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Rothamsted Experimental Station Report for 1965

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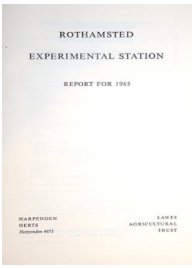

Rothamsted Ley-arable Rotation Experiment

D. A. Boyd

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seemed unlikely to give useful information, and on these plots the levels were all one unit dose more than on other plots.

On the Woburn Ley–Arable sugar beet, with no risk of a loss of yield comparable to that in lodged cereals, the tests are planned to locate the critical part of the response curves close to the point of maximum yield. The standard unit dose is 0·35 cwt throughout, but three different starting levels are used.

Animal movements and soil fertility in the New Forest. Previous observations and analyses (*Rothamsted Report* for 1963, p. 177) showed that grass cut from a reseeded area of high ground had a greater percentage of K than grass from a natural pasture near a stream. This was attributed to the habits of ponies and other grazing animals, which tend to graze much on the lower ground, but rest (and excrete) a good deal on higher ground.

In 1964 cages were used to prevent grazing on sample areas of the reseeded land. Two cages were left in the same positions the whole season, the grass being cut four times; the other two were moved to fresh sites immediately after each cutting. The mean percentage K in the stationary cages varied erratically between 1·9 and 2·2 during the season, but the samples from the moved cages showed an increase from 1·95% K in May to 2·85% in November. This increase confirms the idea that much K is transferred by animals from low ground to high, and demonstrates the importance of unrestricted animal movements in areas such as the New Forest for maintaining fertility on higher ground. (Scowen, with R. J. B. Williams, Chemistry Department)

Rothamsted Ley–Arable Rotation Experiment

By D. A. Boyd

Introduction. The original aim of the experiment was to compare the crop and livestock production from two farming systems, one based on permanent arable and permanent grass, the other having short-term leys alternating with a sequence of arable crops. Limitations on grazing management imposed by the small plot size led, first, to sheep-weighing being discontinued, and, recently, to sheep-grazing being replaced by mowing. Thus the experiment mainly provides information on the relative yields of arable crops in different types of rotation.

The experiment, which began in 1949, is on two fields about 1 mile apart; Highfield had previously been in permanent grass for many years, whereas the other, Fosters, is an old arable field. Four different six-course rotations are compared, three involving 3-year leys and one completely arable, except for a 1-year ley. Two rotations are sown with a grass/clover mixture, one grazed and the other managed as for silage with 4–8 cuts annually; management of the grass leys has now been changed, but test cropping under the new scheme has only just begun and will not be discussed here. The third ley is pure lucerne for mowing. The parallel crops of the arable rotation are a 1-year seeds ley for hay, sugar beet and oats. The

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4th, 5th and 6th years of the rotation consist of test crops, wheat, potatoes and barley, which are common to all the rotations (Table 1). Each phase of the rotation is represented in duplicate on each field. In addition, each block contained one plot of reseeded grass and, on Highfield, one

TABLE 1

Cropping in the Ley–Arable Experiment

	Year 1 2 3 (Treatment crops)	Year 4 5 6 (Test crops)
(1) Grazed ley		Wheat, potatoes, barley
(2) Conserved ley		
(3) Lucerne hay		
(4) Seeds hay, sugar beet†, oats*		
(5) Permanent Grass (Original Sward)‡		
(6) Permanent Grass (Reseeded 1949–51)		

* From 1955 onwards, formerly barley.
† Formerly potatoes.
‡ On Highfield only.

plot of the original sward; some of the reseeded plots are now being put through the sequence of test crops.

When the experiment began, all rotations received the same amounts of fertiliser, but it soon became apparent that uniform treatment was impracticable. K-deficiency on plots of the lucerne and conserved ley rotations was corrected by supplementary dressings starting in 1955, but as extra K was not given to the arable rotation until 1961, the earlier results for this rotation may have been influenced by a shortage of K. To ensure that the yields of the treatment and test crops of each rotation are not limited by insufficient fertiliser, the nutrients removed are estimated, the soils are analysed for P and K, and there are tests of N, P and K and of FYM *v.* equivalent PK on potatoes and of four rates of N on the cereal test crops. At the same time a careful watch is kept to ensure that, as far as possible, comparisons between rotations are not influenced by differential incidence of pests and diseases.

The present report gives results with wheat in the years 1961–64 and potatoes and barley in 1962–64. Results for earlier years were given in the *Rothamsted Report* for 1961, pp. 173–180.

Yields of the treatment crops. The average yield of dry matter from the grazed leys and the permanent and reseeded grass, estimated by sample cuts, was about 30 cwt/acre, about half the dry-matter yield of the conserved ley (Dyke, 1964). The biggest yield was from lucerne, which gave about 70 cwt D.M./acre. Lucerne yielded more on Fosters than on Highfield, probably because on Highfield the lucerne has suffered from attacks by *Verticillium* and in earlier years the 3rd-year lucerne tended to be weedy. The grass leys yielded better on Highfield than on Fosters. Of the three crops of the arable rotation, sugar beet yielded much better on Highfield. The reason is not known: a test of two rates of N on the two fields, made in 1964 to check whether the difference might partly reflect differences in nitrogen requirements, indicated that nitrogen was not a factor.

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Yields from the test crops

Wheat. Table 2 gives the mean yields of the first test crop, wheat, for the period 1961–64. The N dressings on Fosters had increments of 40 units/acre, those on Highfield only 30 units/acre, a distinction made in the expectation that wheat on Fosters would continue to be more responsive to N as it had been in earlier years. In fact, the average response curves for the two fields proved to be similar, but the average yield at the same rate of N manuring was 1½–2 cwt bigger on Highfield than on Fosters. The optimal dressing at current subsidised prices was about 0·8 cwt N/acre.

Previous rotation greatly influenced both the yield without N and the response to N. Even without N, wheat after lucerne yielded well and the optimal N dressing was only 0·4–0·6 cwt N/acre. N responses were unusually big for wheat following a ley, but, even with optimal N (about 0·8 cwt N/acre) wheat yields after the two grass leys were generally much less than after lucerne, particularly in 1961 and 1962, when the wheat after leys may have been damaged by stem-boring (mainly frit-fly) larvae. It was also suspected that the leys might restrict the supply of subsoil N and, for the 1965 crop, a test of extra N applied in autumn was made to discover whether, if this were so, it is possible to "recharge" the subsoil.

Wheat after arable gave large and almost linear responses to N up to the largest dressing given, and on both fields the optimal dressing was probably more than 1·2 cwt N/acre. In 1964 the N dressings on each field were increased by one-third (interpolated values have been used for Table 2); the season was favourable to N effects, and the optimal dressing

TABLE 2

Wheat: effect of N and rotations 1961–64

(cwt grain/acre)

Rates of N (cwt/acre)		Grazed ley	Conserved ley	Lucerne	Arable	Mean
Highfield	0·0	38·8	32·8	45·2	33·5	37·6
	0·3	44·5	42·2	52·0	41·2	45·0
	0·6	47·4	46·9	50·7	48·9	48·5
	0·9	47·6	49·2	50·7	53·2	50·2
	Mean	44·6	42·8	49·6	44·2	45·3
Fosters	0·0	36·2	33·8	45·8	28·0	36·0
	0·4	42·5	42·4	53·7	39·8	44·6
	0·8	45·2	45·4	55·5	46·7	48·2
	1·2	46·1	45·9	54·0	52·3	49·6
	Mean	42·5	41·9	52·2	41·7	44·6

for wheat after arable was still well above the largest tested (1·2 and 1·6 cwt N/acre on Highfield and Fosters respectively).

Potatoes. Potatoes yielded about 10% more on Highfield than on Fosters—the difference being greatest after ley and least after arable. On Fosters the mean yields of the four rotations were almost identical, but on Highfield the grazed ley and lucerne yielded more than the conserved ley and arable rotations (Table 3).

On both fields potatoes following the lucerne and arable rotations responded to the larger amount of N, but there was no response after

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grazed or conserved ley. By contrast, potatoes in the lucerne and arable rotation did not need extra K, whereas after the grazed ley K increased the crop by 0·5 ton/acre on both fields. There were substantial responses to

TABLE 3

Potatoes (2nd test crop): mean yields and mean responses to FYM, N, P and K, 1962–64

(tons total tubers/acre)

	Grazed ley	Conserved ley	Lucerne	Arable	Mean response with PK	Mean response with FYM	Mean
Mean yield Highfield	17·47	16·35	16·93	16·12	—	—	16·72
Fosters	15·06	15·18	15·27	15·12	—	—	15·16
FYM *v.* PK†							
Highfield	0·80	0·64	0·71	0·38	—	—	0·63
Fosters	−0·52	0·14	0·42	0·86	—	—	0·23
Response to N (0·5–0·0 cwt N/acre)*							
Highfield	−0·21	−0·01	0·89	0·32	0·25	0·25	0·25
Fosters	−0·01	−0·03	0·37	0·59	0·37	0·10	0·23
Response to P (1·8–0·9 cwt P_2O_5/acre)							
Highfield	0·07	0·34	−0·16	0·97	0·08	0·52	0·30
Fosters	0·51	0·22	0·36	0·34	0·37	0·36	0·36
Response to K (1·8–0·9 cwt K_2O/acre)							
Highfield	0·55	0·18	−0·01	0·01	0·11	0·25	0·18
Fosters	0·45	0·20	0·07	0·00	0·05	0·32	0·17

† Difference of plots receiving 12 tons FYM/acre and plots receiving equivalent PK.
* Basal dressing: Highfield 0·5 cwt N/acre; Fosters 0·75 cwt N/acre.

the larger amount of P on both fields, and it seems that the requirement for P was underestimated. On both fields the plots receiving FYM out-yielded those with the supposed equivalent PK fertiliser. The pattern of the responses on Fosters suggests that there the difference was partly from N contributed by the dung, which, unlike the PK, was not compensated for in the fertiliser dressing. The equivalents referred to "average" FYM (Boyd, 1959) and might have been underestimates of the PK provided by the FYM used, but this is not borne out by the results of the split-plot tests of the effect of extra P and K fertiliser; without FYM there was little response to extra P or K (except for P on Fosters), whereas, with FYM, extra P and K increased yield by $\frac{1}{4}$–$\frac{1}{2}$ ton. Timing and placement of the two sources of P and K were very different. The FYM was ploughed in in autumn, sometimes as early as September, whereas the fertilisers, including the PK equivalent of FYM, were applied at planting, in April or early May. The crop was planted by machine working on the flat. Thus the observed differences may be an effect of placement, but there are other possible explanations, such as that the FYM supplied some factor limiting fertiliser response, or improved soil structure, increased water-holding capacity or protected the growing tuber against a damaging concentration of salts in the surface soil.

For three years, from 1963 to 1965, plots of the grass reseeded when the experiment began in 1949–51 were ploughed up and put through the

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sequence of test crops. Wheat after these 12–15-year-old grazed leys yielded similarly to wheat after the 3-year grazed leys. However, in 1964 the yield of the first potato crop, after reseeded grass, was on both fields about 2 tons greater than the mean of the four rotations; the reason for this difference is not known.

Barley. As of wheat, the mean yield of barley (Table 4) was similar on

TABLE 4

Barley: effect of N and FYM 1962–64

(cwt grain/acre)

Rates of N (cwt/acre)	Grazed ley	Conserved ley	Lucerne	Arable	Mean
Highfield Mean yield	48·9	46·6	48·5	45·4	47·3
Without FYM to potatoes					
N 0·0	48·0	42·7	48·2	38·6	44·4
0·1	49·8	45·0	48·6	45·1	47·1
0·2	47·7	47·8	49·2	46·3	47·7
0·3	45·3	47·7	48·1	45·3	46·6
With FYM to potatoes					
0·0	50·7	45·9	49·0	45·1	47·7
0·1	49·6	48·0	49·0	46·6	48·3
0·2	49·8	47·0	49·0	48·7	48·6
0·3	50·0	48·9	46·7	47·5	48·3
Fosters Mean yield	47·3	45·8	47·8	45·3	46·5
Without FYM to potatoes					
N 0·0	44·3	41·4	45·7	36·8	42·1
0·2	47·3	45·5	49·0	—	(46·5)
0·4	46·9	47·0	48·1	46·6	47·2
0·6	48·3	46·4	49·5	47·6	48·0
0·8	—	—	—	46·9	—
With FYM to potatoes					
0·0	47·1	45·8	47·6	43·9	46·1
0·2	49·0	47·0	48·9	—	(47·7)
0·4	48·3	48·0	47·9	47·1	47·8
0·6	46·7	45·6	45·5	46·3	46·0
0·8	—	—	—	46·9	—

the two fields. Yields varied little for the different rotations. Without extra nitrogen, barley after lucerne and grazed ley yielded better than after arable. However, a small dressing of nitrogen was sufficient to increase the yield after arable almost to that after the leys. There was some residual effect of FYM applied to the previous years' potatoes; this was greatest for the plots of the arable rotation. The response to FYM when no N was applied shows that a substantial part of the residual effect of FYM came from the nitrogen it provided; on Highfield the shape of the N response curve possibly indicates that P or K in the FYM was also having some effect.

Summary. No important differences in yield were found for arable test crops, whether they formed part of an arable rotation or of a rotation with 3-year leys. Less N was needed after a ley than after arable.

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Boyd, D. A. (1959) The effect of farmyard manure on fertilizer responses. *J. agric. Sci.* **52**, 384–391.
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Cultivation Weedkiller Experiment—Rothamsted and Woburn Report for Years 1961–65

By J. R. Moffatt

In 1961 an experiment was started at Rothamsted and Woburn to measure the immediate and residual effects of herbicides and to see how far weed control by chemicals can simplify field cultivations. The four-course rotation is wheat, potatoes, barley and beans; when conditions are suitable wheat and beans are sown in autumn.

The experiment tests three primary cultivations on each crop in each year:

P the land is mouldboard ploughed followed by seedbed-producing operations.
R the land is rotary cultivated once or twice, but is not mouldboard ploughed.
T the land is worked with a deep-tined cultivator two or three times followed by seedbed-producing operations; it is not mouldboard ploughed or rotary cultivated.

In combination with the primary cultivations there are three systems of post-planting weed control in beans and potatoes:

M mechanical cultivations.
Sx residual herbicides.
Sy residual herbicides differing from Sx in material or time of application.

The M plots get only mechanical operations appropriate to the crop. The Sx and Sy plots have no mechanical operations after planting unless they are done in conjunction with the spray.

In addition, there is a test of hormone herbicide (H) *v.* none (O) on wheat and barley. All treatments are cumulative; herbicide rates are given in terms of active ingredients.

The experimental area is divided into four series, one for each phase of the rotation. Each series consists of two randomised blocks of 12 whole plots, nine plots carrying the nine combinations of primary cultivations and weed control systems. The remaining three plots were "reserve" plots and had the PM treatments, but two are now used as follows:

Since 1964 one plot per block is ploughed in autumn for autumn-sown crops, and for spring crops is spring rotary cultivated only. The object is to see whether delaying cultivations for spring crops affects yields, and whether, in a dry spring, the moisture conserved by giving only one

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