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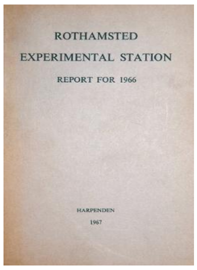

Woburn Experimental Station

C. A. Thorold

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WOBURN EXPERIMENTAL STATION

C. A. THOROLD

T. W. Barnes retired at the end of March after 37 years valuable service.

Woburn soil tends to lack nutrients, especially nitrogen, which is readily leached, and the more than average rain in April, June and August may have affected crop nutrition adversely (Table 1). Winter wheat after summer fallow on widely separated fields suffered so severely from wheat-bulb fly (*Leptohylemyia coarctata*) that it was ploughed in and spring barley sown. Winter wheat after fallow at Woburn has not previously suffered so from bulb fly (*Rothamsted Report* for 1939–45, p. 254). Winter wheat yielded more than 3 tons grain/acre in Workhouse Field, where after potatoes and grass it was uninjured.

TABLE 1

Monthly mean temperatures (means of maximum and minimum), total rainfall and daily means of bright sunshine (departures from long-period means in brackets)

	Mean temperature (° C)	Rainfall (in.)	Bright sunshine (daily mean) (hours)
March	6·1 (+0·6)	0·58 (−1·00)	3·72 (−0·11)
April	7·3 (−0·9)	3·31 (+1·38)	3·01 (−2·09)
May	10·5 (−0·7)	1·88 (−0·32)	6·95 (+0·91)
June	15·3 (+0·9)	4·30 (+2·60)	6·62 (0·00)
July	14·6 (−1·7)	2·38 (−0·06)	4·69 (−1·25)
August	14·5 (−1·5)	3·84 (+1·51)	6·04 (+0·34)
September	13·7 (0·0)	1·92 (−0·10)	5·27 (+0·73)
October	10·1 (+0·3)	4·38 (+2·08)	2·73 (−0·52)

For the first time at Woburn some sugar beet showed symptoms of "Docking disorder", possibly because the spring weather favoured the activity of the nematodes (*Longidorus* and *Trichodorus* spp.), which were found in land where the beet was affected. Some were infected with beet ringspot virus, which is transmitted by *Longidorus* sp., and others with yellows virus.

A sticky aphid-trap caught few vectors of carrot motley dwarf virus until June, but they then became abundant, as in 1965; as then, menazon granules applied with the seed again increased carrot yields by 1 ton/acre. Spraying with "Saphi-col" increased yields by nearly 4 tons/acre.

Intensive cereals experiments. The soil under the old Permanent Wheat and Barley experiments, which were discontinued in their original form in 1927, became acid, contained only about 0·6% organic matter and compacted easily. Experiments were started on the site in 1962 to try to improve the structure (*Rothamsted Report* for 1964, p. 47), and a new long-term experiment began this year to measure the prevalence of soil-borne

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diseases and their effects on the yield of wheat and barley grown continuously and in a five-course rotation: clover/ryegrass ley, potatoes, cereal, cereal, cereal. All crops in the rotation will be grown each year. The winter wheat will be grown on the old Permanent Wheat plots and the spring barley on the old Permanent Barley plots. A basal dressing of 1·0 cwt P_2O_5 and 2·0 cwt K_2O/acre is used to lessen residual effects of the old fertiliser treatments. The leys receive 0·4 cwt N/acre and the potatoes 1·2 cwt N/acre. The cereals, which get four amounts of N, grew well; wheat yields were increased by 0·5 and 1·0 cwt N/acre, but plots given 1·5 and 2 cwt of nitrogen lodged, some severely. Barley yields were increased by 0·4, 0·8 and 1·2 cwt, but not by 1·6, although there was some lodging with only 0·8 cwt N. In spite of uniform manuring, the potatoes and leys yielded very differently in different blocks, suggesting effects from treatments before 1927. Some subplots are superimposed on parts of the original plot positions, and Table 2 shows differences apparently associated with residual effects from the old treatments. The ley plots were not divided into

TABLE 2

Effects of treatments applied between 1876 and 1927 on yields of wheat, barley and potatoes

	Wheat site		Barley site	
Manuring (1876–1927)	Wheat (cwt)	Potatoes (tons)	Barley (cwt)	Potatoes (tons)
Sulphate of ammonia	37·2	6·0	45·7	10·3
No manures	38·3	7·8	46·4	12·0
Nitrate of soda	40·9	8·4	48·0	15·8

subplots for weighing the produce at two cuttings, so yield cannot be related to the "classical" treatments. However, main yields for ley plots on the barley site (47·2 cwt dry matter/acre) exceeded mean yield on the wheat site (39·4 cwt), in agreement with the much greater fertility of the barley site indicated by the potato yields (Table 2).

Irrigation experiments. The previous regular three-course rotations and 3-year leys were broken to continue work on cereal scorch, and start work on potato eelworm (see pp. 35 and 88).

Potatoes. The effect of irrigation on eelworm populations is being tested on Series I and Series IV, which have initial populations differing by a factor of 10, because Series I has carried potatoes three times since 1951, whereas Series IV has carried only ley crops. Populations of eelworms and other soil-inhabiting organisms were modified further by injecting some plots with "D-D" at 400 lb/acre, which almost eliminated the larvae of the potato cyst-nematode. Two potato varieties are grown, Pentland Dell, which is fully susceptible, and Maris Piper, which becomes invaded, but larvae of the pathotype common at Woburn do not reproduce in it. On some plots the two varieties will alternate, on others only one or other will be grown. In June the leaves of some plants became yellow, and later Pentland Dell but not Maris Piper showed typical signs of magnesium deficiency. In August stems on some plots were nearly leafless, dark in

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colour and infected with *Verticillium* sp. Plots were scored on 29 August and awarded marks for amount of foliage retained, from 1 (almost leafless) to 8 (all leaves retained). Pentland Dell had less foliage (3·4) than Maris Piper (4·6) (Table 3), and premature leaf fall in both varieties was greatly

TABLE 3

Amounts of foliage retained by Pentland Dell and Maris Piper with and without irrigation and fumigation (values from: 1, almost leafless; to 8, all leaves retained)

	Without irrigation		With irrigation		
	Not fumigated	Fumigated	Not fumigated	Fumigated	Mean
Potato variety					
Pentland Dell	2·8	4·6	2·3	4·0	3·4
Maris Piper	3·8	6·0	3·2	5·2	4·6
Mean	3·3	5·3	2·8	4·6	4·0

diminished by treating the soil with "D-D", and slightly increased by irrigation (2·5 in. of water was given between 26 May and 18 July). Plants on Series IV had more foliage (4·7) than on Series I (3·3), and Series IV yielded almost 50% more tubers. The smallest yields were of Pentland Dell on Series I without fumigation or irrigation (9 tons/acre with 80% ware), and the largest of Maris Piper on Series IV with fumigation and irrigation (18·5 tons/acre with 95% ware).

The wet season did not favour potato scab, but its incidence was affected by the different cropping histories of Series I and IV and by irrigation. Scab on Maris Piper tubers was estimated on a scale from 1 (slight scab) to 3 (severe scab), and the means of plots on Series IV after leys was 1·9, and on Series I, 1·4. On both Series, scab was less (1·5) on irrigated than on unirrigated plots (1·8).

Spring wheat. The effect of spraying wheat with a solution of the growth regulator CCC (2-chloroethyltrimethylammonium chloride) was tested for the first time at Woburn, and combined with effects of irrigation on "scorch" symptoms.

Irrigation (2 in.) applied during a dry spell of 2 weeks starting 25 May prevented symptoms of "scorch", which occurred in unwatered plots given large amounts of N. A further 0·5 in. water were given on 6 and 15 July. Irrigation increased the mean straw length by about 7 in. Spraying with CCC greatly shortened the straw and eliminated lodging with all nitrogen dressings. The mean straw length with CCC was 26·7 in. and without CCC 38·5 in. CCC without irrigation increased grain yield by about 2 cwt/acre; with irrigation it had no effect on grain yield, but decreased straw yield (Table 4).

TABLE 4

Effects of irrigation and CCC on grain and straw of spring wheat (Kloka)

	Without CCC			With CCC		
	Grain (cwt/acre)	Straw (cwt/acre)	Straw (in.)	Grain (cwt/acre)	Straw (cwt/acre)	Straw (in.)
Without irrigation	35·5	26·1	35·3	37·7	22·1	25·5
With irrigation	44·5	36·1	42·0	44·0	28·7	28·0

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After rain in June and July the wheat in the unirrigated plots improved and the "scorch" symptoms became less evident, but at harvest the plots were uneven, had many green tillers and the ears were mouldy. Plots with similar amounts of nitrogen but sprayed with CCC ripened more evenly and had fewer late tillers. This contrast between plots with large amounts of N but with or without CCC was reflected in moisture contents of harvest samples of grain and straw. With CCC, values were 17·4% and 22·8%; without CCC, 18·3% and 28·7%. With CCC and without irrigation there was a response of about 7 cwt grain/acre to extra 0·4 cwt N at 1·2 cwt N/acre. Without both CCC and irrigation yields with 0·8 and 1·2 cwt N/acre were the same.

Ley–arable rotation experiment

Sugar beet. With K, P and Mg in basal dressings, differences in yield between rotations and between plots with and without dung were expected to depend mainly on the different amounts of nitrogen remaining from the leys and arable rotations, and in 1965 four amounts of N were tested. The optimal dressing was larger for plots in the arable rotations (AH, A) than in the 3-year ley rotations (L, LU). More nitrogen is needed after 1-year ryegrass ley than after clover, so most nitrogen (2·1 cwt N/acre) was given with the AH rotation (arable with hay). Even at the amount of N that gave the largest yield for any particular treatment, there were differences between yields with and without dung; these ranged from 1 cwt for LU to 5 cwt for AH. Similar effects showed in 1966; sugar beet in the A rotation (arable with roots) responded to 1·4 cwt N/acre and the yield with this dressing was 7·5 cwt more with than without dung. It seems that there are still differences between rotations and plots with and without dung not accounted for by Mg, N, P and K. Mean yields of roots and tops were 23·5 and 22·1 tons/acre, with 15·9% mean sugar percentage. Plots without dung in all rotations had some plants showing signs of magnesium deficiency, with most in the arable rotations (AH), and few in the plots given 15 tons/acre FYM.

Barley. Lodging was less than in 1965, and again there was most after grazed ley and sainfoin; nevertheless, these plots yielded more grain and straw (45 cwt and 30 cwt/acre) than those in the arable rotations (40 cwt grain and 24 cwt straw/acre).

Rye. The straw was again tall (about 60 in.) and weighed 44·7 cwt/acre, more than that of the grain (33·6 cwt/acre). Plots in the ley rotations (L, LU) lodged badly.

Seeds hay. Yields equalled the large ones of 1965, and two cuts totalled 98 cwt dry matter/acre.

Carrots. Sown on 10 May, they developed poorly at first, as did carrots sown at about the same time in another experiment. Three sprayings with "Saphi-col" controlled motley dwarf. The mean yield was 19·6 tons roots/acre and 12 tons tops/acre.

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Potatoes. Maris Piper planted on 29 March grew poorly, particularly on plots in the arable rotation that carried potatoes in 1956 and 1961, and showed signs of magnesium deficiency. Plants were worst affected on plots without dung, and yielded little more than half (5·4 tons/acre) of plots with dung (10 tons/acre).

Grazed leys. Grazing was almost continuous from April to October. The mean number of sheep/days grazing/acre for 1st-, 2nd- and 3rd-year leys was 2,257, fewer than in 1965 (2,875), an exceptional year, but exceeded the mean (1,537) of the previous 20 years (1944–63).

Sainfoin. The 2nd-year crop grew well and gave 64 cwt dry matter/acre from 3 cuts.

Market-garden experiment. Since 1965 the two areas (Series A and B) have been treated differently. The leek crop on Series B was harvested early unweighed, in preparation for an experiment starting with globe beet in 1965 followed by carrots in 1966 (see p. 39). The small plots on this area are used to provide information on FYM and its residues that may be tested later under farming conditions on Series A. Series A grew carrots in 1965, and globe beet in 1966, with some tests prompted by the results from Series B summarised in Table 5. The best yields with fertilisers alone exceeded those with FYM alone, but giving N fertiliser up to 1·8 cwt N/acre with FYM further increased yields. Accordingly, whole plots in Series A were split for tests of extra N in 1966. Soil analyses in 1965 showed that plots given only fertiliser contained much less P than the FYM plots, so P and K were doubled in 1966 (P_1K_1 in Table 6 is P_2O_5 and K_2O at 1·5 cwt/acre and P_2K_2, 3 cwt/acre). Before 1965 the largest nitrogen dressings were 1·8 cwt N/acre without organic manures and 0·9 cwt with. Mann and Patterson (*Rothamsted Report* for 1962, p. 191) noted "significant responses to small seed-bed dressings of N fertiliser on manured

TABLE 5

Effects of nitrogen and FYM on yields of globe beet

	Yields*				
Cwt N/acre as "Nitro-Chalk"	0	0·6	1·2	1·8	Mean
With FYM	12·33	14·55	15·78	16·70	14·84
Without FYM	5·80	11·76	13·70	14·15	11·35

* Yields in tons roots/acre are the means of two harvests.

TABLE 6

Effects of nitrogen on yields of roots (tons/acre) and numbers (thousands/acre) of globe beet plants with and without FYM and sewage sludge residues

Cwt N/acre as "Nitro-Chalk"	0		0·9		1·8		2·7		3·6	
	Roots	No.	Roots	No.	Roots	No.	Roots	No.	Roots	No.
P_1K_1	—	—	4·14	165	7·26	161	8·98	147	9·73	154
P_2K_2	—	—	5·20	163	8·72	157	10·63	155	10·73	154
FYM (20 tons)	6·72	155	10·60	154	12·85	166	12·82	170	—	—
FYM(20) + P_1K_1	8·84	155	13·37	144	15·16	155	15·47	168	—	—
*Sludge residues	3·44	164	7·85	162	9·74	166	9·98	166	—	—

* Applications of sewage sludge ceased in 1962.

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plots, even though the manures themselves contained large amounts of N. These responses were smallest on plots with sewage sludge, the manure containing most nitrogen." Table 6 summarises effects of amounts up to 3·6 cwt N/acre. Without organic manures, yields were doubled by increasing N dressings from 0·9 to 2·7 cwt N/acre and then exceeded FYM yields without extra N. Plant numbers in 1966 were similar with or without organic manures, and the largest yield with fertiliser alone exceeded that on the FYM plots. The larger yields previously obtained with FYM probably reflected the larger plant populations achieved on plots with organic manures, as in 1964, with a seed rate of 11 lb/acre, when seedlings were fewer than in 1966 with a seed rate of 14 lb/acre.

Dates of sowing experiment. Earlier experiments with spring wheat and barley sown in mid-March showed that nitrogen applied in the seed-bed was as effective as early or late top dressings and that there was no advantage from dividing dressings (*Rothamsted Report* for 1958, p. 163). However, in 1964 spring cereals drilled in February showed signs of nitrogen deficiency in April and May, probably because much of the nitrogen applied in the seed-bed had been leached by heavy rain. Early sown wheat and barley may suffer more than late-sown crops from take-all, especially if they lack nitrogen. To test possible interactions between date of sowing, date of applying nitrogen and take-all, Kloka spring wheat was sown on three dates (17 February, 15 March, 13 April) and given 0·8 cwt N/acre, either all at sowing or half at sowing and half on 11 May. Mean soil temperatures between 1st and 2nd sowings and between 2nd and 3rd sowings were 41·1° F and 42·1° F; rain was not more than average until after the 3rd sowing. All sowings germinated fairly quickly; the crops did not become obviously nitrogen deficient, and all were ripe for combining on 6 September. Take-all was very patchily distributed, with no significant differences between treatments. On 6 July only 13% plants were infected, 6% severely, too few to affect yields appreciably. Applying nitrogen at different dates did not affect grain yield, but the wheat yielded a little less when sown in February than in March or April (30·2, 33·4, 32·7 cwt/acre respectively. (Slope and Thorold)

Direct-seeding experiment. Conventional drilling of spring wheat (Kloka) after ploughing grass in January was compared with slit-seeding into an unploughed grass sward sprayed with aminotriazole in autumn 1965 and with paraquat in early spring. The seed was combine-drilled with NPK fertiliser (20 : 10 : 10 at 3 cwt/acre) on 14 March. Whole plots were used to see effects of a seed dressing containing insecticide and fungicide, and half-plots to see effects of spraying with an insecticide applied before sowing (*Rothamsted Report* for 1965, pp. 43 and 189). Table 7 shows that mean yields on ploughed and unploughed land were similar, although the straw was slightly taller and there was more lodging on the ploughed land. Unlike previous experiments at Rothamsted, perennial grass weeds were few in the unploughed plots. One direct-seeded plot sprayed with diazinon and chlordane yielded 52 cwt grain/acre, and this spray increased the mean yield by 2 cwt grain/acre.

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TABLE 7

Spring wheat drilled in ploughed and unploughed land

	Ploughed land	Land unploughed, treated with herbicide
Yield (cwt grain/acre)	45·8	45·1
Length of straw (in.)	43·6	40·9
Lodging (0–3)	2·6	1·4

Green-manuring experiments. On the "Upper Half" of this long-term experiment, four amounts of N were applied to assess the effects of the green manures ploughed in. Green manures were not undersown in 1966. Table 8 shows that the amount of both dry matter and nitrogen in the ploughed-in trefoil decreased with increasing N applied to the barley, whereas with the ryegrass the dry matter remained constant and the nitrogen increased with increasing N. Tables 9 and 10 summarise 1966 yields

TABLE 8

Effects of "Nitro-Chalk" applied to barley seed-bed in 1965 on dry matter and nitrogen (cwt/acre) content of green manures

	Trefoil		Ryegrass	
"Nitro-Chalk" (N, cwt/acre)	Dry matter (cwt)	N (cwt)	Dry matter (cwt)	N (cwt)
None	15·6	0·48	24·3	0·23
0·3	9·6	0·28	21·6	0·21
0·6	8·2	0·25	25·7	0·26
0·9	4·2	0·11	23·0	0·32

and effects from the treatments; because the experiment is so complex, each entry in Table 9 refers to a single subplot (two subplots with (*d*)). Table 10 shows that the residual effect from green manures ploughed in during the period 1936–63 (L) was to increase grain by about 3·5 cwt (13%), regardless of the amount of N given in 1965 or in 1966. (See page 55.)

Trefoil undersown in 1964 and 1965 increased average yield by 7·5 cwt (29%), but its effect depended on how much N was given in 1965 and 1966, and decreased with increasing amounts. However, even with 0·9 cwt N in 1966, it still increased yield by 3·7 cwt/acre.

Ryegrass gave 1·2 cwt (5%) extra grain, and its effect was little influenced by the amount of N applied in either year. Averaging over the different amounts of N in 1965, on plots with recent (*a*, *b*) or earlier (*d*) green manures (Table 9), maximum yields of 38–43 cwt were obtained with 0·9 cwt N given in 1966. On plots never green manured (*c*), 0·9 cwt N gave 33 cwt and 1·2 cwt N 38 cwt/acre.

"Lower Half" plots were undersown in 1966 in preparation to repeat there in 1967 the experiments done this year on the "Upper Half". Barley after trefoil and ryegrass (undersown in 1965) yielded 32·5 and 24·8 cwt grain/acre and 22·4 cwt/acre on plots without green manures since 1936.

A further gift of a book by Mr. P. A. Vasavada, in memory of his association with the late Dr. H. H. Mann, is gratefully acknowledged.

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TABLE 9

Barley yields (cwt grain/acre) on "Upper Half" of long-term green-manuring experiment

"Nitro-Chalk" applied N (cwt/acre) 1966	N, cwt/acre 1965 0	0·3	0·6	0·9	1·2	Mean*
(a) Trefoil undersown 1964 and 1965 (after green-manure treatments 1936–63)						
0	25·1	21·3	27·8	16·8	—	22·0
0·3	33·8	32·0	27·2	30·3	—	29·8
0·6	44·0	39·0	34·5	33·9	—	35·8
0·9	42·2	44·1	42·6	40·7	—	42·5
1·2	—	—	—	—	—	—
*Mean (a)	40·0	38·4	34·8	35·0	—	36·0
(b) Ryegrass undersown 1964 and 1965 (after green-manure treatments 1936–63)						
0	16·8	10·1	10·8	12·4	—	11·1
0·3	20·0	22·6	20·5	27·5	—	23·5
0·6	33·7	28·2	38·2	30·4	—	32·3
0·9	42·3	36·8	41·0	43·2	—	40·3
1·2	—	—	—	—	—	—
*Mean (b)	32·0	29·2	33·2	33·7	—	32·0
(c) Without green manures since 1936						
0	—	—	—	—	—	—
0·3	—	18·0	17·1	14·1	16·5	16·4
0·6	—	32·0	29·0	32·6	18·0	31·2
0·9	—	33·7	29·9	34·4	29·7	32·7
1·2	—	40·2	35·0	38·3	40·8	37·8
*Mean (c)	—	27·9	25·3	27·0	21·4	26·8
(d) Not undersown 1964 and 1965 (after green-manure treatments 1936–63)						
0	10·2	11·6	13·2	11·2	—	12·0
0·3	22·3	19·0	19·7	19·9	—	19·5
0·6	33·2	33·6	33·6	33·3	—	33·5
0·9	41·0	38·8	38·2	36·9	—	38·0
1·2	—	—	—	—	—	—
*Mean (d)	32·2	30·5	30·5	30·0	—	30·3

* Means: including treatments 0·3, 0·6 and 0·9 cwt N/acre; excluding treatments 0 and 1·2 cwt N/acre.

TABLE 10

"Upper Half" of green-manuring experiment; long-term (L) and short-term (S) effects on barley (cwt grain/acre)

	N (cwt/acre) 1965 0	0·3	0·6	0·9	N (cwt/acre) 1966 0	0·3	0·6	0·9	Mean
L*	—	+2·6	+5·2	+3·0	—	+3·1	+2·3	+5·3	+3·5
Trefoil (S†)	+9·6	+8·3	+6·8	+5·1	+11·2	+10·6	+4·4	+3·7	+7·5
Ryegrass (S†)	+1·5	−1·4	+1·4	+3·1	+1·0	+2·4	−0·8	+2·1	+1·2

L: average effect of green-manuring treatments 1936–63, difference (d)–(c) Table 9.
S: effect of undersowing in 1964 and 1965 Trefoil (a)–(d), Ryegrass (b)–(d) Table 9.
* Means: including 0·3, 0·6 and 0·9 cwt N.
† Means: including 0, 0·3, 0·6 and 0·9 cwt N.

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