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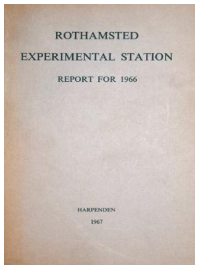
ROTHAMSTED RESEARCH

Rothamsted Report for 1966

Full Table of Content



The Effect of Chalk on Soil pH and the Yield of Beans

J. R. Moffatt

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sowing gave a similar big response to N in 1964; the mean yield of plots given 1 cwt N/acre was almost twice that of plots given 0·4 cwt. In 1965 and 1966 increasing the amounts of N decreased yield with all methods of sowing.

Conclusions

The conclusions drawn from these experiments are:

1. Yields of winter wheat were nearly the same, however it was sown; yields of barley were a little larger from 4-in. than from 7-in. rows, and a little smaller from broadcast than from drilled seed, but in 1965, in dry weather, broadcasting gave much smaller yields at Rothamsted.
2. On these fertile soils there was no advantage from combine-drilling NPK fertilisers for winter wheat or PK fertilisers for spring barley.
3. Sowing 140 lb seed/acre always gave a larger yield of winter wheat than sowing 240 lb; yields of barley were also larger with the smaller seed-rate when the seed was drilled, but not when it was broadcast.
4. The largest amounts of N (0·8 and 1·2 cwt N/acre) caused the wheat to lodge (it followed well-manured potatoes) and decreased yield; with barley the best amount of N depended on the previous cropping, but the largest amounts given caused lodging and loss of yield on the most fertile soils.
5. Changing seed-rates and amounts of N affected yield more than changes in methods of sowing.

The Effect of Chalk on Soil pH and the Yield of Beans

By J. R. Moffatt

The acreage of beans in England and Wales is increasing, mainly because of the necessity for "break" crops in rotations where cereals predominate. Most factors affecting their yield have been investigated, and two main reasons for their greater reliability and larger yields are the use of systemic insecticides to control black aphids, and residual weedkillers. Water is important, and in dry seasons irrigation is needed to give good yields, especially on light soils.

Another, less widely recognised, factor affecting the yield of beans is the soil pH, a measure of acidity. A few years ago beans grew poorly in patches at Rothamsted and Woburn where the only known difference from other parts of the field was in the soil pH, though acidity was not thought enough to be the cause. To find whether pH differences within this range affected beans, experiments were done at Rothamsted and Woburn in fields initially acid.

The first experiment at Rothamsted ran for three years (1961–63) on a site where in 1960 pH ranged between 5·9 and 6·3; five pH values were

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produced by applying four amounts of finely ground chalk (through $\frac{1}{8}$-in. mesh) of 47% neutralising value, in December 1960, half before ploughing and half after. The effect of the carbonate on the pH value over the 3 years of the experiment was:

TABLE 1

pH range

Ground chalk: tons/acre

	0	1	2	3	4
Before chalking	6·0–6·1	5·9–6·2	6·0–6·3	5·9–6·3	6·0–6·2
After 1st Crop	6·0–6·3	6·5–6·6	6·8–7·0	7·0–7·2	7·0–7·4
After 2nd Crop	6·2–6·5	6·4–6·6	6·7–6·9	6·8–7·3	7·1–7·6
After 3rd Crop	6·3–6·4	6·5–6·8	6·9–7·1	7·1–7·4	7·1–7·7

There were four blocks each of five plots; the plots were 60 ft long and 14 ft wide.

Spring tick beans (Garton's 30B) were sown in 1961 at 200 lb/acre and winter beans (Garton's S.Q. Pedigree) in 1962 and 1963 at 275 lb/acre. Each year $3\frac{1}{4}$ cwt/acre of a 0 : 14 : 28 granular compound fertiliser was placement drilled. The rows were 21 in. apart.

The spring beans in 1961 were sprayed with "Metasystox"; winter beans were not sprayed in 1962, but were sprayed with menazon in 1963. The site of the 1963 crop was sprayed with simazine in December 1962 at 1 lb/acre (a.i.).

Five rows of each plot were combine-harvested in 1961 and 1962. The 1963 crop suffered badly from the hard winter; two blocks had to be discarded, from another only one row per plot was harvested, and on the fourth the rows harvested were fewer than planned.

In 1961 the spring beans on the more acid plots were lighter in colour, less tall and generally less vigorous than the others; visual difference in the winter beans of 1962 were small, though there were rather fewer plants on the acid plots, and they were shorter. Chocolate Spot (*Botrytis* spp.) was widespread in 1962 and hastened leaf-fall, but it occurred late and had little effect on yield. The date of leaf-fall differed greatly on different plots; by 11 August about 80% of the plants on the most acid plots had lost all their leaves, but only 7% had done so on the least acid ones. In 1963 the plants were so damaged by frost that visual observations were not made.

TABLE 2

Grain (at 85% DM): cwt/acre

Ground chalk: tons/acre

	0	1	2	3	4	
Mean pH	6·3	6·6	6·9	7·1	7·3	Mean
1961*(±0·82)	15·0	17·9	21·7	22·0	22·5	19·8
1962 (±0·65)	26·3	28·1	29·9	31·9	30·7	29·4
1963 (±2·83)	10·3	16·7	18·5	27·3	27·7	20·1
Mean	17·2	20·9	23·4	27·1	27·0	23·1

* Spring beans.

Each year the beans in the pH ranges above 6·7 yielded best; those on the most acid plots yielded poorly.

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TABLE 3

Plant, pod and bean counts (in '000/acre)

Ground chalk: tons/acre

	0			1			2			3			4		
Mean pH		6·3			6·6			6·9			7·1			7·3	
	Stalks	Pods	Beans	Stalks	Pods	Beans	Stalks	Pods	Beans	Stalks	Pods	Beans	Stalks	Pods	Beans
1961	165	738	2,213	178	948	2,845	140	878	2,715	178	990	3,000	163	980	3,033
1962	135	958	2,785	150	1,023	3,055	138	1,028	3,090	145	1,010	3,013	155	1,093	3,213
1963	108	538	1,380	105	740	2,093	105	1,040	2,933	130	1,175	3,483	115	1,010	2,880
Mean	136	745	2,126	144	904	2,665	128	982	2,913	151	1,058	3,165	144	1,028	3,042
Mean beans per pod			2·85			2·95			2·96			2·99			2·96

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In 1961 and 1962 bean plants were pulled from a 2-ft length of each of the five harvested rows; in 1963 five lengths were taken from fewer rows, but on one block only one length per plot was taken. The stalks, pods and number of beans were counted.

There was little difference between treatments in the number of stalks, but the plants on the most acid plots had fewer pods and beans; there was an average of just under three beans per pod in all pH ranges.

Other experiments were done at Rothamsted and Woburn on the same site in each of the three years 1962–64. Each site was old arable land which had not grown beans for many years; the soil was acid and deficient in phosphorus and potassium. The soil at Rothamsted was a clay loam; at Woburn it was light and so usually considered unsuitable for beans.

Three amounts (2, 4 and 6 tons/acre) of finely ground chalk (through $\frac{1}{8}$-in. mesh) were given in spring 1962 to produce four pH ranges. At Rothamsted the initial pH ranged between 4·8 and 5·6, at Woburn between 5·6 and 6·3. At Rothamsted 4 tons of chalk brought the soil to near neutrality, at Woburn 2 tons. Soil samples taken after the first crop showed that the pH at the higher ranges was smaller than desired. At Rothamsted a further 2 tons of chalk was given to the highest range before the second crop was sown; at Woburn $1\frac{1}{2}$ tons was given to the highest range, and $\frac{3}{4}$ ton to the second highest.

TABLE 4

pH range

Ground chalk: tons/acre

Rothamsted

	0	2	4	6·0 (before 1st crop) +2·0 (before 2nd crop)
Before chalking	4·8–5·2	4·9–5·3	4·8–5·4	4·9–5·6
After 1st crop	4·8–5·2	6·0–6·4	6·8–7·2	7·1–7·4
After 2nd crop	4·8–5·2	5·5–6·2	6·3–7·2	7·2–7·4
After 3rd crop	4·8–5·1	5·5–6·1	6·3–7·3	7·3–7·5

Woburn

	0	2	4·0 (before 1st crop) +0·75 (before 2nd crop)	6·0 (before 1st crop) +1·5 (before 2nd crop)
Before chalking	5·6–6·0	5·7–6·2	5·7–6·3	5·7–6·9
After 1st crop	5·7–6·2	6·7–7·1	6·9–7·4	7·2–7·4
After 2nd crop	5·6–5·9	6·5–6·9	7·2–7·5	7·3–8·0
After 3rd crop	5·3–5·7	6·5–6·8	7·1–7·4	7·5–7·6

Each year there was a comparison of no phosphate *v.* 0·5 cwt P_2O_5/acre as superphosphate, and no potash *v.* 1·0 cwt K_2O/acre as muriate of potash; the treatments were cumulative. In 1964 broadcasting phosphate and potash was compared with placement drilling; a basal dressing of 0·25 cwt N was broadcast as "Nitro-Chalk".

In each field there were two randomised blocks of 16 plots each; the plots were 60 ft long and 21 ft wide.

Spring tick beans (Garton's 30B in 1962 and 1963, Garton's Pedigree in

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1964) were sown at 200 lb/acre each year; in 1964 at Woburn they replaced winter beans that had been damaged by birds. Rows were 21 in. apart in 1962 and 1963, and five rows were harvested; in 1964, when rows were 10½ in. apart, 11 rows were harvested at Rothamsted and eight at Woburn. They were cut by combine-harvester.

Each year the ground was sprayed with simazine at 1 lb/acre (a.i.); in 1962 and 1963 the crops were sprayed with "Metasystox", but not in 1964.

At Rothamsted the summer of 1962 was drier than usual, and though much rain fell in the second half of July, it came too late for the bean crop, which yielded poorly. In the dull, wet summer of 1963 the beans grew well and continued to do so into the wet autumn. The crop ripened unevenly and there was some shedding. In the wet June 1964 beans grew well, but in the warm, dry weather in July and August they stopped growing and ripened earlier than usual.

None of the years favoured beans on the light Woburn soil. In 1962 early differences were few, but during the very dry weather in June and early July the crop on the acid plots lost some colour and grew slowly. By mid-July many of the lower bean leaves had turned yellow and dropped. In 1963 May, June and July had little rain and the crop grew slowly. The leaves of the plants on the most acid plots turned yellow before the end of July, and there was a late bean-aphis attack. In August the plants, especially those on the acid plots, died prematurely in patches and yields were small. In 1964 the plants looked short and stunted, probably damage by the residues of simazine applied for the failed autumn sowing. May and July were dry, but the wet June enabled the crop to produce a reasonable yield.

As beans had not been grown on the sites for many years, the plots were divided in 1962 to compare uninoculated seed with seed inoculated with *Rhizobium leguminosarum*. Inoculation had no appreciable effect on yield.

At both Rothamsted and Woburn the plots given both P and K yielded increasingly more as the pH increased to about pH 7, but above this yields were less.

At Rothamsted P always increased yield on the neutral plots, but

TABLE 5

Spring beans Rothamsted and Woburn

Grain (at 85% Dry Matter): cwt/acre (PK plots)

	pH range				
Rothamsted	4·8–5·2	5·8–6·3	6·7–7·2	7·1–7·5	Mean
1962 (±3·01)	10·5	16·7	19·9	18·0	16·3
1963 (±2·42)	12·0	22·0	24·9	24·8	20·9
1964 (±2·52)	15·1	21·6	22·8	19·2	19·7
Mean (±1·54)	12·5	20·1	22·5	20·7	19·0
Woburn	5·6–5·9	6·5–6·9	6·9–7·4	7·3–7·6	Mean
1962 (±1·73)	17·2	20·8	18·9	20·9	19·4
1963 (±1·68)	14·7	22·9	17·7	19·7	18·7
1964 (±1·15)	22·1	22·3	17·8	17·2	19·8
Mean (±0·89)	18·0	22·0	18·1	19·3	19·3

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decreased it at pH 5·5–6·4. In the other ranges the effect varied from year to year. Potash increased yield on all plots except the most acid, where it decreased yield in two of the three years. At Woburn the responses to P were small but mainly positive each year; K lessened the yield on the two alkaline plots in 1962, but in 1963 and 1964 it increased yield on all plots. At both farms the increase from potash was more when phosphate was given.

TABLE 6

Spring beans Rothamsted and Woburn
Summary of results

Grain (at 85% dry matter): cwt/acre
Means over 3 years 1962–64

Rothamsted

pH range	4·8–5·2	5·5–6·4	6·3–7·3	7·1–7·5	Mean
Mean	12·6	18·6	21·0	19·4	17·9
(±0·77)		(±1·09)			(±0·54)
No P	12·7	20·0	21·1	18·3	18·0
P	12·5	17·1	21·0	20·5	17·8
No K	13·2	17·0	19·5	18·1	16·9
K	12·0	20·2	22·6	20·7	18·9

	No P	P
	(±0·77)	
No K	17·3	16·6
K	18·8	19·0

Woburn

pH range	5·3–6·2	6·5–7·1	6·9–7·5	7·2–8·0	Mean
Mean	15·4	17·7	16·2	17·2	16·6
(±0·44)		(±0·62)			(±0·31)
No P	14·1	17·1	16·3	16·5	16·0
P	16·8	18·2	16·1	18·0	17·3
No K	14·4	15·4	15·3	16·6	15·4
K	16·6	20·0	17·2	17·9	17·9

	No P	P
	(±0·44)	
No K	15·6	15·2
K	16·5	19·3

P = 0·5 cwt P_2O_5 as superphosphate
K = 1·0 cwt K_2O as muriate of potash

In 1964 at Rothamsted and Woburn the plots given both P and K were subdivided to compare powder fertiliser broadcast (rates and material as in 1962 and 1963) and placement drilling of a granular compound (0 : 14 : 28) to give about the same amount of P and K. Both methods gave the same yield in each experiment.

In 1962 and 1963 at Rothamsted and Woburn bean plants were pulled from five 2-ft lengths in the harvested rows; in 1964 at Rothamsted when rows were 10½ in. apart, three 2-ft lengths were pulled. The stalks, pods and number of beans were counted.

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TABLE 7

Method of application of fertilisers
Rothamsted and Woburn, 1964

(Grain (at 85% DM): cwt/acre

	pH range				
Rothamsted	4·8–5·1	5·8–5·9	6·7	7·3–7·5	Mean
		(1) and	(2)		(±0·34)
Broadcast	15·1	21·6	22·8	19·2	19·7
Drilled	15·9	21·5	22·4	20·9	20·1
Mean (±1·23)	15·5	21·5	22·6	20·0	19·9
Woburn	5·7	6·6–6·8	7·1–7·4	7·5–7·6	Mean
		(3) and	(4)		(±0·79)
Broadcast	22·1	22·3	17·8	17·2	19·8
Drilled	22·3	21·4	17·4	16·5	19·4
Mean (±0·65)	22·2	21·8	17·6	16·9	19·6

(1) (±0·68) for use in vertical and diagonal comparisons
(2) (±1·80) for use in horizontal and interaction comparisons
(3) (±1·58) for use in vertical and diagonal comparisons
(4) (±1·44) for use in horizontal and interaction comparisons

As in the previous experiment, the number of stalks in each experiment was the same at all pH values, though Woburn had fewer than Rothamsted. At Rothamsted beans in the pH range 4·8–5·2 had fewer pods and beans; the number of beans per pod and the 100-bean weight was slightly less. At Woburn pods and beans were fewer at pH 5·6–6·2, and the 100-bean weight was less. The number of beans per pod was the same at all pH values. Fertilisers had little effect on the number of stalks, pods or beans.

In 1964 at Rothamsted with rows 10½ in. apart there were fewer beans and pods on the acid plots, but there were more pods and beans than in 1962 and 1963, possibly because there were fewer plants per unit length of row. Though the 100-bean weight was similar to 1962 and 1963, the harvested yield was not increased. This may be due to sampling errors in an uneven plant population or to shedding at harvest. The conclusions to be drawn from these experiments are:

1. Applying ground chalk to acid soil increased the yield of beans until the soil was about pH 7.
2. Soil pH had no effect on the number of plants at harvest, but did affect the number of pods and the number and size of beans. It had little effect on the number of beans per pod.
3. Phosphate increased yield at Rothamsted at pH values around 7, but decreased it on acid soil. At Woburn responses were small but positive at all pH values.
4. Potash at Rothamsted increased yield at all except the most acid pH. At Woburn it usually gave more yield at all pH values. At both farms it increased yield more with than without phosphate.
5. When placement drilled, phosphate and potash gave no more yield than when broadcast.
6. Seed inoculated with *Rhizobium leguminosarum* yielded no better than uninoculated seed.

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TABLE 8

Plant, pod and bean counts (in '000/acre) pH range

Rothamsted

pH	4·8–5·2			5·5–6·4			6·3–7·2			7·1–7·4 1962 7·2–7·4 1963		
	Stalks	Pods	Beans	Stalks	Pods	Beans	Stalks	Pods	Beans	Stalks	Pods	Beans
1962	218	795	2,070	215	888	2,410	208	1,040	2,915	220	950	2,575
1963	153	638	1,848	168	1,003	3,013	160	1,115	3,423	158	1,020	3,198
Mean	186	717	1,959	192	946	2,712	184	1,078	3,169	189	985	2,887
Mean beans per pod			2·73			2·87			2·94			2·93
Mean 100 bean/wt in grams at 85% DM			36·83			43·69			43·98			45·27
pH	4·8–5·1			5·5–6·1			6·3–7·3			7·3–7·5		
1964	206	1,044	2,899	216	1,286	3,723	203	1,367	4,000	189	1,377	3,917
Mean beans per pod			2·67			2·90			2·93			2·84
Mean 100 bean/wt in grams at 85% DM			37·46			39·36			40·33			40·53

Woburn

pH	5·6–6·2			6·5–7·1			6·9–7·4 1962 7·2–7·5 1963			7·2–7·4 1962 7·3–8·0 1963		
	Stalks	Pods	Beans	Stalks	Pods	Beans	Stalks	Pods	Beans	Stalks	Pods	Beans
1962	133	828	2,378	133	915	2,755	133	963	2,798	130	1,013	2,913
1963	165	660	1,973	163	835	2,393	163	823	2,258	168	775	2,148
Mean	149	744	2,176	148	875	2,574	148	893	2,528	149	894	2,531
Mean beans per pod			2·92			2·94			2·83			2·83
Mean 100 bean/wt in grams at 85% DM			38·10			42·17			42·59			43·93

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