ROTHAMSTED RESEARCH

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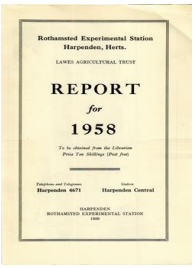

Three-course Rotation Experiment : Revised Scheme, Summary, 1952-1958

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Three-course Rotation Experiment: Revised Scheme, Summary, 1952–58

by H. D. Patterson

The original experiment was designed to test the effects of straw, ploughed into the land in autumn or composted, on a three-course rotation of potatoes, barley and sugar beet. Plots receiving straw and NPK fertilizers every second year were compared with plots receiving the same rates of NPK fertilizers but no straw.

The results of the experiment were reviewed at the end of 1951 (*Rep. Rothamst. exp. Sta. for 1951*, p. 135). Dr. E. M. Crowther pointed out that the effects of straw produced in the experiment up to that time might be due to nitrogen immobilized by the straw and potassium provided by the straw rather than to changes in soil structure or organic-matter content.

To test this hypothesis a revised scheme of treatments incorporating separate tests of nitrogen and potassium was introduced in 1952. The compost treatment was discontinued. One-third of the plots previously having straw or compost were now given 53⅓ cwt. straw/acre ploughed into the land in every second autumn and 0·2 cwt. N/acre (additional to the treatments and basal dressings mentioned below) in the following spring. A further one-third of these plots was given a dressing of muriate of potash, applied in the spring of every second year, calculated to be equivalent to the amount of K_2O supplied by the straw. The remaining one-third of the old straw or compost plots received neither straw nor the potassium equivalent of straw in the new experiment.

Nitrogen and potassium fertilizers were applied at two levels each—0 *v.* 0·4 cwt. N/acre, 0 *v.* 0·5 cwt. K_2O/acre—additional to basal dressings. One-half of all the plots received the lower level of nitrogen in one year and the higher level in the next; in the other plots the phasing was reversed. All plots were split to accommodate the two levels of potassium which alternated between half plots from year to year. Barley and sugar beet were not expected to show large responses to potassium, so half plots were not harvested separately for these crops. There was no test of phosphorus fertilizer.

The nitrogen and straw (or potassium equivalent to straw) treatments were combined as shown in the following scheme for one series of twenty-four plots (treatments shown are additional to basal dressings):

Even years commencing 1952	Odd years commencing 1953	Original treatments: Straw	Compost	Fertilizers
		Number of plots involved		
0·4N	—	2	1	3
—	0·4N	2	1	3
S + 0·6N	—	1	1	—
—	S + 0·6N	1	1	—
S + 0·2N	0·4N	1	—	—
0·4N	S + 0·2N	1	—	—
K_s + 0·4N	—	1	1	—
—	K_s + 0·4N	1	1	—
K_s	0·4N	1	—	—
0·4N	K_s	1	—	—

S: straw.
K_s: potassium equivalent of straw.

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The amount of potassium in the straw averaged 0·45 cwt. K_2O/acre, but this varied from year to year from 0·25 to 0·71 cwt. K_2O/acre.

The basal dressings of N and K were the same as in the original experiment, but those for P were increased by 0·2 cwt. P_2O_5/acre.

Basal dressings	Cwt./acre N	P_2O_5	K_2O
Barley	0	0·2	0
Sugar beet	0·2	0·4	0·25
Potatoes	0·4	0·6	0·5

The fertilizers used, both for treatments and basal dressings, were sulphate of ammonia, superphosphate and muriate of potash. All were applied in the spring. For potatoes the fertilizers were broadcast on the flat before planting. This represents a departure from the practice in the original experiment, when fertilizers were placed in the furrows immediately before planting.

TABLE 6

Mean yields of potatoes, 1953–58 (tons/acre)

Treatments to		K_2O (cwt./acre)		Original treatment (1933–51):					
				Straw		Compost		Fertilizers only	
				Nitrogen (cwt. N/acre) to potatoes					
Potatoes	Preceding sugar beet	Potatoes	Preceding sugar beet	0·4	0·8	0·4	0·8	0·4	0·8
—	—	0·5	0·75	7·54	8·60	7·36	8·52	6·97	8·31
		1·0	0·25	7·80	9·14	7·73	9·07	7·50	8·70
		Mean		7·67	8·87	7·54	8·79	7·24	8 50
		Difference		0·26	0·54	0·37	0·55	0·53	0·39
S + 0·2 cwt. N/acre	—	0·5	0·75	7·96	9·52	—	8·76	—	—
		1·0	0·25	8·44	9·85	—	8·94	—	—
		Mean		8·20	9·68	—	8·85	—	—
		Difference		0·48	0·33	—	0·18	—	—
K_s	—	0·5	0·75	8·05	9·18	—	9·29	—	—
		1·0	0·25	7·96	10·13	—	10·00	—	—
		Mean		8·01	9·66	—	9·64	—	—
		Difference		−0·09	0·95	—	0·71	—	—
—	S + 0·2 cwt. N/acre	0·5	0·75	8·41	9·37	8·44	—	—	—
		1·0	0·25	8·33	9·69	7·86	—	—	—
		Mean		8·37	9·53	8·15	—	—	—
		Difference		−0·08	0·32	−0·58	—	—	—
—	K_s	0·5	0·75	8·02	9·21	8·19	—	—	—
		1·0	0·25	8·55	9·66	8·17	—	—	—
		Mean		8·28	9·43	8·18	—	—	—
		Difference		0·53	0·45	−0·02	—	—	—

Results. Mean yields of potatoes, barley grain and sugar in the revised experiment are set out in Tables 6–8. The results for 1952, the initial year of the revised scheme, are not included, because some plots did not receive their new treatments until 1953.

The mean yields set out in Tables 6–8 tend to support the hypothesis that the total immediate effect of straw ploughed in is to reduce available nitrogen and increase supplies of potassium.

Neither barley nor sugar beet showed any significant response to potassium, but both crops responded to nitrogen, the average responses to 0·4 cwt. N/acre being 3·3 ± 0·27 cwt. barley grain/acre

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and 6·4 ± 0·40 cwt. sugar/acre. Apart from a small decrease in the yield of barley at the lower level of nitrogen, straw ploughed in during the autumn with an additional 0·2 cwt. N/acre applied in the spring had little effect on the yields of the following crops of sugar beet or barley. Thus the effect of straw alone, without

TABLE 7

Mean yields of barley, 1953–58 (cwt. grain/acre)

Treatments to		Original treatment (1933–1951)					
		Straw		Compost		Fertilizers only	
		Nitrogen (cwt. N/acre) to barley:					
Barley	Preceding potatoes	0·0	0·4	0·0	0·4	0·0	0·4
—	—	27·2	30·8	29·4	31·7	27·8	31·1
S + 0·2 cwt N/acre	—	26·3	31·2	—	31·2	—	—
K_s	—	27·7	31·9	—	30·6	—	—
—	S + 0·2 cwt. N/acre	28·2	31·0	29·0	—	—	—
—	K_s	27·4	32·0	27·4	—	—	—
	Mean	27·3	31·3	28·6	31·2	27·8	31·1

additional nitrogen, is equal to the effect resulting from a loss of about 0·2 cwt. of applied N/acre, or possibly a little more with barley.

These results are in line with those obtained in the original experiment. Assuming no response to potassium, the responses to nitrogen quoted above and the standard nitrogen response curve,

TABLE 8

Mean yields of sugar beet, 1953–58 (cwt. sugar/acre)

Treatments to		Original treatment (1933–51):					
		Straw		Compost		Fertilizers only	
		Nitrogen (cwt. N/acre) to sugar beet:					
Sugar beet	Preceding barley	0·2	0·6	0·2	0·6	0·2	0·6
—	—	35·9	42·5	34·4	43·0	34·4	41·7
S + 0·2 cwt. N/acre	—	35·7	42·2	—	41·2	—	—
K_s	—	37·6	43·4	—	41·0	—	—
—	S + 0·2 cwt. N/acre	37·0	44·0	34·6	—	—	—
—	K_s	36·9	41·6	37·8	—	—	—
	Mean	36·5	42·7	35·6	41·7	34·4	41·7

the decreases in yield from straw alone would be expected to be about 1·2 cwt. barley grain/acre and about 2·5 cwt. sugar/acre at the higher level of nitrogen. The actual decreases between 1934 and 1951 averaged 1·5 cwt. barley grain/acre and 2·3 cwt. sugar/acre.

Potatoes also responded well to nitrogen. There were also appreciable responses to potassium, but these were somewhat irregular, more so in fact than would be expected from experimental error. As far as can be judged, however, the results do not contradict the hypothesis that potatoes benefit from potassium provided by the straw. Straw together with an additional 0·2 cwt. N/acre applied to potatoes produced almost as good yields as the potassium equivalent of straw. Thus, if the additional nitrogen merely compensated

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for losses from immobilization by the straw, as appears to have happened with the other two crops, the benefit from the straw was about the same as that from an equivalent amount of potassium. The increased yield on application of straw to potatoes in the original experiment was 0·42 tons/acre (at the higher levels of nitrogen and potassium), a little but not significantly greater than would be expected from the results of the revised experiment. It should be remembered, in this connection, that the method of applying fertilizer to potatoes and the method of planting potatoes were changed between the two parts of the experiment.

The revised experiment also provides information on the long-term effects of straw applied every 2 years between 1933 and 1951. Both sugar beet and potatoes showed residual effects of the original straw treatments, but there is no evidence of similar effects on barley.

At the lower level of nitrogen the old straw plots yielded, on the average, between 1953 and 1958, 2·1 $\pm$ 0·69 cwt. more sugar/acre than plots receiving fertilizers only throughout the experiment. This difference was considerably decreased by giving 0·4 cwt. N/acre. The old compost plots showed a similar but smaller residual effect.

For potatoes the residual effects were about the same at each level of nitrogen and each level of potassium. The mean yields for plots receiving fertilizers only since 1951 were as follows:

	Original treatment (1933–51):		
	Straw	Compost	Fertilizers only
Mean yield, 1953–58 (tons potatoes/acre)	8·27	8·17	7·87

The difference between the old straw plots and the old fertilizer plots averaged 0·40 $\pm$ 0·144 tons potatoes/acre and is, therefore, significant.

It is of interest to consider whether these long-term residual effects could be caused by residues of nutrients or by some factor or factors influencing the capacity of the crops to respond to nutrients. The average amounts of N, P and K applied per annum (including basal dressings) between 1933 and 1951, allowing for losses in composting and nutrients in straw, were approximately as follows:

Treatment	Cwt./acre N	P_2O_5	K_2O
Straw	0·55	0·45	0·80
Compost	0·45	0·35	0·65
Fertilizers only	0·40	0·40	0·50

Thus the plots originally receiving the largest amounts of nutrients in the first part of the experiment showed the largest residual effects in the second part. Some part of the nitrogen was immobilized by the straw and compost, and may later have become available to the crops.

There are indications that the residual effects may have been related to supplies of nitrogen. The increased yields of sugar on the old straw and compost plots, relative to the old fertilizer plots, were about equivalent to those which would be expected from extra dressings of 0·08 cwt. N/acre and 0·04 cwt. N/acre, respectively.

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Also, the residual effects on potatoes in individual years showed a significant positive correlation with responses to nitrogen. However, some factor besides nitrogen is also indicated by the results for potatoes, because the residual effects for this crop were scarcely affected by the addition of 0·4 cwt. N/acre. A proper assessment of the various possibilities on the basis of yield values alone is impossible, but it is at least conceivable that the residual effects on potatoes were associated with both nitrogen and potassium supplies, the response to either nutrient being limited by the availability of the other.

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