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Report for 1962

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The Woburn Long-term Green-manuring Experiment: Revised Scheme, Summary 1955-62

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(4) Proportionally more beet plants bolted on the organic manure plots, particularly those with sewage sludge.

(5) A slightly larger percentage of marketable leeks was obtained on manure plots.

(6) The proportion of headed cabbages was largest on the manure plots.

Point (4) was dealt with in detail by Mann (1951). It is not possible to judge how far these effects were caused by factors other than nutrients in the manures. Nitrogen fertiliser also affected the features mentioned in (4), (5) and (6), but less so than the organic manures.

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The Woburn Long-term Green-manuring Experiment: Revised Scheme, Summary 1955–62

By T. W. Barnes and R. T. Clarke

The original experiment (1936–53) was designed to test the effects of four green manures on kale (replaced by winter cabbages in 1946) followed by barley. Two of the green manures were the legumes, lupins and clover; the other two were rape and ryegrass. The clover and ryegrass were undersown in the barley, and the lupins and rape were sown in spring. The following treatments for kale (later cabbages) were also tested factorially on plots both with and without green manures: (1) farmyard manure; (2) straw ploughed in; (3) nitrogen fertiliser. From 1944 onwards a top dressing of nitrogen was also tested on the barley.

The results of the experiment up to 1953 were reported by Mann (1959). Clover and lupins increased the yield of cabbages, and lupins had a small but significant residual effect on barley. Ryegrass and rape lowered the yield of cabbages and had little or no effect on the barley. Straw was ineffective, but 10 tons farmyard manure/acre produced larger effects than any other treatment.

The green manures were ploughed in during June or July, so the choice of crops to follow them was severely restricted. The experiment was therefore redesigned in 1954 to fit the green manures into the main cropping scheme instead of vice versa, and also because club-root was damaging the cabbage. In the redesigned experiment the effects of two green manures, trefoil and ryegrass undersown in the barley, were tested on early potatoes, and the effects of trefoil and of ryegrass sown after lifting the early potatoes were tested on barley. Before 1954 the sulphate of ammonia had been applied when the green manures were ploughed in, so that the kale (or cabbages) did not derive maximum benefit from its application. In the new scheme the nitrogen fertiliser was therefore applied in the seedbeds of the test crops. Mann (1959) states that a green manure should be followed as soon as possible by the crop which it is intended to benefit, but as the

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bulk of green manure was often diminished by frost and other causes during winter, the experiment was further modified to determine the effect of ploughing in green manure in autumn instead of in spring. Plots that grew no green-manure crop before 1954 again grew none in the re-designed experiment.

Description of the revised experiment. The experiment consisted of 80 plots divided into two series of 40. Crops of barley and early potatoes were taken in succession from each series; in any one year barley grew on one series, early potatoes on the other. There were four treatment-crop sequences with green manure:

T: trefoil grown as a green manure after early potatoes, in preparation for barley.
R: ryegrass grown after early potatoes, in preparation for barley.
T_u: as *T*, but with trefoil undersown in the barley in preparation for the coming potato crop.
R_u: as *R*, but with ryegrass undersown in the barley in preparation for the potato crop.

These were combined factorially with the following:

S: chaffed barley straw applied after the barley harvest at two rates, 0 and 30 cwt/acre.
E: autumn *v.* spring ploughing in of the green manures before the barley crop was sown.
N: "Nitro-Chalk" applied to the barley seedbed at two rates, 0·23 and 0·46 cwt N/acre, followed on the same plots by 0·6 and 1·2 cwt N/acre to the seedbed of the early potato crop.
D: farmyard manure applied at two rates, 0 and 10 tons/acre to the kale (later cabbage) crops of the period 1936–54. Farmyard manure was not applied after 1954.

Thirty-two plots from each series formed a half replicate of a 4×2^4 factorial with defining contrast $I = (T_u + R - R_u - T) \times SEND$. The remaining eight plots in each series grew no green manure and formed one replicate of the eight combinations of *D*, *S* and *N* at the above rates. For convenience these plots will be called fallow (*F*). A basal granular compound PK fertiliser was given to the early potatoes at 0·75 cwt/acre of P_2O_5 and 1·5 cwt/acre of K_2O before mechanical planting. The barley and green-manure crops received no basal fertiliser but a dressing of ground chalk which ranged over the years between 15 and 23 cwt/acre. Until 1959 this was applied before the barley crop was sown, but later plots received ground chalk after the preceding potato crop had been lifted and before the trefoil and ryegrass were sown. Ulster Chieftain was the variety of potatoes grown in all years, and Herta barley was grown every year except 1962, when it was replaced by Proctor.

Results. Every year of the experiment the roots and tops of the green-manure crops were collected from a 3-sq ft sample area of each plot on

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TABLE 1

Estimated mean amounts of dry matter and N (cwt/acre) ploughed in as green manure, 1955–62

Green manure	Time of ploughing	Following crop	DM	N	Ratio N : DM
Trefoil	Autumn	Barley	22·6	0·729	0·032
Ryegrass	Autumn	Barley	26·5	0·462	0·017
Trefoil	Spring	Barley	11·2	0·339	0·030
Ryegrass	Spring	Barley	23·7	0·431	0·018
Trefoil	Spring	Potatoes	16·8	0·497	0·030
Ryegrass	Spring	Potatoes	19·6	0·262	0·013

TABLE 2

Mean nitrogen percentage in the top 9 in. of soil (February 1961)

Green manure	Time of ploughing	N dressing Low	High	Mean
		(±0·0031)		(±0·0022)
Trefoil	Autumn	0·099	0·104	0·102
Ryegrass	Autumn	0·093	0·097	0·095
Trefoil	Spring	0·099	0·103	0·101
Ryegrass	Spring	0·098	0·100	0·099
Fallow		0·089	0·090	0·090
Mean (±0·0014)		0·095	0·099	0·097

		Mean % N in soil
Straw (cwt/acre) after barley harvest	0	0·094
	30	0·100
FYM (tons/acre) applied biennially 1936–55	0	0·092
	10	0·101

TABLE 3

Mean yields of barley 1955–62 (cwt grain/acre)

Green manure	Time of ploughing		Nitrogen (cwt/acre) to barley 0·23	0·46	Mean	Difference
			(±0·86)		(±0·61)	(±1·22)
Trefoil	Autumn		25·8	28·0	26·9	2·2
Ryegrass	Autumn		21·8	25·8	23·8	4·0
Trefoil	Spring		28·7	30·4	29·5	1·7
Ryegrass	Spring		25·6	30·4	28·0	4·8
Fallow			18·8	23·5	21·2	4·7
			(±0·54)		(±0·38)	(±0·76)
FYM (tons/acre)	applied	0	23·3	26·9	25·1	3·6
before 1955		10	24·9	28·3	26·6	3·4
Mean (±0·38)			24·1	27·6	25·8	3·5

TABLE 4

Mean yields of potatoes 1955–62 (tons/acre)

		F	T_u	R_u	T	R	Mean
				(±0·188)			(±0·084)
Straw (cwt/acre)	0	5·12	5·95	5·54	5·33	5·35	5·46
	30	5·30	5·56	5·72	5·64	5·30	5·50
FYM (tons/acre)	0	4·81	5·34	5·16	4·98	5·11	5·08
	10	5·60	6·14	6·10	5·99	5·54	5·87
N (cwt/acre) to	0·6	4·96	5·63	5·51	5·45	5·18	5·35
potatoes	1·2	5·46	5·88	5·75	5·52	5·46	5·62
Mean (±0·134)		5·21	5·76	5·63	5·48	5·32	5·48

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which they were grown. The amounts of dry matter and N ploughed in were estimated from these samples (Table 1). In February 1961 all plots were sampled to a depth of 9 in. for the measurement of nitrogen in the soil (Table 2). Tables 3 and 4 show the mean yields of barley and potatoes for the period 1955–62.

Discussion. Both green manures increased the mean yield of barley, trefoil by 7·0 ± 0·75 cwt/acre and ryegrass by 4·7 ± 0·75 cwt/acre, but their effects depended on the time of ploughing in and the amount of nitrogen given to the barley (Table 3).

Table 3 also shows that barley responded less to nitrogen after trefoil (2·0 ± 0·86 cwt/acre) than after ryegrass (4·4 ± 0·86 cwt/acre) or after fallow (4·7 ± 1·22 cwt/acre). This difference in nitrogen response is perhaps associated with the larger mean nitrogen content of the legume. Ploughing in during spring enhanced the effects of both green manures, and with spring ploughing barley yields after ryegrass were as good as after trefoil, when the barley also received the larger N dressing. Both green manures, but particularly the trefoil, contained considerably more dry matter and nitrogen in autumn than in spring (Table 1). Presumably much of the nitrogen was lost from the unploughed crop by drainage or other causes during the winter. Comparison of the amounts of nitrogen ploughed in as green manure in autumn with the standard nitrogen-response curve constructed with $k = 1{\cdot}1$ (Crowther & Yates, 1941) showed that the increase in yield after the autumn-ploughed trefoil was the same as would be obtained from 0·49 cwt N fertiliser/acre; in fact, 0·73 cwt N/acre had been added in the green manure. The 0·46 cwt N/acre supplied in the ryegrass was equivalent to a dressing of only 0·17 cwt N fertiliser/acre. Thus, about a third of the nitrogen supplied by the trefoil and more than half the nitrogen supplied by the ryegrass was lost during the winter. When the green manures were ploughed in during spring, however, the barley yields were at least as good as those from equivalent nitrogen dressings.

The residues of FYM applied before 1954 increased barley yields by 1·5 ± 0·54 cwt/acre over the course of the revised experiment (Table 5).

TABLE 5

Mean responses to residual FYM

Crop	Period 1955–58	1959–62	1955–62
Barley (cwt/acre)	1·8 ± 0·61	1·1 ± 0·82	1·5 ± 0·54
Potatoes (tons/acre)	1·03 ± 0·181	0·54 ± 0·128	0·79 ± 0·119

Table 6 shows that the residual effect on barley after ryegrass (2·4 ± 0·86 cwt/acre) was greater than on barley after trefoil (0·8 ± 0·86 cwt/acre) or no green manure (0·8 ± 1·22 cwt/acre).

There was no evidence throughout the experiment that undersowing the barley significantly affected its mean yield. When undersown with trefoil, yield was increased by 0·4 ± 0·86 cwt/acre and when undersown with ryegrass by 1·0 ± 0·86 cwt/acre.

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TABLE 6

Mean barley yields (cwt/acre) with and without residual FYM after green manuring treatments (1955–62)

		Fallow (±0·86)	Trefoil (±0·61)	Ryegrass (±0·61)	Mean (±0·38)
Residual FYM (tons/acre)	0	20·7	27·8	24·7	25·1
	10	21·5	28·6	27·1	26·6
Mean		21·1 (±0·61)	25·9 (±0·43)	27·2 (±0·43)	25·8

Early potatoes. Table 4 shows that both trefoil and ryegrass undersown in the barley increased yields of potatoes by 0·55 ± 0·189 tons/acre and 0·42 ± 0·189 tons/acre respectively. These responses may be slightly overestimated, however, because small residual effects from the previous green manures (grown for the barley preceding the early potatoes) were also apparent. In individual years responses to green manuring were positive but seldom large enough to be statistically significant, and although the effects of green manures on the early potato crop were less than on barley, the increase of ½ ton/acre they produced is of considerable importance in a crop that fetches high prices.

The larger nitrogen dressing increased yield of early potatoes after each green manure by about the same extent, 0·27 ± 0·119 tons/acre on average.

The straw application had no effect on yield of early potatoes (Table 4). There was no evidence that the straw which lay on the trefoil plots through the winter decreased the amount of N ploughed in as trefoil green manure before the early potato crop.

The residual effects of FYM were larger on potatoes than on barley (Table 5), averaging 0·79 ± 0·119 ton/acre. There was no evidence that the responses to residual FYM differed after different green manures, as they did with barley.

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