ROTHAMSTED RESEARCH

Report for 1948

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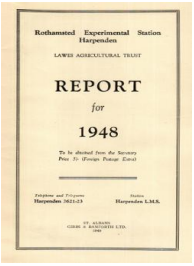

Six Course Rotation Experiment

Rothamsted Research

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was by far the most productive first year grazing season on record. Lucerne sown on May 18th showed some loss of plant during the season especially on plots which had frequently grown lucerne in past years. Block 5 shows the second years' test crop, barley, which at 30·6 cwt. was the best crop so far grown in this experiment. It showed small but appreciable residues of dung applied to the previous potato crop, but very little effect due to the previous systems of cropping. Blocks 1 and 2 showed leys in their 2nd and 3rd years and various arable crops. In 1948 the 2nd year of the ley at 4·4 tons of hay equivalent was more productive than the third year at 3·4 tons. Third year lucerne gave 3·2 tons of hay during the season, and 2nd year lucerne 4·3 tons. Wheat failed twice from autumn sowings due to birds and was resown in the spring. The final yield was only 14 cwt. 1 year seeds for hay undersown in wheat in 1947 failed in the summer drought and were resown on the bare ground in the spring of 1948. Only a poor crop of 1·2 tons per acre resulted. Sugar beet was a satisfactory crop of 10·8 tons with a rather high proportion of tops. This experiment is summarized on p. 94.

Organic manure experiment, market garden crops, 7th year

This experiment tests the effect of yearly applications of dung, vegetable compost, sewage sludge, and sewage sludge compost on a rotation of vegetable crops. The organics are applied at 15 and 30 tons per acre to peas and to red beet. Sulphate of ammonia at several levels is also tested. The peas drilled on March 16th turned out a very weedy crop and there was a rather large proportion of unfilled pods. Better germination was noticed on the plots receiving organic manures, but the crop was very variable. Dung increased the yield of saleable peas and sludge decreased it. There was no advantage from the addition of sulphate of ammonia. Red beet was a gappy plant partly owing to an attack of flea beetle; there were more plants where organics were applied. There were many bolters and the number of these was increased by those treatments which increased the crop yield. The yield of bulbs was very small on the control plots but was considerably increased by organics, especially dung and sewage sludge. Sulphate of ammonia was also effective.

Annual Experiments

The only annual experiments at Woburn in 1948 were replications of the two linseed experiments as carried out at Rothamsted.

Six Course Rotation Experiments, 1930-1948

In 1930 two long-period rotation experiments were started, one at Rothamsted and the other at Woburn. The purpose was to provide data on the effects of varying amounts of the three standard nutrients, nitrogen, phosphate and potash on the yield of the six crops of the rotation in the different weather conditions of successive years.

The rotation is sugar beet, barley, clover, wheat, potatoes, rye. For the first 4 years the rye was harvested as green fodder, but subsequently it has been carried on to maturity and weighed as

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grain and straw. The crops rotate on six areas on each farm so that each crop of the rotation is present every year. Within each area there are 15 plots consisting of three sets of 5 treatments, testing 5 levels of nitrogen, 5 levels of phosphate, and 5 levels of potash respectively. The plots do not receive the same treatment throughout, but on each plot the 15 treatments follow each other in a definite order in successive years, thus avoiding cumulative effects of any nutrient. In each set the order is 4, 3, 2, 1, 0. The 15 treatments are :

Nitrogen set 0, 1, 2, 3, 4 units of N with 2 units of P and 2 units of K
Phosphate set 0, 1, 2, 3, 4 units of P with 2 units of N and 2 units of K
Potash set 0, 1, 2, 3, 4 units of K with 2 units of N and 2 units of P

The fertilisers are sulphate of ammonia, superphosphate, and muriate of potash. The units are 0·15 cwt. N per acre, 0·15 cwt. P_2O_5 per acre, and 0·25 cwt. K_2O per acre. Thus in terms of fertiliser the nitrogen dressings ranged, in round figures, from 0 to 3 cwt. sulphate of ammonia, the phosphate from 0 to 3½ cwt. superphosphate, and the potash from 0 to 2 cwt. muriate of potash. No dung is given, but a uniform application of calcium carbonate is applied after sugar beet and again after potatoes. The experiment has not yet been continued long enough to provide sufficient data for a full statistical examination of seasonal fertiliser responses in relation to weather conditions, but in the meantime the general nature of the fertiliser responses on the two farms has emerged fairly clearly and the 19-year means are recorded in this preliminary statement.

It was soon apparent that nitrogen was by far the most effective nutrient on both farms and on almost all crops. The average responses to phosphate and potash were in general much smaller, although certain crops, notably potatoes at Rothamsted, gave big returns for potash and appreciable increases for phosphate. In Table 1 will be found the mean yields for all crops at the five levels of nitrogen, but for the much smaller effects due to phosphate and potash the mean linear regressions give a sufficient picture of the results, and these are therefore tabulated. For comparison the regression figures for nitrogen are also included.

At Rothamsted almost all crops show clear responses to nitrogenuous manuring. Thus 1½ cwt. sulphate of ammonia (the mean rate of dressing) gave increases of 0·74 tons sugar beet, 1·2 tons potatoes, 5·2 cwt. barley, 3·5 cwt. wheat, 5·7 cwt. rye per acre, but for clover hay the increases for nitrogen although appreciable are probably due in part to the presence of self-sown barley and weeds. For most crops there is a distinct falling off in the responses at the higher rates of fertiliser application. In rye straw and in particular in sugar beet tops the nitrogen responses are well maintained at the higher levels ; for the sugar beet tops the higher dressings appear to be if anything more effective than the lower ones.

At Woburn all crops except clover responded well to nitrogen. The increases for 1½ cwt. sulphate of ammonia were 1·6 tons sugar beet and potatoes, 7·7 cwt. barley, 3·5 cwt. wheat, and 4·9 cwt. rye. The actual responses were usually higher than the corresponding ones at Rothamsted, though the level of cropping was better at Rothamsted than Woburn. As at Rothamsted the increases tended

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to fall off at the higher levels, but once again sugar beet tops kept up their responses to the highest level of manuring. The nitrogen responses vary considerably from year to year. Taking sugar beet as an example, the most favourable year on both farms was 1943 when Rothamsted showed an increase in roots at the rate of 7·4 tons per 1 cwt. N, and Woburn 9·5 tons per 1 cwt. N; on the other hand in 1932 both farms showed a loss of 2 tons roots for 1 cwt. N, the worst result on record. The parallelism between the nitrogen effects at these two localities is by no means always as close as this; the nitrogen effects observed yearly at Rothamsted are much nearer to the general behaviour of nitrogen on sugar beet in the Eastern Counties, as measured by experiments carried out annually on commercial farms in all sugar factory areas, than are those at Woburn. In 1948 for instance, a year of low nitrogen response generally, Rothamsted gave practically no increase for nitrogen, while Woburn gave no less than 9·1 tons per 1 cwt. N.

As will be seen by the regressions, there are few striking responses to either phosphate or potash. The only crop that shows appreciable responses to phosphate is potatoes; this is found on both farms. Potash at Rothamsted gives a big response in potatoes, the successive increases over no-potash being 1·27 tons for ½ cwt. muriate of potash, 1·77 for 1 cwt., 2·07 for 1½ cwt., 2·43 tons for 2 cwt. muriate of potash per acre. In addition there is some evidence of a small response to potash in sugar beet and clover hay. At Woburn the small responses to potash in sugar beet and clover hay are very similar to these obtained at Rothamsted, but the potato crop behaves quite differently on the two farms. At Woburn 2 cwt. of muriate of potash gives only 0·3 tons of potatoes in contrast to the 2·4 tons obtained at Rothamsted.

The productivity of the two farms may be compared by examining the mean yield for each of the crops over the whole period of the experiment. Each crop had exactly the same manurial treatment on the same variety for the whole course of the experiment, except that from 1947 Squareheads Master wheat was substituted for Yeoman at Woburn on the grounds that it was more suited to the light soil. Rothamsted is on the whole the more productive farm, particularly for wheat where the yields exceed those at Woburn by 12·3 cwt. grain and 15·5 cwt. straw per acre; it also grows 0·81 tons more sugar beet with 3·23 tons more tops, and substantially more barley and rye. Woburn on the other hand gives somewhat bigger crops of clover hay and slightly more potatoes.

In Table 1 will be found the mean yield of each crop taken over three successive periods of six years. Such figures should reveal any pronounced tendency towards soil exhaustion during the course of protracted cropping with fertilisers alone, the only organic matter given being the sugar beet tops ploughed in on their respective plots. It should be noted however that certain changes in crop variety were made on both farms. In 1942 Majestic potatoes were substituted for Ally and in 1943 Kleinwanzleben sugar beet was substituted for Kühn. In other words during the last six-year period slightly heavier yielding varieties of roots were being grown, and in particular the yield of tops of the sugar beet might be expected to be appreciably increased by the change from Kühn to Klein-

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TABLE 1

Mean yields per acre at 5 nitrogen levels, Rothamsted and Woburn 1930-48

	Nitrogen cwt. per acre	Sugar Beet Roots tons	Sugar Beet Tops tons	Sugar Beet Total Sugar cwt.	Barley Grain cwt.	Barley Straw cwt.	Clover Hay Dry Matter cwt.	Wheat Grain cwt.	Wheat Straw cwt.	Potatoes Total Tubers tons	Rye Grain cwt.	Rye Straw cwt.
Rothamsted	0	7·98	7·57	28·8	25·9	28·3	22·1	24·1	34·5	6·48	19·8	35·1
	0·15	8·46	8·15	30·7	28·9	32·1	24·5	26·7	40·9	7·06	22·8	38·1
	0·30	8·72	8·75	31·6	31·1	35·2	26·0	27·6	42·0	7·64	25·5	41·9
	0·45	9·01	9·47	32·3	32·2	37·1	27·6	27·9	44·8	7·91	27·2	45·2
	0·60	9·28	10·50	33·1	32·7	38·8	27·5	28·4	45·9	8·32	27·6	45·8
Woburn	0	6·56	4·59	23·5	15·3	23·9	28·5	11·4	20·1	6·40	13·4	22·7
	0·15	7·35	5·02	26·4	19·8	27·9	28·0	12·7	22·5	7·10	15·9	29·9
	0·30	8·11	5·66	29·0	23·0	30·5	26·6	14·9	29·0	8·03	18·3	33·4
	0·45	8·60	5·93	30·3	24·2	31·5	24·2	18·2	32·5	8·73	20·8	37·2
	0·60	8·73	6·34	30·6	25·1	35·5	27·2	18·2	34·0	9·27	22·1	39·2
Mean Yield :												
Rothamsted		8·72	8·65	31·4	30·4	34·5	21·4	27·5	43·3	7·69	24·5	41·1
Woburn		7·91	5·42	28·2	22·5	30·5	27·0	15·2	27·8	8·05	18·0	32·9
Increase for :												
1 cwt. N	Rothamsted ..	2·11	4·79	7·5	11·3	17·3	8·7	6·4	17·5	3·01	13·2	19·0
	Woburn	3·73	3·02	12·2	16·0	20·7	–4·2	12·8	25·2	4·90	14·9	26·9
1 cwt. P_2O_5	Rothamsted ..	–0·28	–0·42	–0·5	1·3	3·0	–0·2	0·0	0·9	0·91	–0·5	1·2
	Woburn	–0·37	0·16	–0·9	1·5	0·5	0·0	–0·7	–0·7	0·68	–1·1	–1·6
1 cwt. K_2O	Rothamsted ..	0·27	–0·38	1·8	0·0	1·8	1·8	0·4	1·0	2·27	–0·3	–0·9
	Woburn	0·45	0·37	2·3	0·9	0·7	1·8	–0·3	–0·7	0·29	–0·2	0·5

Six Course Rotation. 6 year means

Yield per acre

	Sugar Beet Roots tons	Sugar Beet Tops tons	Sugar Beet Total Sugar cwt.	Barley Grain cwt.	Barley Straw cwt.	Clover Hay Dry Matter cwt.	Wheat Grain cwt.	Wheat Straw cwt.	Potatoes tons	Rye Grain cwt.	Rye Straw cwt.
Rothamsted											
1931–1936	7·68	8·43	27·1	28·6	36·3	14·4†	23·2	41·7	6·80	22·5*	45·7*
1937–1942	8·75	8·79	31·7	31·2	33·3	23·6	28·4	40·6	7·48	23·4	35·5
1943–1948	10·10	8·62	37·1	31·8	34·3	21·4	30·8	43·5	9·01	26·6	44·5
Woburn											
1931–1936	7·88	6·67	26·8	23·9	39·5	23·0‡	12·2	26·0	8·13	20·2*	36·8*
1937–1942	7·58	4·79	27·6	23·9	27·8	29·9	19·5	30·2	7·39	19·8	33·8
1943–1948	8·92	4·69	32·6	20·1	23·1	26·9	13·4†	26·9†	8·09	15·2	30·0

* 3 years only. † 4 years only. ‡ 5 years only.

wanzleben. These changes may have tended to obscure in part any deterioration in fertility as far as the roots were concerned.

Taking the crops in which little or no change was made, namely barley, wheat, and rye, it appears that at Rothamsted the last six-year period gave better yields than either of the two preceding periods. Wheat in particular was much better at the end than at the beginning of the experiment. The yield of cereal straws showed a depression in the middle period, especially in rye, but recovered in the final period. At Woburn barley and rye showed a fairly marked decline in yield in the final six-year period, amounting to 3·8 cwt. and 5 cwt. grain respectively, the reduction in straw was even more marked. There was no definite trend in wheat yields at Woburn, where the level of production was low in any case.

Woburn Ley-Arable Experiment, 1938-1948

In 1938 a long period rotation experiment was begun at Woburn to test the effects on soil fertility of leys, lucerne and different systems of arable cropping. The cropping schemes under test are :

1. A three-year ley, grazed by sheep.
2. Lucerne, cut for hay for three years.
3. An arable sequence with one-year seeds : potatoes, wheat, one-year ley for hay.
4. A purely arable sequence without ley : potatoes, wheat, kale.

The results of these four methods of cropping the land are measured in two test crops, potatoes followed by barley. There are thus a series of five-course rotations in which the fourth and fifth crops are always potatoes and barley. There are five blocks, each of eight main plots, on four of these plots the above four cropping systems are tested without change to bring out cumulative effects. Since it is possible that some of the continuous rotations might lead to rather large differences in fertility, as for example by the exhaustion of organic matter, the remaining four plots carry the ley and arable sequences alternately, thereby testing the effects of the cropping at a steadier fertility level. The blocks were started off at yearly intervals so that after five years all phases of the rotations were represented annually. The only manurial factor in the experiment is the effect of 15 tons of dung per acre applied to the potato test crop. Its residual effects are followed through the subsequent crops. The dung treatments are repeated on their respective plots. Phosphate and potash applications are equalised for all treatments over a five-year period, but nitrogenous manures are applied according to a schedule based on crop requirements. Certain modifications in cropping have taken place in the course of the experiment. Kale was never a very satisfactory crop at Woburn, mainly owing to damage by birds and vermin, and in 1945 it was replaced by sugar beet. In 1940 Italian ryegrass was included in the mixture for the three-year ley to add bulk to the produce of the first year. In the autumn of 1948 rye was introduced in place of wheat, on the grounds that it was a more suitable crop and less damaged by birds.

To illustrate the information that becomes available as the experiment proceeds we may take the sequence on the first block

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