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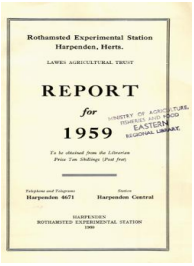

Farmyard Manure and Its Interactions With Fertilisers

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broadcast nitrogen, and drilled nitrogen was not noticeably harmful; only one big effect was obtained, and this was in favour of drilling.

In 1957, a dry year, plants were counted at Rothamsted. The effects were less well determined than in the other years, but sulphate of ammonia drilled at the highest rate gave fewer wheat plants than when broadcast; on barley, effects were smaller and in favour of drilling.

For both spring wheat and barley at Rothamsted sulphate of ammonia was generally more effective when combine-drilled than when broadcast. At 3½ cwt./acre, the highest rate tested, the mean advantage in favour of combine drilling was +2·3 cwt. of wheat grain and 0·9 cwt of barley, even though the plant populations were sometimes decreased by combine-drilling. At Woburn combine-drilling was less favourable, particularly in the dry year 1957, when the heaviest dressing of drilled nitrogen gave a yield of barley significantly below that given by broadcast nitrogen; in 1958 the same happened with spring wheat. In the wet spring of 1959 barley benefited from drilling even the heaviest dressing of nitrogen. Combine-drilling a small dressing (0·2 cwt. N) was never harmful at Woburn.

Farmyard Manure and its Interactions with Fertilisers

by H. D. Patterson & D. J. Watson

Eight experiments of uniform design were made to measure the responses of crop yield to increasing dressings of farmyard manure and how they depend on fertiliser applications, and from these relationships to assess how far the effects of farmyard manure can be ascribed to the plant nutrients it supplies. Another purpose was to compare the use of farmyard manure on potatoes and sugar beet, so experiments with both crops in the same field were made at Rothamsted and Woburn in 1956 and 1957. The treatments were all combinations of:

Farmyard manure: 0, 5, 10, 20 tons/acre ploughed in during the winter;
N: ammonium sulphate at 0 and 0·9 cwt. N/acre;
P: superphosphate at 0 and 0·75 cwt. P_2O_5/acre;
K: potassium chloride at 0 and 1·5 cwt. K_2O/acre;
and for sugar beet only,
S: agricultural salt at 0 and 5 cwt./acre.

The NPK fertilisers were broadcast in the seedbed and the salt was broadcast some weeks earlier. Each experiment had 4 randomised blocks of 16 plots (i.e., two replicates for potatoes and a single replicate for sugar beet).

Tables 1 and 2 show the mean yields of potatoes and sugar beet over the 2 years and distinguishes between rates of farmyard manure and rates of those fertilisers that were effective. The tables also give responses to manure of 10 tons farmyard manure/acre, averaged over the whole range of rates of application, for each fertiliser treatment.

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TABLE 1

Effects of farmyard manure on potatoes

Mean yields of potatoes, 1956–57 (tons/acre)

Fertiliser	Rothamsted Farmyard manure (tons/acre) 0	5	10	20	Mean increase/10 tons farmyard manure/acre
		(±0·44)			(±0·30)
—	9·84	10·74	12·76	13·89	2·10
N	9·96	11·24	12·58	14·24	2·13
P	9·14	11·90	13·11	14·00	2·25
NP	10·94	13·50	14·83	15·20	1·97
K	10·06	11·32	13·42	13·56	1·78
NK	11·20	13·38	13·38	14·12	1·25
PK	12·64	13·77	14·32	15·45	1·35
NPK	13·91	15·02	15·68	15·98	0·98

Fertiliser	Woburn Farmyard manure (tons/acre) 0	5	10	20	
		(±0·46)			(±0·31)
—	9·02	10·24	11·00	13·26	2·08
N	12·64	13·85	14·69	15·26	1·26
K	9·85	9·62	10·98	12·69	1·56
NK	13·98	14·22	14·95	15·16	0·62

Responses to farmyard manure were obtained in all experiments. At Rothamsted potatoes responded to all three main nutrients N, P and K (Table 3). In the same fields no additional sugar was obtained from N applied to sugar beet, but responses to P were unusually large; the main effects of P without farmyard manure were 13·0 cwt. sugar/acre on Great Field II in 1956 and 8·8 cwt. sugar/acre on West Barnfield II in 1957. At Woburn responses to N were large

TABLE 2

Effects of farmyard manure on sugar beet

Mean yields of sugar, 1956–57 (cwt./acre)

Fertiliser	Rothamsted Farmyard manure (tons/acre) 0	5	10	20	Mean increase/10 tons farmyard manure/acre
		(±2·21)			(±1·49)
—	26·7	32·5	39·5	44·3	8·8
P	32·8	40·1	42·9	46·8	6·5
K	30·7	33·8	38·1	42·3	5·9
PK	39·3	44·6	45·7	49·4	4·7
S	30·7	39·0	44·2	44·6	6·5
PS	44·8	45·4	49·7	49·9	2·8
KS	30·3	39·8	43·7	45·6	7·0
PKS	45·2	48·1	46·2	53·0	3·6

Fertiliser	Woburn Farmyard manure (tons/acre) 0	5	10	20	
		(±1·77)			(±1·20)
—	44·3	51·4	51·8	60·8	7·7
N	55·6	56·8	61·7	61·3	3·1
S	47·6	57·8	57·5	59·4	4·9
NS	60·4	62·2	62·3	63·6	1·4

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TABLE 3

	Potatoes (tons/acre) Rothamsted	Woburn		Sugar beet (cwt. sugar/ acre) Rothamsted	Woburn
Mean effects of fertilisers in the absence of farmyard manure					
	(±0·31)	(±0·46)		(±1·57)	(±1·78)
N	1·08	3·88	N	−0·8	12·1
P	1·38	0·21	P	10·9	−0·1
K	1·98	1·08	K	2·6	0·8
			S	5·4	4·1
Mean effects on fertiliser responses of 10 tons farmyard manure/acre					
	(±0·21)	(±0·31)		(±1·06)	(±1·19)
N	−0·28	−0·88	N	−0·7	−4·1
P	−0·18	0·18	P	−2·6	−1·2
K	−0·77	−0·58	K	−0·8	−0·3
			S	−1·5	−2·2

in both crops; potatoes also responded to K but not to P. Salt increased yields of sugar at both farms.

In general, responses to fertilisers were decreased by adding farmyard manure (Table 3); decreases were greatest when main effects were greatest.

The large decrease in N response at Woburn, particularly in sugar yield, caused by adding farmyard manure, deserves special mention, because farmyard manure has often been supposed to have little effect on responses to N fertilisers. In this connexion Boyd (1959) * showed that, although responses to N may be unaffected or even increased by applying farmyard manure when P or K is deficient, responses may be decreased when supplies of P and K are adequate. Responses to P and K were relatively small at Woburn, and there is no evidence that lack of either nutrient limited responses to N.

These effects of farmyard manure on responses to fertilisers (and vice-versa, see Tables 1 and 2) are to be expected if farmyard manure acts mainly by supplying the major plant nutrients. As only two levels of each fertiliser were tested and as the experiments were few, the results are inadequate for an independent assessment of the fertiliser equivalents of farmyard manure. They can, however, be used to test the conclusion of Boyd (1959) from work on potatoes, that each 10 tons of farmyard manure effectively equals 0·3 cwt. N, 0·4 cwt. P_2O_5 and 0·75 cwt. K_2O applied as fertiliser. The method of analysis used involved the calculation of multiple regressions on the total effective amounts of nutrients applied to each plot on the hypothesis under test, and is too complicated to describe here.

The results with potatoes support Boyd's hypothesis, but there is an indication that farmyard manure increased the sugar yield of sugar beet more than the suggested fertiliser equivalents. This point can be demonstrated by comparing (*a*) the yields obtained from full fertiliser dressings excluding salt but no farmyard manure, and (*b*) the yields obtained from 20 tons farmyard manure/acre and no fertilisers, in Tables 1 and 2. On the hypothesis under test yield (*b*) should be rather less than (*a*), whereas for sugar (*b*) exceeds (*a*) by about 5 cwt./acre at both farms. Thus the N, P or K equivalents of

* *J. agric. Sci.* **52**, 384–91.

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farmyard manure may be greater for sugar beet than for potatoes, but it seems more likely that some other factor is involved. The fact that the effect of salt on sugar beet decreases as more farmyard manure is added may be relevant; the combination of NPK and salt gives as good yields of sugar as does 20 tons farmyard manure/acre. Chemical analyses showed that the farmyard manure contained insufficient sodium to account for the differences between its effects on potatoes and sugar beet.

The conclusion, that farmyard manure is more effective relative to fertilisers for sugar beet than for potatoes, does not of course imply that farmyard manure applied to sugar beet gives a greater economic return than farmyard manure applied to potatoes; this depends on the relative prices of the two crops.

Residual effects

To provide information on the residual effects of farmyard manure each of the experiments was continued for a second year in a barley crop. This received the following fertiliser treatments, combined factorially with the treatments to the previous crop:

N: " Nitro-Chalk " at two levels, 0 and 0·4 cwt. N/acre;

and, after potatoes at Rothamsted only:

P: Superphosphate at two levels, 0 and 0·4 cwt. P_2O_5/acre.

The barley after potatoes at Rothamsted received a basal dressing of 0·8 cwt. K_2O/acre as potassium chloride. In the other experiments in 1957 0·4 cwt. P_2O_5 and 0·2 cwt. K_2O/acre, and in 1958 0·4 cwt. P_2O_5 and 0·4 cwt. K_2O/acre were applied as compound fertilisers.

TABLE 4

Residual Effects

Mean yields of barley (cwt./acre)

Fertilisers *	Farmyard manure to previous potatoes or sugar beet: 0 tons/acre	5 tons/acre	10 tons/acre	20 tons/acre	0 tons/acre	5 tons/acre	10 tons/acre	20 tons/acre
	Rothamsted (4 experiments) (±0·40)				Woburn (4 experiments) (±0·82)			
—	33·6	35·4	36·5	37·1	17·6	18·5	20·1	21·7
N_r	36·3	37·0	37·3	38·7	19·7	19·4	20·8	22·1
N	38·0	39·1	38·9	39·9	27·7	26·5	29·0	29·8
N_rN	37·8	38·4	38·4	39·2	27·4	28·7	28·6	29·9
	Rothamsted (2 experiments with sugar beet) (±0·41)							
—	35·5	36·6	36·9	38·2				
P_r	36·6	38·0	38·6	39·5				
	Rothamsted (2 experiments with potatoes) (±0·54)							
—	33·4	35·6	35·8	37·0				
P_r	36·6	37·5	38·0	39·5				
P	37·9	37·8	38·6	38·9				
P_rP	39·4	40·0	38·9	39·2				

* Averages over both levels of all other fertilisers. The suffix r denotes that the N or P was applied to the previous crop.

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When no fertilisers were applied to either crop, 20 tons farmyard manure/acre gave residual responses of 3–4 cwt. barley grain/acre (Table 4). These residual effects were, however, smaller when N fertiliser was applied in either year. At Rothamsted applying P fertiliser also decreased the residual effect on barley of farmyard manure applied to potatoes.

These results suggest that farmyard manure can supply both N and P in the year after application; the same may be true of K, but the experiments did not include a test of K fertiliser for barley, nor did K applied to the previous crop affect the barley. The residual effects of farmyard manure are estimated to have been equivalent to about 0·1 cwt. N and 0·15 cwt. P_2O_5/10 tons of farmyard manure/acre.

Ammonium sulphate applied to sugar beet or potatoes given no farmyard manure produced small but definite increases in the yields of the following barley crops both at Rothamsted and Woburn. This is contrary to the commonly held idea that the effects of this fertiliser on annual crops are confined to the year of application, but agrees with recent work of the Chemistry Department (see page 48.) At Rothamsted the residual effects of 0·9 cwt. N/acre were about the same as the effects of 0·1 to 0·15 cwt. N/acre applied directly to the barley. At Woburn the equivalents were much smaller, although the actual effects were about the same because the crops responded much more to N.

The residual effects of ammonium sulphate were decreased by farmyard manure residues or N fertiliser applied to the barley. In the presence of both factors the residual effect was actually negative in the experiments with sugar beet, averaging $-1{\cdot}6 \pm 0{\cdot}4$ cwt. grain/acre over the two highest levels of farmyard manure. No explanation can be offered for this effect, which was not repeated in the experiments with potatoes.

The residues of 0·75 cwt. P_2O_5/acre applied as superphosphate to potatoes at Rothamsted were equivalent to about 0·3 cwt. P_2O_5/acre applied to the barley. This is in accordance with the results of other experiments (see, for example, the summary of the four-course rotation experiment given in *Rep. Rothamst. exp. Sta.* for 1954, p. 153).

Although these experiments agree with the hypothesis that farmyard manure acts mainly by supplying mineral nutrients, a critical test of whether its effect is wholly nutritional would require much more elaborate experiments with many treatments, preferably conducted on soils where substantial effects of organic matter on soil structure are to be expected, and with a number of contrasting crops.

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