased by nitrogenous manuring but decreased by potassic fertiliser and also by rape cake or dung. Variations in rainfall do not account for the variations in yield due to annual causes though rainfall in excess of the average appears to be somewhat harmful when it comes in Spring (mid-March to end of May) and beneficial when it comes in June and July.

The value of fodder crops. Chemistry is not yet sufficiently advanced to give a complete statement of the feeding value of these fodder crops, and it is still necessary to use the animal as the means of testing. It is proposed to use sheep and pigs, and feeding experiments of a new type have been designed to eliminate the effect of variations in location of the stalls and to reduce the effect of individuality of the animal.

THE SOIL CULTIVATION EXPERIMENTS

In view of the changes brought about by mechanisation in the cultivation of wheat and other cereals, a number of experiments have been made on different methods of seed-bed preparation, including shallow and deep ploughing and rotary cultivation, each in conjunction with spring harrowing, rolling and top dressing with sulphate of ammonia. No significant differences in yield of grain were observed between any of the treatments, and the choice of the different methods would apparently be dictated by their relative cost and convenience. Neither rolling nor harrowing increased the yield.

The conditions were, however, unusual in that sulphate of ammonia had no effect on the yield of grain. On the other hand the yield of straw was increased by the addition of nitrogen. The response to nitrogen varied according to the cultivation. Rolling increased it.

It would be interesting to know whether the grain would show similar responses to cultivation on land where sulphate of ammonia increased its yield.

THE IMPROVEMENT OF FIELD PLOT TECHNIQUE

Some interesting advances have been made during the year in the theory of field plot design, particularly in the methods available for combining several different problems into one experiment. Here the method of "partial confounding" has been developed; this considerably increases the utility of "confounding" for combining different problems into one experiment, since it serves to provide more flexible arrangements. The methods of analysis when the data are incomplete have been extended to cases where several plots are missing, and their validity established. Convenient methods of forming Latin squares for field experiments have been placed on record.