ROTHAMSTED RESEARCH

Report for 1970 - Part1

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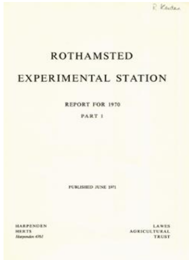
ROTHAMSTED
EXPERIMENTAL STATION
REPORT FOR 1970
PART 1

Field Experiments Section

G. V. Dyke

G. V. Dyke (1971) *Field Experiments Section ;* Report For 1970 - Part1, pp 222 - 238 **- DOI: https://doi.org/10.23637/ERADOC-1-125**

FIELD EXPERIMENTS SECTION

G. V. DYKE

The field experiments at Rothamsted, Woburn and Saxmundham are controlled by the Field Plots Committee: D. J. Watson (Chairman), G. V. Dyke (Secretary), J. McEwen (Deputy Secretary), F. C. Bawden, G. W. Cooke, J. M. Hirst, F. G. W. Jones, J. R. Moffatt, R. Moffitt and J. A. Nelder. During the year the Garden Plots Committee was dissolved. Business formerly put to this Committee now goes to one or other of the Working Parties of the Field Plots Committee.

Table 1 shows the number of plots on the three farms; there were 800 more grain plots at Rothamsted than in 1969 and about 500 more microplots in all. There were fewer plots of root crops, partly because Barnfield was in cereals in 1970; other changes were small.

TABLE 1

Number of plots in 1970

	Grain	Roots	Hay	Total
Full scale plots (yields taken):				
Classical experiments:				
Rothamsted	488	35	200	723
Saxmundham	—	—	80	80
Long-period rotation experiments:				
Rothamsted	780	440	76	1296
Woburn	462	296	64	822
Saxmundham	60	—	—	60
Crop-sequence experiments:				
Rothamsted	540	2	166	708
Woburn	304	251	—	555
Annual experiments:				
Rothamsted	1286	372	88	1746
Woburn	380	238	—	618
Saxmundham	36	—	—	36
Totals:				
Rothamsted	3094	849	530	4473
Woburn	1146	785	64	1995
Saxmundham	96	—	80	176
Total	4336	1634	674	6644
Full scale plots (no yields taken):				
Rothamsted				515
Woburn				107
Microplots:				
Rothamsted				1257
Woburn				861
Saxmundham				370
			Total	9754

The Classical Experiments

Table 2 shows the yields given by some of the more important treatments in the Broadbalk, Hoos Barley and Barnfield experiments.

https://doi.org/10.23637/ERADOC-1-125

TABLE 2

Rothamsted Classical Experiments 1970; yields of crops from selected treatments

Grain, cwt/acre and total tubers, tons/acre

	Treatment: —				PKNaMg					FYM		P
	—	N1	N2	N3	—	N1	N2	N3	N4	—	N2	N2
BROADBALK												
Winter Wheat (Broadbalk)												
(i) after 2 year break	18	—	35	—	20	37	42	39	41	47	45	36
(potatoes, beans)	—	—	39[1]	—	—	—	—	—	—	—	—	—
(ii) 1st after fallow	24	—	34	—	32	36	37	38	37	50	46	30
	—	—	37[1]	—	—	—	—	—	—	—	—	—
(iii) 19th after fallow	17	—	15	—	21	33	41	46	44	42	36	29
	—	—	29[1]	—	—	—	—	—	—	—	—	—
Beans (no simazine)	3	—	5	—	3	5	7	9	9	11	8	5
	—	—	8[1]	—	—	—	—	—	—	—	—	—
Potatoes	5·0	—	4·2	—	7·6	10·4	13·7	15·9	16·7	17·5	19·6	3·4
	—	—	8·1[1]	—	—	—	—	—	—	—	—	—
HOOS BARLEY												
Barley	8	16	17	18	12	24	35	42	—	35	46	23
	(13)	(28)	(34)	(38)	(16)	(27)	(36)	(37)	—	—	—	(38)
Beans (no simazine)	(9)	—	—	—	(11)	—	—	—	—	—	—	—
Potatoes	—	—	—	(7·6)	—	—	—	(13·4)	—	—	—	(6·3)[2]
BARNFIELD												
Spring Wheat	22	17	24	12[3]	11	20	17[3]	29	—	10[3]	16[3]	16
	(12)	(20)	(14)	(26)	(12)	(24)	(26)	(31)	—	(23)	(26)	(21)
Barley	6	21	25	30	9	23	29	32	—	33	42	32
	(15)	(28)	(33)	(34)	(9)	(22)	(30)	(37)	—	(30)	(44)	(37)
Beans												
(i) Cultivated	7	—	—	—	7	—	—	—	—	21	—	13[4]
(ii) Simazine	2	—	—	—	6	—	—	—	—	13	—	7[4]

[1] 86 lb N as castor meal
[2] N3P
[3] Damaged by birds
[4] P alone

Symbols:
- N1, N2, N3, N4 — 'Nitro-Chalk' at 43, 86, 129, 172 lb N/acre—i.e. about 0·4, 0·8, 1·2, 1·6 cwt N/acre
- P = Superphosphate annually, at 0·6 cwt P_2O_5/acre
- K = Sulphate of potash annually, at 0·9 cwt K_2O/acre (Barnfield 2·2 cwt K_2O/acre)
- Na = Sulphate of soda annually, at 14 lb Na/acre (Barnfield agricultural salt at 80 lb Na/acre)
- Mg = Sulphate of magnesia annually, at 10 lb Mg/acre (Barnfield 20 lb Mg/acre)
- FYM = Farmyard manure annually, at 14 tons/acre
- ( ) = Indicates yield with residues of castor meal last applied 1967 (Hoos Barley), 1961 (Barnfield)

Broadbalk. Yields of wheat were generally less than in 1969, and the best was 50 cwt, given by two sections of the old FYM plots. Without FYM several plot sections gave more than 45 cwt grain. Average yields after the 2-year break were better than elsewhere but on plots without applied N the first crop after fallow yielded more than wheat after potatoes, beans. During the growing season the appearance of the crop showed clearly that wheat was getting more N from the soil after fallow than after beans. The 19th successive crop of wheat on Section 0 yielded on average 2·4 cwt less than the first after fallow, and about 5 cwt less than after the 2-year break.

Elsewhere on the farm Cappelle wheat yielded (with best rates of N) 40–54 cwt where it followed a 'break' of one or two years. Where it followed wheat or barley, best yields ranged more widely, from 20 to 44 cwt.

The results obtained in the two seasons in which wheat has been grown after the 2-year break suggest that the average increase (compared with the first crop after fallow) is about 3 cwt (Table 3). On plots without applied N there has been a decrease (especially this year—see above); also where castor meal is applied. Presumably on these three plots the effects of the extra N made available during the fallow year (compared with the N left after beans) more than counteracts any greater amount of root disease after fallow than after beans. On other plots (except the one receiving 172 lb N as 'Nitro-Chalk' and the new plot with FYM and NPK), yields after the 2-year break have been 3–8 cwt more than after the 1-year fallow.

https://doi.org/10.23637/ERADOC-1-125

All manures except 'Nitro-Chalk' are now applied in the fallow year and so on most plots yields of the first crop after fallow may be a little greater than they would have been under the old scheme when manures were not applied to the fallow. It seems that,

TABLE 3

Broadbalk: mean yields of wheat, 2 seasons (1969 and 1970)

Grain, cwt/acre

Treatment	After 2-year break (A)	After 1-year fallow (B)	Difference (A−B)
None	22	24	−2
PKNaMg	27	30	−3
N1PKNaMg	42	39	+3
N2PKNaMg	45	41	+4
N3PKNaMg	45	42	+3
N4PKNaMg	42	42	0
N2	35	29	+6
N2P	38	33	+5
N2PK	44	40	+4
N2PNa	43	37	+6
N2P(K)Mg	47	39	+8
N2 + ½(PKNaMg)	45	40	+5
D	53	49	+4
DN2	50	47	+3
DN2PK	48	47	+1
R	38	39	−1
Mean	42	39	+3

Notes (K) indicates K applied 1968–70 only
½(PKNaMg) indicates PKNaMg at half-rate since 1968 (formerly at full rate every second year)

TABLE 4

Hoos Barley Experiment: Comparison between barley after potatoes, beans and barley after barley

Yields of barley, grain, cwt/acre

	N to barley, lb/acre 0	43	86	129	Mean
	With castor meal residues, mean of 2 seasons, 1969 and 1970				
After:					
Potatoes, beans	22	33	39	40	34
Barley	17	29	39	42	31
Difference	+5	+4	0	−2	+3
	Without castor meal residues, 1970 only				
(i) *With silicate of soda*					
After:					
Potatoes, beans	23	36	37	38	34
Barley	13	26	34	36	27
Difference	+11	+10	+3	+2	+6
(ii) *Without silicate of soda*					
After:					
Potatoes, beans	22	33	35	36	32
Barley	10	22	27	28	22
Difference	+12	+12	+8	+8	+10

Note: The apparent inconsistency of this table is caused by the independent rounding-off of means and differences.

https://doi.org/10.23637/ERADOC-1-125

so far, the 2-year break has not caused any great increases in yield of wheat on Broadbalk; the change from Squarehead's Master to Cappelle has probably given a greater increase. There is no sign yet that even the best-manured plots of Broadbalk will give yields better than we can achieve elsewhere at Rothamsted.

Hoos Permanent Barley. Yields of barley (variety Julia) with adequate N were good (Table 2); they were only slightly better where barley followed potatoes, beans than in continuous barley, and none was much better than best yields of barley on modern experiments.

We now have the comparison (Table 4) between barley after potatoes, beans and barley after barley:

(i) on the area with castor meal residues, in 1969 and 1970; and
(ii) in 1970 only, on the old nitrate of soda series, with and without silicate of soda.

The average increase from the 2-year break was 3 cwt of barley on land with castor meal residues, 8 cwt without. The increases were greatest with no N or with 43 lb N. With 86 or 129 lb N, the increases were negligible except on land with neither castor meal residues nor applied silicate. Here the 2-year break gave 8 cwt more grain. In general it seems that the 2-year break has been beneficial wherever the yield of barley after barley was less than about 35 cwt, but not where it was more.

As with wheat on Broadbalk, there is no sign yet that introducing break crops on the Hoosfield experiment is going to give spectacular increases in yield of barley.

Barnfield. Without FYM, yields of barley (Julia) varied little between the strips where different treatments have been applied cumulatively for a century (None, P, PK, PNaMg, PKNaMg). Best yields on these strips were 32–38 cwt grain (with 86 or 129 lb N as 'Nitro-Chalk'), but on the FYM strips were about 30 cwt without 'Nitro-Chalk', 39 cwt with 43 lb N and 41–44 cwt with 86 or 129 lb N. This contrasts with 1968 when best yields of barley were about the same on all strips. Spring wheat suffered damage by birds when ripe but it seems improbable that without this damage yields would have exceeded 35 cwt.

Beans on the Classicals. Yields of beans in 1970 were very poor, as they were on all our experiments and fields on both farms. Possible causes are discussed on p. 231.

Potatoes on the Classicals. The best yields of King Edward potatoes on Broadbalk were 16·7 tons/acre without FYM, 19·6 with. On the Hoos Barley experiment the best

TABLE 5

Maximum yields of potatoes, total tubers, tons/acre*

(1968, Majestic; 1969 and 1970, King Edward)

	Broadbalk		Hoos Barley	Fosters		Highfield	
	FYM	No FYM	No FYM†	FYM	No FYM	FYM	No FYM
1968	15·7	14·7	15·0	15·8	15·5	17·6	16·9
1969	19·2	17·9	19·1	18·4	17·8	21·6	21·2
1970	19·6	16·7	13·7	17·3	15·7	23·5	24·2
Mean	18·2	16·4	15·9	17·2	16·4	20·9	20·8

* For Broadbalk and Hoos Barley, greatest of individual plot-yields; for Ley–Arable experiments, greatest mean in table showing (N to potatoes) × (fertilisers, FYM) × (rotations excluding plots formerly in reseeded or permanent grass)

† With castor meal residues

https://doi.org/10.23637/ERADOC-1-125

yield was 13·7 with fertilisers (potatoes are not grown on the FYM plot). Table 5 shows the best yields with and without FYM from Broadbalk, Hoos Barley and the Ley–Arable Experiments (excluding plots recently ploughed from long-term grass). All the figures are subject to large random 'errors' but it seems that, without FYM, Broadbalk and Fosters give equal yields; the yields on the Hoos experiment ranged widely; the poor yield this year was possibly partly caused by aphids (as on Fosters, see p. 231). Highfield, ploughed from permanent grass about 20 years ago, outyielded the Classicals, whether FYM was given or not.

Annual summary of yields from standard experiments at Rothamsted and Woburn

Winter wheat. Cappelle wheat yielded less on Broadbalk than in 1969 but more than in 1968. After the 2-year break and with adequate fertilisers yields were 40–48 cwt, 5–10 cwt less than in 1969. Continuous wheat, the 19th successive crop, gave a maximum of 46 cwt, about equal to that of 1969 but 16 cwt more than in 1968.

FYM, alone or with 86 lb N as 'Nitro-Chalk', gave more wheat than fertilisers only except in the continuous wheat where minerals plus 129 lb or 172 lb gave a little more than FYM.

Since autumn 1967 FYM and minerals have been applied to the appropriate plots of the fallow and, as a result, a change in the relation between yields from FYM and fertilisers in the first crop after fallow might be expected. The 1968 results, however, differed greatly from those of 1969 and 1970, and it is too soon to detect any average change.

On the Ley–Arable Experiment in Highfield (old grass ploughed in 1949–51 for the

TABLE 6

Rothamsted Ley–Arable

Wheat (Joss Cambier), grain, cwt/acre

Previous cropping	2nd test-crop 1970 cwt N/acre 0·0	0·4	0·8	1·2	2nd test-crop 1969 maximum yield (N)	5th test-crop 1970 cwt N/acre 0·6	1·0	1·4	1·8	5th test-crop 1969 maximum yield (N)	6th test-crop 1970 cwt N/acre 0·6	1·0	1·4	1·8
Highfield														
Lu	48	58	59	61	64 (0·8)	29	36	33	30	43 (1·4)	24	24	27	31
Lc	52	61	63	64	63 (0·8)	27	32	30	35	47 (1·4)	27	30	34	33
Ln	45	56	60	60	66 (1·2)	21	23	28	32	45 (1·8)	23	27	32	28
Ah	44	54	58	58	66 (1·2)	29	31	31	34	48 (1·0)	27	26	25	31
Rc }	49[8]	55[8]	59[8]	65[8]	68[2] (0·4)	52[2]	43[2]	50[2]	55[2] }	52[5] (0·6)	25[6]	26[6]	30[6]	31[6]
Rn }					68[2] (0·4)	44[2]	54[2]	56[2]	56[2] }					
Gc	53[2]	52[2]	60[2]	59[2]	68[2] (0·8)	50[2]	55[2]	39[2]	51[2]	57[2] (0·6)	40[3]	32[3]	52[3]	41[3]
Gn	54[2]	60[2]	60[2]	64[2]	66[2] (1·2)	54[2]	52[2]	51[2]	41[2]	56[2] (1·0)	33[3]	46[3]	38[3]	44[3]
Fosters														
Lu	47	52	55	56	71 (0·4)	25	27	32	32	66 (1·4)	38	33	38	44
Lc	46	50	52	54	68 (0·8)	37	37	39	43	67 (1·0)	39	40	41	43
Ln	43	48	50	50	70 (0·8)	32	37	40	42	68 (1·0)	35	43	43	46
Ah	38	45	49	51	72 (1·2)	31	32	34	37	65 (1·8)	32	35	38	40
Rc }	46[8]	50[8]	54[8]	55[8]	68[2] (0·8)	45[2]	42[2]	46[2]	44[2] }	63[5] (1·0)	35[6]	41[6]	44[6]	44[6]
Rn }					74[2] (0·8)	43[2]	48[2]	47[2]	48[2] }					

Symbols: Lu = lucerne (3 years), arable (3 years) alternating
Lc = clover–grass ley (formerly grazed ley), (3 years), arable (3 years) alternating
Ln = all-grass ley (formerly cut ley), arable (3 years), alternating
Ah = arable with hay (3 years), arable (3 years) alternating
R = reseeded grass
G = old permanent grass
c = PK but no N applied (as Lc)
n = PK and N applied (as Ln)
[2] 2nd crop after grass; followed potatoes
[3] 3rd crop after grass; followed potatoes, wheat
[5] 5th crop after grass; followed wheat, potatoes, barley, wheat
[6] 6th crop after grass; followed wheat, potatoes, barley, wheat, wheat
[8] 8th crop after grass; cropping as 'Ah' meanwhile

Basal dressing: 0·9 cwt P_2O_5, 0·9 cwt K_2O

https://doi.org/10.23637/ERADOC-1-125

experiment), wheat grown as 2nd test-crop following potatoes gave maximum yields of 58–65 cwt according to preceding cropping; at least 0·8 cwt N was needed for maximum yield (Table 6). In 1969 maximum yields were 5 cwt greater. In the old arable field (Fosters), by contrast, maximum yields were about 15–20 cwt less than in 1969. 'Nitro-Chalk' was applied late in 1970 and a long drought ensued; perhaps the soil of Highfield retained more moisture than Fosters and made the N more effective. At any rate Fosters, which yielded more than Highfield in 1969, yielded less in 1970. (Yields of potatoes on the two fields in 1970 also differed exceptionally—see below.)

Fifth test-crop wheat (the third successive cereal crop) gave not much more than half the yield of the 2nd test-crop in Highfield, although given more N. In Fosters it yielded more than in Highfield and differed less from the 2nd test-crop. In both fields, yields of 5th test-crop wheat were much less than in 1969; as with the 2nd test-crop the difference was much greater in Fosters than in Highfield. The 6th test-crop wheat yielded similarly to the 5th, but as the two phases are on different blocks the comparison is not precise.

Note that, on plots ploughed out of 'reseeded grass' in autumn 1962, which have been cropped as 'arable with hay' since, yields of wheat (2nd test-crop) were about 5 cwt more than on the permanent 'arable with hay' plots on Fosters, but on Highfield, wheat grown as the 2nd crop after ploughing old permanent grass yielded better than wheat after the other sequences without N fertiliser, but about the same with.

On the Cultivation–Weedkiller Rotation (see Table 7), wheat yields were about 12 cwt less than in 1969, and 6–10 cwt more than in 1968.

TABLE 7

Cultivation–Weedkiller Rotation Experiment

Wheat (Cappelle), grain, cwt/acre

	1970	1969	1968
P	45	57	35
R	44	56	38
T	45	57	38

Symbols: P = ploughed
R = rotary cultivated
T = tine cultivated

Basal dressing: 0·15 cwt N, 0·38 cwt P_2O_5, 0·30 cwt K_2O (0·38 cwt K_2O in 1969 and 1968) at sowing, plus 0·63 cwt N in spring

TABLE 8

Winter Wheat after Intensive Spring Barley Experiment

Wheat, grain, cwt/acre

	1970 (Joss Cambier) cwt N/acre				1969 (Cappelle)
	0·6	1·0	1·4	1·8	Maximum yield (N)
(i)	48	49	49	54	55 (1·0)
(ii)	29	32	39	35	54 (1·4)

(1968: spring wheat)

(i) After 1-year break
(ii) Continuous wheat since 1961 (spring sown 1961–68)

Basal dressing: 1·25 cwt P_2O_5
2·50 cwt K_2O (1970)
1·43 cwt P_2O_5, 2·55 cwt K_2O (1969)

https://doi.org/10.23637/ERADOC-1-125

On Little Knott wheat has been grown for two seasons following the Intensive Barley Experiment. On plots where wheat followed a fallow yields of Joss Cambier were 48–54 cwt, about the same as given by Cappelle in 1969. But on plots where wheat (formerly spring-sown) has been grown without a break, the best yield was 39 cwt; the 1-year 'break' gave an increase of 10–15 cwt (Table 8). By contrast, in 1969 the 1-year break gave a negligible increase.

At Woburn, wheat on the Intensive Cereals Experiment yielded much less than in 1969; after a 2-year break the difference was 19 cwt and on the continuous wheat plots about 12 cwt. Wheat after the break yielded 9 cwt less than in 1968; continuous wheat only 2 cwt less (Table 9).

TABLE 9

Woburn Intensive Cereals Experiment

Wheat (Cappelle), grain, cwt/acre

	1970 cwt N/acre				1969	1968
	0·5	1·0	1·5	2·0	Maximum yield (N)	Maximum yield (N)
(i)	21	23	25	25	44 (1·5)	34 (1·0)
(ii)	17	18	20	17	32 (1·5)	22 (1·5)

(i) After ley, potatoes
(ii) Continuous wheat since 1966

Basal dressing: 1 cwt P_2O_5
2 cwt K_2O

To sum up, yields of winter wheat grown after one or more non-cereal crops were at best equal to those of 1969, at worst about 12 cwt less at Rothamsted and 19 cwt at Woburn. Yields of wheat following wheat or barley were less than in 1969 by 10–20 cwt, except on Broadbalk where, after an exceptionally long sequence of wheat crops, yields in 1970 equalled those of 1969. Perhaps where roots were damaged by diseases such as take-all, the crop failed to benefit fully from the nitrogen fertiliser, which was applied late when the weather changed abruptly from wet to dry.

Barley. On the Classical Barley Experiment in Hoosfield (Table 2) maximum yields were about the same as in 1969, 40 cwt or a little more. Without PKNaMg, N had less effect than in 1969, but with them the effect was about the same. Surprisingly for a season with a long drought, castor meal residues gave less than in 1969; the last application was in 1967 and the effect is perhaps decreasing.

On Barnfield (where barley was not grown in 1969) the yields of barley with adequate 'Nitro-Chalk' were about 32 cwt with fertilisers only, similar to those of 1968 (Table 2). Without N, yields were less than in 1968. Castor meal residues gave yields ranging to 37 cwt; FYM without castor meal residues gave 42 cwt, with residues 44; these yields, by contrast with 1968, were distinctly better than those without FYM.

On the Ley–Arable, best yields of Julia barley on the rotation plots in Highfield were similar to those of Maris Badger in 1969, about 6 cwt more than in 1968 (Table 10). Best yields on the four rotations were equal; in 1969 (when less N was used) the barley after all-grass ley and 'arable' yielded rather less than after lucerne and clover–grass leys.

In Fosters, best yields were about equal to those of 1968, 10 cwt less than those of 1969. The differences between the two fields in 1970 and 1969 thus conforms to the pattern of the yields of winter wheat (2nd test-crop). Yields of barley after 'reseeded' and

https://doi.org/10.23637/ERADOC-1-125

TABLE 10

Rothamsted Ley–Arable

Barley, grain, cwt/acre

Previous cropping	1970 (Julia) cwt N/acre 0·0	0·4	0·7	1·0	1969 (Maris Badger) Maximum yield (N)	1968 (Maris Badger) Maximum yield (N)
				Highfield		
Lu	37	47	47	48	48 (0·2)	42 (0·2)
Lc	37	48	46	46	47 (0·3)	43 (0·2)
Ln	35	46	48	47	45 (0·2)	42 (0·3)
Ah	29	45	46	48	45 (0·3)	42 (0·3)
Rc	46	51	53	49	— —	— —
Rn	46	52	52	50	— —	— —
Gc	48	49	52	50	— —	— —
Gn	49	51	51	49	— —	— —
				Fosters		
Lu	26	38	40	40	51 (0·6)	41 (0·4)
Lc	27	36	38	36	49 (0·4)	40 (0·4)
Ln	29	35	37	37	49 (0·4)	40 (0·6)
Ah	23	36	37	38	49 (0·4)	39 (0·6)
Rc	27	38	37	37	— —	— —
Rn	31	36	37	40	— —	— —

Symbols: Lu = lucerne
Lc = clover grass–ley
Ln = all-grass ley
Ah = arable with hay
R = reseeded grass ploughed autumn 1967
c = PK but no N applied (as Lc)
n = PK and N applied (as Ln)

Barley 1970 followed potatoes, wheat on all plots
Barley 1969 and 1968 followed wheat, potatoes

Basal dressing: 0·3 cwt P_2O_5
0·6 cwt K_2O

'permanent' grass (obtained in 1970 only) exceeded those after the rotations by 3–4 cwt in Highfield, but not at all in Fosters. Apparently 18 years under grass (grazed for about half that period) did nothing to improve the yield of barley on this old arable field (it did little or nothing to wheat in 1969—see *Rothamsted Report for 1969*, Part 1, 285 and increased the yield of potatoes in 1968 by less than 10%—see *Numerical Results of the Field Experiments for 1968*, p. 68/B/1.10).

Julia barley on the Cultivation–Weedkiller Rotation (Table 11) yielded 4–7 cwt less than Maris Badger in 1969 (and a little more than Maris Badger in 1968).

TABLE 11

Cultivation–Weedkiller Rotation Experiment

Barley, grain, cwt/acre

	1970 (Julia)	1969 (Maris Badger)	1968 (Maris Badger)
P	40	44	36
R	37	44	35
T	37	44	36

Symbols: P = ploughed
R = rotary cultivated
T = tine cultivated

Basal dressing: 0·75 cwt N, 0·30 cwt P_2O_5, 0·30 cwt K_2O

https://doi.org/10.23637/ERADOC-1-125

On the Residual Phosphate Rotation Experiments (Table 12), Julia barley without P yielded less than Maris Badger in 1969 especially in Sawyers I (old arable). Where 3 cwt P_2O_5 were applied in 1960, yields were better, especially in Great Field IV (formerly grass); with an annual dressing of 0·5 cwt P_2O_5 yields were still better and in Great Field IV this treatment gave more grain than in 1969 or 1968. The comparison between the two fields to some degree confirms the results of the Ley–Arable where, on the old arable field (but not the old grass field), 1969 gave better yields than 1970 or 1968.

TABLE 12

Residual Phosphate Rotation

Barley, grain, cwt/acre
(1970: Julia. 1969, 1968: Maris Badger)

P_2O_5 (cwt/acre) as superphosphate	Sawyers I 1970	Sawyers I 1969	Sawyers I 1968	Great Field IV 1970	Great Field IV 1969	Great Field IV 1968
0	24	39	28	24	30	25
3·0 in 1960	28	39	30	32	32	25
0·5 annually	32	45	34	38	31	26

Basal dressing: 0·78 cwt N, 0·50 cwt K_2O (1970)
0·8 cwt N, 1·0 cwt K_2O (Sawyers I, 1969 and 1968)
0·4 cwt N, 1·0 cwt K_2O (Great Field IV, 1969 and 1968)

On the Woburn Intensive Cereals Experiment Julia barley yielded little more than Maris Badger (resown after the failure of the first sowing) did in 1969, or in 1968. As in previous years, barley after the two-year break yielded about 4 cwt more than continuous barley (Table 13).

TABLE 13

Woburn Intensive Cereals Experiment

Barley, grain, cwt/acre

	1970 (Julia) cwt N/acre				1969 (Maris Badger)	1968 (Maris Badger)
	0·4	0·8	1·2	1·6	Maximum yield (N)	Maximum yield (N)
(i)	29	34	37	36	36 (0·8)	34 (0·8)
(ii)	13	21	30	33	31 (1·2)	30 (0·8)

(i) After ley, potatoes
(ii) Continuous barley since 1966

Basal dressing: 1 cwt P_2O_5, 2 cwt K_2O

On the Woburn Ley–Arable (Table 14) Maris Badger yielded much less than in 1969, and rather less than in 1968. The difference between best yields in 1970 and 1969 ranged from 8 cwt after 'arable with hay' to 15 cwt after 'grazed ley', which gave exceptionally poor yields in comparison with the other rotations. In each of the three seasons, 0·4 cwt more N was needed for maximum yield after the two arable sequences than after the ley sequences.

To sum up: yields of barley at Rothamsted were generally less than in 1969 and about equal to those of 1968; the introduction of Julia in 1970 to replace Maris Badger on several experiments seems to have had little effect. Where plenty of fertiliser was applied to land following old grass, yields in 1970 equalled those of 1969; on land with less

https://doi.org/10.23637/ERADOC-1-125

TABLE 14

Woburn Ley–Arable

Barley (1st test-crop, Maris Badger), grain, cwt/acre

	1970 cwt N/acre					1969 Maximum yield (N)	1968 Maximum yield (N)
	0·0	0·4	0·8	1·2	1·6		
L	19	24	21	22	—	39 (0·4)	33 (0·0)
S	23	29	28	28	—	40 (0·4)	32 (0·0)
AH	—	24	26	25	25	34 (0·8)	32 (0·4)
AR	—	25	28	28	26	41 (0·8)	33 (0·4)

Symbols: L = grazed ley (3 years)
S = sainfoin (3 years)
AH = arable with hay (potatoes, rye, hay)
AR = arable with roots (potatoes, rye, carrots)

PK dressings: 0·5 cwt P_2O_5, 0·5 cwt K_2O, plus 'corrective' K varying with rotation

organic matter, or deficient in nutrients, yields were less than in 1969, by 15 cwt. At Woburn, there is a suggestion that the change to Julia compensated for the loss of yield caused by seasonal differences.

Beans. Yields of all spring beans at Rothamsted and Woburn were small, few exceeding 15 cwt and many 10 cwt or less. No single cause can be given. Most of the crops were sown late because of the late spring, many into wet seedbeds; there was a severe drought before, during and after flowering; weevils were numerous (though aphids did little damage), many plants were infected with virus and there was evidence of damage to the roots by pathogens (see pp. 136 and 184).

Potatoes. On Broadbalk, potatoes (King Edward) yielded much as in 1969 (Table 2). The best yield each year was between 19 and 20 tons, from FYM and 86 lb N. With fertiliser only, the best yield was 16·7 tons, about 1 ton less than in 1969. Planting was 3 weeks later than in 1969, and there was a drought from about midsummer so it is surprising that the yields were so good. On Hoos Barley, however, where potatoes were planted on the same dates as on Broadbalk each year, yields were 2½–5 tons less than in 1969, except where P is given but not K, Na or Mg, where 1970 yields were a little greater than in 1969.

On the Ley–Arable (Table 15) in Highfield (old grass), best yields of King Edward exceeded those of 1969 by about 2 tons (despite later planting in 1970) whereas on Fosters (old arable) they were smaller. The differences (1969 minus 1970) were:

	Highfield	Fosters
Lu	−2·3	+2·4
Lc	−1·6	+3·1
Ln	−2·6	+1·2
Ah	−2·4	+1·5
R	−2·1	+1·8

Best yields were about the same or a little better than those of 1968 in Highfield but 4–6 tons less in Fosters. The droughts of 1969 and 1970 seemingly affected the yields in Fosters more than in Highfield; an additional factor is that in 1970 aphids severely damaged the haulm in Fosters, but not in Highfield. How much this affected yield is not known.

https://doi.org/10.23637/ERADOC-1-125

TABLE 15

Rothamsted Ley–Arable

Potatoes (King Edward), total tubers, tons/acre

Previous cropping	1970 cwt N/acre 0·0	0·6	1·2	1·8	1969 Maximum yield (N)	1968 Maximum yield (N)
			Highfield			
Lu	19·6	21·6	21·5	22·4	20·1 (1·8)	20·2 (0·6)
Lc	18·6	22·8	22·7	22·4	21·2 (1·2)	19·6 (0·0)
Ln	17·8	21·1	20·9	21·8	19·2 (1·8)	19·7 (0·0)
Ah	16·1	20·6	20·0	21·5	19·1 (1·8)	21·3 (1·8)
R	18·6	20·8	21·7	23·0	20·9 (1·2)	22·2 (0·0)
Date of planting		7 May			30 April	17 April
			Fosters			
Lu	13·0	15·4	15·0	15·3	17·8 (1·8)	19·9 (0·6)
Lc	14·4	14·7	14·6	14·1	17·8 (1·2)	20·3 (1·2)
Ln	13·8	15·6	16·3	16·0	17·5 (1·8)	20·8 (0·6)
Ah	10·3	13·2	14·4	15·5	17·0 (1·8)	20·1 (1·8)
R	12·7	15·2	16·6	16·8	18·6 (1·8)	22·1 (0·0)
Date of planting		7 May			30 April	16, 17 April

Symbols: Lu = lucerne (3 years), arable (3 years) alternating
Lc = grass–clover ley (formerly grazed ley) (3 years), arable (3 years) alternating
Ln = all-grass ley (formerly cut ley) (3 years), arable (3 years) alternating
Ah = arable with hay (3 years), arable (3 years) alternating
R = reseeded grass, followed by one 6-year cycle as Ah. (1968 only reseeded grass ploughed for potatoes 1968)

PK dressings: with FYM, 1·5 cwt P_2O_5, 0·9 cwt K_2O; without FYM, 1·95 cwt P_2O_5, 1·8 cwt K_2O
plus 'corrective' K varying with rotation
plus sub-plot tests of 0 *v* 0·9 cwt P_2O_5, 0 *v* 0·9 cwt K_2O

On the Cultivation–Weedkiller Rotation (Table 16), yields of potatoes were 1–2 tons better than in 1969 although planting was later, but much less than in 1968. This crop (variety Pentland Dell) showed signs of damage by aphids, although less than in Fosters, and this may explain the difference in the effects of season on the two fields.

TABLE 16

Cultivation–Weedkiller Rotation Experiment

Potatoes (Pentland Dell), total tubers, tons/acre

	1970	1969	1968
P	13·0	11·4	18·2
R	13·0	12·0	15·7
T	14·6	12·4	16·6
Date of planting	1 May	15 April	29 March

Basal dressing: 1·3 cwt N, 1·3 cwt P_2O_5, 2·0 cwt K_2O

On the Residual Phosphate Rotations, as in the Ley–Arable, there was a great contrast between the old grass field (Great Field IV) where, with 1·5 cwt P_2O_5 annually, potatoes yielded more than in either 1969 or 1968, and the old arable field (Sawyers I) where yield was intermediate between those of 1969 and 1968. As in the Ley–Arable, the difference between fields on plots given 1·5 cwt P_2O_5 annually was small in 1968, greater in 1969 and greater still in 1970 (Table 17).

https://doi.org/10.23637/ERADOC-1-125

TABLE 17

Residual Phosphate Rotations

Potatoes (Majestic), total tubers, tons/acre

Cwt P_2O_5/acre (as superphosphate)	Sawyers I 1970	1969	1968	Great Field IV 1970	1969	1968
0	9·2	9·3	12·3	11·7	12·8	11·9
1·5 annually	13·4	12·7	14·9	17·3	15·8	14·2
3·0 in 1960	11·0	10·8	11·8	13·6	13·7	12·4
Date of planting	6 May	16 April	29 March	6 May	16 April	28 March

Basal dressing: 1·2 cwt N, 1·5 cwt K_2O (1968, 1969)
2·0 cwt N, 2·0 cwt K_2O (1970)

On the Woburn Intensive Cereals Experiment (Table 18) where planting dates differed little between 1970 and 1969, yields of potatoes were less than in 1969, by about 1 ton on the Wheat site, 3 tons on the Barley site. The difference in yield between the two sites continues to diminish (in 1966 and 1967 the Barley site gave about double the yield of the Wheat site).

TABLE 18

Woburn Intensive Cereals Experiment

Potatoes (Majestic), total tubers, tons/acre

After Classical Experiment on:	1970 0*	1970 Mg	1969 0	1969 Mg	1968 0
Wheat	12·8	12·6	13·6	14·2	10·5
Barley	13·1	13·9	15·8	17·2	13·7
Date of planting	22 April		18 April		27 March

* These plots received Mg in 1969 (and, Wheat site only, in 1968 also)

Basal dressing: 1·2 cwt N, 1·0 cwt P_2O_5, 2·0 cwt K_2O

TABLE 19

Woburn Ley–Arable

Potatoes (Maris Piper), total tubers, tons/acre
(Means of 1·0, 1·5, 2·0 cwt N)

Cropping in last 5 years	1970 0	1970 F	1969 0	1969 F	1968 0	1968 F
L	14·1	20·8	17·9	19·0	17·8	21·0
S	11·6	15·4	18·6	22·7	18·1	22·0
AH	9·7	15·9	13·8	20·9	8·5	19·2
AR	10·5	15·5	13·8	17·6	9·0	21·3
Date of planting	22 April		17 April		10 April	

Symbols: L = 3-year ley (grazed)
S = 3-year sainfoin (formerly lucerne) (cut)
AH = potatoes, rye, hay
AR = potatoes, rye, carrots
(L, S, AH, AR all followed by barley, barley (1970), sugar beet, barley (1969, 1968))
0 = no fumigant
F = chloropicrin in current year

Note: plots of treatments AH, AR have carried potatoes more frequently than those of L, S since 1938.

Basal dressing: 0·9 cwt P_2O_5, 1·8 cwt K_2O

https://doi.org/10.23637/ERADOC-1-125

On the Woburn Ley–Arable, where part of each plot of the treatment-crop potatoes has been fumigated with chloropicrin in each year, yields of more than 20 tons of Maris Piper have been recorded from at least one of the rotations in all three years (Table 19). In 1970 alone the grazed ley gave appreciably greater maximum yields than the other rotations (see p. 155).

To sum up: at Rothamsted planting was later than in 1969 or 1968 and on the Classical Barley experiment, and perhaps some other fields with long arable histories, yields were correspondingly less than in 1969 or 1968. On fields that have been ploughed from old grass 15–20 years ago, however, best yields (for which 1–2 cwt N or more was needed) were equal to or a little more than in 1969 or 1968. The difference between old arable and old grass fields noted in 1969 was even greater in 1970. At Woburn planting dates differed less and where pathogens were controlled yields were a little less than in 1969.

Small-plot experiments

The section undertook all agricultural operations on 24 experiments, involving 703 plots, and some operations on another 20 experiments. A cedarwood building on the Garden Plots provides a workshop, garage, dutch barn and an office for the staff.

Machinery for small plots. The sprayer built in 1969 to spray small plots from the side-paths was much used. With the experience so gained, we built an improved machine with a single wheel, and this was used late in the 1970 season.

The grain hopper of the Fiona drill was modified so that the drill retains much less seed when the mechanism ceases to deliver seed, enabling small batches of seed to be used more economically. (Wilson, Crabtree and Bailey)

Effects of seed-spacing and N on sweet corn. Seed-spacings of 3, 6 and 12 in. were compared in rows 24 in. apart, with N at 0, 0·5, 1·0 and 1·5 cwt/acre, all applied in the seedbed. The crop again grew well and the mean yield was 20 900 saleable cobs/acre, weighing 99 cwt. (The mean number of saleable cobs in the 1969 experiment was 22 500, not as stated in the *Report for 1969*, Part 1, 293.)

Most cobs were produced from seed spaced 3 in. apart, but the average weight of cobs increased with increased spacing. 0·5 cwt N and 1·0 cwt N gave successive increases in yield but more N decreased yields. (Wilson)

Residual effects of atrazine. Atrazine applied at 1½ or 3 lb/acre for sweet corn in 1968, had no effect on turnips grown in 1970. (Wilson)

Growth regulators for spring beans

Two microplot experiments tested the effects of growth regulators. One tested all combinations of none, B-Nine (4 lb a.i./acre), JF2579 (4 lb a.i.) and F529 (N-pyrrolidino-succinamic acid, 2 lb a.i.) applied at the 6-leaf stage; 200 and 400 lb/acre of seed; 5½ in. and 21 in. spacing between rows. The mean yield, 17 cwt grain, was poor and there was no benefit from growth regulators. Close row spacing gave 3 cwt more grain, on average, than wide; there was no benefit from the increased seed rate. Beans were so little favoured by the season that untreated stems reached a height of only 21 in. at maturity. JF2579 shortened this to 16 in. and both B-Nine and F529 to 14 in. The other tested PRB-8 (2-(β-chloro-β-cyanoethyl)-6-chloro-toluene) at 0·45, 4·5 and 45 oz a.i./acre; yield

https://doi.org/10.23637/ERADOC-1-125

was significantly lessened by 45 oz but not by the smaller amounts. PRB-8 had no effect on stem height. (McEwen)

Effects of defoliation on spring beans

A simple attempt was made to determine which of four zones of the bean plant made the largest contribution to photosynthetic products in the grain.

(i) Leaves on nodes below first flowering node (Zone A).
(ii) Leaves on first nine flowering nodes—the zone that usually sets pods (Zone B).
(iii) Leaves and stem above the first nine flowering nodes (Zone C).
(iv) Pods and stem up to the 9th flowering node.

The experiment tested all combinations of untouched, leaves of Zone A removed when 1st flower buds produced; untouched, leaves of Zone B removed when flower buds formed on 9th flowering node; untouched, decapitated when flower buds formed on 9th flowering node to remove Zone C.

Yields were poor, 18 cwt grain from untouched beans. Naked stems + pods produced 2 cwt grain. The effects of removing each zone depended greatly on the presence or absence of other zones:

Effects of removing zone	Other zones untouched	Both other zones removed
A	−1·7	−11·4
B	−4·2	−13·7
C	−1·4	− 5·7

These results indicate that the leaves on the nodes bearing pods usually make the largest contribution, but other zones can make considerable contributions. (McEwen)

Soil fumigation and nitrogen for spring beans at Woburn

The experiment, started in 1969, testing all combinations of no fumigant, dazomet at 400 lb/acre in autumn; none, 1 and 2 cwt N as 'Nitro-Chalk', was sown to spring beans again in 1970 with all treatments repeated on the same plots.

Soil samples taken in April showed dazomet had lessened populations of *Trichodorus* to 70/litre of soil (550 unfumigated), *Tylenchorhynchus* to 150/litre (2750 unfumigated), *Pratylenchus* to none (150 unfumigated). Samples taken after harvest showed *Trichodorus* had increased to 250/litre on fumigated plots (300 unfumigated), *Tylenchorhynchus* to 1450/litre (3450 unfumigated), *Pratylenchus* was still not found (150 unfumigated) (Nematode counts by Fraser, Nematology Department).

Root blackening, associated with *Fusarium*, was prevalent and unaffected by the treatments. (Hornby and Salt, Plant Pathology Department)

Yields were very poor, only 9·6 cwt/acre on plots without N, dazomet alone having no effect. With 2 cwt N, yield on unfumigated plots was 5·5 cwt but on fumigated plots was 12·9 cwt, confirming the positive interaction between dazomet and nitrogen shown in 1969. (McEwen)

Rothamsted Garden Clover. Yields from the 1970 sowing were greater than in 1969. Untreated plots gave a total yield of 32 cwt dry matter (three cuts), increased by nitrogen and magnesium together to 44 cwt. (McEwen)

https://doi.org/10.23637/ERADOC-1-125

The relative values of alternative break crops before winter wheat

Farmers who have abandoned traditional rotations of crops, but have not gone to the lengths of cereal monoculture suggested by Broadbalk and Hoos Barley, resort periodically to 'break crops' to alleviate their troubles.

The ideal break crop for such people would:

(i) make soil-borne pests and diseases of cereals unimportant,
(ii) eliminate weeds that flourish in continuous cereals in spite of spraying,
(iii) leave the soil in the best possible condition, physically, chemically and microbiologically, for cereals,
(iv) be sown and harvested with the machines used for cereals—but not at the same seasons,
(v) be as profitable as an average cereal crop.

Clearly, most cereal farmers know no such crop; if they did they would grow it in rotation with cereals.

We know from experiments and from practice on our farm that a two-year break with well-chosen crops and good husbandry can prevent losses from some important soil-borne diseases of cereals; where there are perennial grass weeds, it may be necessary to replace the first break-crop by a bare fallow. But many farmers pin their hopes on a one-year break and it is this situation we have started to investigate.

The first experiment designed to compare different crops used as a 1-year break in a sequence of cereal crops started in 1969 with the following treatments:

Red clover cut for hay
Spring beans
Spring oats given 0·4 or 0·8 cwt N/acre as 'Nitro-Chalk'
Spring barley given 0·4 or 0·8 cwt N/acre as 'Nitro-Chalk'
Spring barley, spring oats as above but undersown with trefoil

The site had carried winter wheat in 1968, following spring beans.

In November 1969 all plots were sown with winter wheat and split in spring to test 'Nitro-Chalk' at none, 0·4, 0·8, 1·2 cwt N/acre. At least one crop of spring barley will be taken after the wheat. Soil-borne diseases of all cereal crops are being assessed throughout the experiment.

The preliminary crops grew well in 1969 except that the clover suffered from the drought and gave only 46 cwt dry matter in a single cut. Where 0·8 cwt N was given, the nurse crops smothered the undersown trefoil, which after harvest covered only about one-tenth of the area; the amounts of dry matter and N in the greenstuff ploughed in was the same as in weeds etc. on plots not undersown. Where only 0·4 cwt N was given, however, trefoil established fairly well and about half the area was covered; about 0·15–0·2 cwt N was contained in the greenstuff, about double the amount on plots not undersown. Clover as ploughed in contained about 0·6 cwt N. We did not assess the N from beans. The yields of the nurse crops were lessened by about 0·5 cwt by the competition of the trefoil, a loss less than that commonly caused by weedkillers correctly applied to wheat. The quality of the nurse crops, assessed by sieving samples of grain, was not appreciably affected.

On 20 April, wheat after clover looked distinctly better than after the other crops, and on 4 May was still much the best, but wheat after beans was now clearly better than wheat after oats or barley, which were indistinguishable.

https://doi.org/10.23637/ERADOC-1-125

However, grain yields showed a very different pattern (Table 20). Wheat after barley yielded very little; even with 1·2 cwt N it gave less than wheat without applied N after oats, beans or clover. Responses to 'Nitro-Chalk' after oats and after beans were about equal, 1·2 cwt N giving 9–10 cwt more grain. Wheat after beans yielded 5–6 cwt more grain than wheat after oats with each amount of 'Nitro-Chalk'. After clover, by contrast, applied N had only small effects. Whether giving wheat after beans more than 1·2 cwt N would have produced a yield equal to the best after clover, is uncertain.

Table 21 shows the effects of trefoil ploughed in. Where 0·8 cwt N was given in 1969 there was very little trefoil and, on average, very little effect on wheat. Where 0·4 cwt N was given in 1969 trefoil gave 3 cwt more wheat after barley, 4 cwt after oats; the average effect differed little with rates of 'Nitro-Chalk' applied to wheat.

On plots without trefoil, the residual effects of 'Nitro-Chalk' applied in 1969 were small, 0·8 cwt N giving 1·4 cwt more wheat than 0·4 cwt after barley, 2·5 cwt more after oats. (Dyke, with Prew, Plant Pathology Department)

TABLE 20

Wheat after break crops (omitting undersown plots)

Grain, cwt/acre

	'Nitro-Chalk' to wheat (cwt N/acre)				
Preceding crop	0·0	0·4	0·8	1·2	Mean
Barley	9·9	12·4	16·1	17·0	13·9
Oats	22·2	28·1	29·3	32·4	28·0
Beans	28·1	33·5	34·2	37·2	33·2
Clover	36·6	38·0	39·4	39·4	38·4

Standard errors of means over N rates: ±0·96 (22 d.f.)

TABLE 21

Wheat after break crops; increases in yield of wheat for trefoil ploughed in

Grain, cwt/acre

	'Nitro-Chalk' to wheat (cwt N/acre)				
Preceding crop	0·0	0·4	0·8	1·2	Mean
Barley with 0·4 cwt N	+4·5	+2·8	+2·7	+2·8	+3·2[1]
Barley with 0·8 cwt N	+4·3	+3·3	+0·9	−1·9	+1·6[1]
Mean	+4·4	+3·0	+1·8	+0·4	+2·4[2]
Oats with 0·4 cwt N	+3·6	+3·3	+4·7	+4·6	+4·1[1]
Oats with 0·8 cwt N	−0·5	−2·5	+1·5	−1·7	−0·8[1]
Mean	+1·6	+0·4	+3·1	+1·4	+1·6[2]

[1] ±1·92
[2] ±1·36

Suppression of couch grass by ryegrass and clover undersown in barley. A small experiment compared barley alone, barley undersown with Italian ryegrass and barley undersown with red clover. On each plot about the time the barley and small seeds were sown, six pieces of rhizome of *Agropyron repens*, each about 6 in. long, were planted 4 in. deep. The pieces were about 3 feet apart so that there was no competition between couch 'plants'. (This followed a similar experiment in 1969 in which the barley was very vigorous and neither ryegrass, clover, nor couch grew appreciably.)

https://doi.org/10.23637/ERADOC-1-125

The barley was a moderate crop and the ryegrass and clover established and grew well in spite of the drought. When the plots were 'harvested' in December, some of the couch could not be found (especially in clover plots). Whether they had died or not is uncertain. If we assume they were alive and equal in growth to those that were found, the clover plots gave 2·2 g of air-dry couch (whole plant) per station, ryegrass plots 1·8 g, and plots not undersown 4·7 g. (The amount planted was 0·7 g per station.) The undersown crops at least halved the final amount of couch. (Dyke and Barnard)

https://doi.org/10.23637/ERADOC-1-125