Report for 1955

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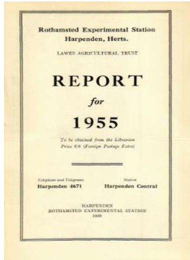
Rothamsted Experimental Station
Harpenden, Herts.

LAWES AGRICULTURAL TRUST

REPORT
for
1955

Field Experiments Section

Anon

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FIELD EXPERIMENTS SECTION

The following members of the staff, who constitute the Field Plots Committee, are responsible for planning and carrying out the programme of field experiments : F. Yates (Chairman,) H. V. Garner (Secretary), F. C. Bawden, H. H. Mann, J. R. Moffatt, R. K. Schofield, R. G. Warren and D. J. Watson.

Four Working Parties were constituted to prepare material for the Plot Committee : Classical and Long-Period Experiments (Chairman F. Yates), Pathology Experiments (Chairman F. C. Bawden), Agronomy Experiments (Chairman D. J. Watson) and Field Methods (Chairman R. G. Warren).

The number of plots comprised in the field experiments at Rothamsted and Woburn in 1955 were :

	Grain	Roots	Hay	Grazing	Total
Classical experiments					
Rothamsted	162	73	47	—	282
Woburn	15	—	—	—	15
Long-period experiments					
Rothamsted	532	384	209	96	1,221
Woburn	133	314	59	12	518
Annual experiments					
Rothamsted	563	181	48	—	792
Woburn	148	—	—	—	148
Total	1,553	952	363	108	2,976

Some of these plots were put down to provide material for observation only, but 2,781 were harvested and weighed. In addition, some 470 microplots were carried out at Rothamsted by members of the Chemistry Department, mainly on phosphatic fertilizers and fertilizer placement; and the Garden Plots Committee were responsible for about 360 microplots, mostly conducted by the Plant Pathology and Botany Departments. At Woburn H. H. Mann had twenty-five microplots for studies on exotic crops.

The weather as it affected agricultural operations is described in detail in the farm report; the following brief notes put on record the main features of 1955 to provide a general background for an account of the year's experimental work.

The general picture of the season 1955 was a very wet autumn, a severe and prolonged cold spell early in the new year, followed by one of the best summers for many years. In the period May to September inclusive there was a quite unusual succession of perfect summer days.

October opened dry and warm, ploughing was well forward, and on 15 October the first experimental wheat was drilled. Rain set in towards the end of the month and persisted all through November and most of December. The land soon became unworkable : Broadbalk was put in under very sticky conditions on 6 December, and a very small area of commercial wheat was sown on 28 December, leaving the bulk of the wheat and all the beans for spring sowing.

The last week of the year turned out dry with unusually high temperatures, but on 4 January a wintry spell set in which lasted for all practical purposes till the middle of March. Very little productive field work could be done during this long period. Ploughing started again on 12 March, and sowing a week later in excellent frost tilths. April, with only ½ inch of rain, was a month of almost uninterrupted field work, but May turned out wet and cold, with an exceptional blizzard on the night of 17 May. At this stage crops were backward owing to cold nights. June was a very dull month, with 50 hours less sunshine than average. The low evaporation kept the soil surface moist, and it was impossible to control the weeds in the root crops, particularly on Barnfield, while the early cut hay made only very slowly.

The warm, dry weather started towards the end of June and lasted with only slight interruptions for over 2 months. July had only ¼ inch of rain, and very effective horse-hoeing was carried out in the root crops. In the dry weather birds made an early start on the filling grain, but the new programme of crop protection reduced the damage to small proportions.

The dry weather continued in August, which only gave 0·85 inch of rain. There were no thunderstorms and practically no lodging. In spite of the good summer, ripening was not particularly rapid, and harvesting actually started on 4 August, and was nearly finished by the end of the month. By this time roots and potatoes were seriously affected by drought. It was not till 5 September that the long, fine spell was broken, but the rain was badly needed to soften the stubbles for ploughing, although it came too late for the potato crop. Further heavy rain fell on 22 September, but only stopped the ploughs for 1 day. With warm, bright days and ½ inch of rain less than the average the month was a favourable one for farm operations. All cereal plots were in by 2 September, and the late-sown bean plots were combined by 12 September. Grass grew well after the long summer drought, and the sheep were put back on the grazing plots for the second half of the month. The first 18 days of October saw almost all the potatoes lifted in excellent condition, but there was then a week's rain that stopped all field work. The weather then improved with falling temperatures, and mangold lifting started on Barnfield at the end of the month. There was little rain in November, ploughing was well forward and by 24 November Barnfield was completed with the land in much better condition than usual at this time of year. The dry weather continued for the first half of December, all ploughing being completed by this time.

The Classical Experiments

Broadbalk

The main point of interest on Broadbalk is the re-establishment of a small section of the field in continuous wheat commencing with the crop of 1955–56. A full account of the bare-fallowing operations which broke the long series of wheat crops grown by Lawes and Gilbert is given in another contribution to this report. The land intended for continuous wheat lies at the West end of the field adjoining the Wilderness; it is part of Section I, which has carried 104 wheat crops since the beginning of the experiment, and has been fallowed 8 times since 1914. The last bare fallow on Section I was in 1951, and it was therefore due to be fallowed once more in 1956; instead only the East half of Section I will continue in the fallowing cycle, leaving the West half to be drilled every year with wheat. At first it is proposed that the continuous section shall have the same cultivations as the rest of the field, but special cultivations or the use of herbicides may be considered if weeds become serious.

The wheat crop of 1955 was sown with difficulty on 6 December 1954, and the young plants had a long wintry spell from January till March. Nevertheless, all plots carried a good plant, and in the hot, dry summer which followed the field looked exceptionally well. There was practically no lodging and comparatively little trouble from eyespot (*Cercosporella herpotrichoides*); even Plot 8 with 6 cwt. of sulphate of ammonia per acre was harvested without difficulty —a most unusual occurrence. Wild oats were hand-pulled as usual but, thanks to systematic pulling in the past, this weed is now well under control. Bird damage, which in some years has been quite serious on Broadbalk, was unusually light this summer, partly owing to the stringing of the danger spots. The damage on the worst areas near the Wilderness and cottages was estimated at only 2 per cent.

Hoosfield

The first chalking under the new system was completed in hard weather in mid-March, and the barley was drilled in a very good frost tilth on 7 April. Heavy rains in May damaged the surface tilth, especially on Strip 3, which, being slightly hollow in the centre, held much water and was very badly capped. On 24 May the routine spraying with DNOC was carried out. It was only possible to hand-pull wild oats for 4 days at the end of July, and this was insufficient to clear the whole area completely, consequently a reduced area was picked clean for harvest on certain plots, the remainder of the produce being cut and carted green. The liming of the acid areas of this field, although only carried out a month before drilling, certainly improved the crop; Plot 5A in particular, which has grown practically no barley for several years, produced almost a normal crop after liming. In the summer drought the straw was very short except on the dung plot, where a little lodging occurred. Some of the poorer plots in the no-phosphate series were too short for the binder and were cut by mower.

Barnfield

Mangolds and sugar beet were sown on 23 April in a fairly good seedbed. Growth was slow in the cold weather which followed, and singling did not start till 23 June. By that time there was an extraordinary growth of annual weed, and wet weather very seriously hindered inter-row cultivations, so much so that the plants on the worst-affected plot (4AC) were cultivated out, leaving only 4 rows to stand for yield. Growth on all plots was poor during the summer drought, though the usual treatment differences appeared on a reduced scale, and when the dry weather broke in September it was clearly too late and yields turned out very light.

Owing to the alarming spread of " twitch " (*Agropyrum repens*) along the dung plots and across the no-nitrogen series, it was decided to make a test of TCA (sodium trichloracetate) against this

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weed. Consequently one-half of each plot that was badly affected was sprayed on 9 April at 20 lb./acre in 80 gal., leaving the other half unsprayed. Although the roots were drilled only a fortnight afterwards, no harm resulted, but the twitch was reduced to a very satisfactory degree on the treated areas, though it showed some signs of recovery at lifting time. This procedure will be trested again.

Plot 8N, sodium nitrate only, started with a good plant, but this gradually failed during the growing season. At lifting time many of the plants were small and carried a tuft of dead leaves, some plants being completely dead. Magnesium deficiency was suspected, and crop samples are being examined in the laboratory.

Park Grass

The showery weather in May followed by the cool weather in June was on the whole favourable for hay production. Some of the acid plots which normally show bare patches in a droughty spring were colonized by seedling Yorkshire Fog, which contributed appreciably to the yield, and the crop turned out well above average. Cutting began on 29 June under ideal conditions, and the hay was baled and weighed within a week. The second cut, taken on 16 September following the long, dry summer, was very light indeed.

Agdell

This field was drilled with spring wheat with a basal dressing of nitrogen. The crop was rather more uniform than the previous two barley crops, but still showed marked variations within the old treatments, partly but not entirely due to irregular distribution of take-all disease. The wheat was not weighed by plots, but just before harvest soil and crop samples were taken from good and bad areas for chemical examination and assessment of take-all.

Exhaustion Land

The first dressing of ground chalk was given in December 1954 and the remainder in March 1955. On Plot 2 (unmanured), which was originally very acid, the chalk produced a marked improvement. There was a good plant everywhere, and the residual effect of the early dung applications was unusually striking all through the growing season. Weeds are now giving some trouble locally on this experiment : part of Plot 2 was infested with twitch (*Agrostis alba*) and had to be rejected at harvest, and mayweed (*Matricaria inodora*) was very plentiful in Plot 6 (nitrogen only).

Long-period Experiments

The four-course rotation has now been recast to measure the effect of small annual dressings of superphosphate as affected by the residuals of the original organic treatments. This is done at two levels of nitrogenous manuring on each crop of the new rotation : potatoes, barley, beans, wheat, in which beans take the place of ryegrass. During the growing season there were visible residual effects of bulky organic manures in the cereal crops, though the most striking effect was that due to the direct application of nitrogenous fertilizers. Potatoes cropped badly owing to the drought and turned yellow very early in the season. Beans started well, but they were attacked by aphis late in the season and gave a poor and rather variable crop.

The six-course rotation testing deep cultivation has completed two whole rotations on the earliest blocks, and these have now been discontinued; the remaining blocks will also terminate as they complete their cycles. The cereals and hay were very good this year, and showed visible improvement from the farmyard manure applied to roots earlier in the rotation. Potatoes and sugar beet were both rather light crops, showing considerable benefit from dung, which kept the potatoes in active growth when those without dung were dead; potash had a similar effect. Deep ploughing appeared to benefit the sugar beet.

The ley–arable rotation, now in its seventh year, has been slightly modified in the light of further experience. It was found that the barley test crop invariably lodged on Highfield, where fertility is still high after the old grass; consequently Plumage Archer has now been replaced by Proctor and the levels of nitrogen on test have been reduced by 0·2 cwt. N. As mentioned in the last report, eyespot disease (*Cercosporella herpotrichoides*) was increasing to dangerous levels in the wheat and barley of the entirely arable rotations, especially on Fosters. To reduce this trouble the barley in the treatment phase has been replaced by oats. In view of the widely different amounts of potash withdrawn by the various treatment crops, cut grass, for example, removing much more than grazed ley, it was decided to introduce a test of potash in the following potato crop to measure differential effects due to previous cropping. To complete the information a similar test of phosphate was introduced also. A system of compensating dressings to take account of the differential withdrawals of potash is being worked out and put into operation. The first year's results of these additional treatments are given in Table 1, which also contains the effects of the leys on the three test crops.

Highfield, still showing after 7 years the benefit of the old turf, was more productive in all crops than Fosters, and at this stage rotations based on leys had no particular advantage over purely arable cropping. Dung showed up well on potatoes on both fields, but was less necessary after grazed ley. Increasing the potash from 0·9 to 1·8 cwt. K_2O gave better results after cut lucerne and cut grass than after grazed ley or arable cropping.

The grasses and leys of 1955 started the season well. Grazing began on 27 April and continued for 3 months, holding out well against the increasing drought. On 27 July, however, the sheep had to be removed for nearly 2 months, when rain then brought on a second flush and grazing was resumed till the middle of October. The first-year ley was fairly good on Highfield but very poor and weedy on Fosters; aftermath grass on the hayed plots was rather small. The output of dry matter from the permanent grasses and the rotation leys is given in Table 2.

In this droughty summer the permanent reseeded grasses on Fosters were more productive than the grazing leys. The outstanding success was lucerne, for although the first year's crops were below expectation, established lucerne in its second and third season

TABLE 1

Yield of test crops, 1955

	After 3 years' cropping with :				
	Lucerne	Grazed ley	Cut grass	Arable crops	Mean
First test crop :					
Wheat, grain, cwt./acre					
Highfield	48·0	48·9	38·9	47·9	45·9
Effect of 0·3 cwt. N ...	5·6	0·0	1·6	0·9	2·0
Fosters	38·2	34·8	34·6	32·9	35·1
Effect of 0·3 cwt. N ...	3·8	3·5	−0·6	4·6	2·8
Second test crop :					
Potatoes, tons/acre					
Highfield	10·05	10·48	9·78	10·53	10·21
Effect of 12 tons dung ...	2·58	0·77	1·81	1·58	1·68
Effect of 0·5 cwt. N ...	1·10	0·59	0·00	0·50	0·54
Effect of 0·9 cwt. P_2O_5 ...	0·56	−0·11	0·13	0·26	0·20
Effect of 0·9 cwt. K_2O ...	1·34	1·07	1·67	0·82	1·22
Fosters	8·62	8·29	7·35	7·65	7·97
Effect of 12 tons dung ...	1·61	0·63	2·26	0·77	1·31
Effect of 0·5 cwt. N ...	−0·23	0·31	−0·59	0·13	−0·09
Effect of 0·9 cwt. P_2O_5 ...	0·45	0·49	0·54	0·12	0·39
Effect of 0·9 cwt. K_2O ...	0·65	0·34	0·95	0·25	0·55
Third test crop :					
Barley, grain, cwt./acre					
Highfield	50·6	48·6	48·6	49·0	49·2
Effect of 0·2 cwt. N * ...	1·8	0·2	−4·0	4·4	0·6
Fosters	48·4	46·5	45·1	45·5	46·4
Effect of 0·2 cwt. N ...	2·2	4·0	3·1	1·7	2·8

Note : The fertilizer effects are the increases of the double dose of nutrients above the single dose; i.e., the effect of 0·5 cwt. N to potatoes is 1·0 cwt. N–0·5 cwt. N.

* No single dose of nitrogeni n this case.

TABLE 2

Rothamsted ley–arable experiment, Highfield and Fosters, 1955

Yield of dry matter, cwt./acre

	Old grass Hay	Old grass Grazing	Reseeded grass Hay	Reseeded grass Grazing	3-year ley Grazing	Cut grass	Cut lucerne	1-year ley hay
				Highfield				
Blocks :								
First year ...	—	34·3	—	33·3	27·1	34·1	24·5	49·7
Second year ...	—	40·9	—	51·9	57·0	53·7	109·8	—
Third year—								
Blocks 6 and 7	55·9	25·2*	65·0	30·1*	61·2	39·0	79·6	—
Blocks 5 and 8	—	35·3	—	42·1	—	—	—	—
				Fosters				
Blocks :								
First year ...	—	—	—	33·5	10·4	10·5	23·3	54·2
Second year ...	—	—	—	39·5	37·6	40·2	111·9	—
Third year—								
Blocks 8 and 9	—	—	67·6	19·6*	41·5	34·2	106·9	—
Blocks 5 and 7	—	—	—	28·4	—	—	—	—

* Aftermath grazing.

averaged well over 5 tons of dry matter per acre. The season was unfavourable for cut grass, although extra nitrogen greatly improved the level of yield. The undersown 1-year ley yielded less than usual, but nevertheless produced far more than any spring-sown ley in the first year.

Annual and Short-period Experiments

These experiments fall into two classes, depending on whether the main interest is in plant nutrition or plant disease. Many of them are carried out by or on behalf of the scientific departments who undertake the necessary sampling and observations.

Fertilizer experiments

(1) Spring wheat, Sawyers I. Residues of dung and fertilizers applied to the potato crop of 1954. This experiment again showed higher wheat yields on the plots that received sulphate of ammonia for the potato crop.

(2) Spring wheat, Great Field I. Seedbed applications compared with early and late top dressings of " Nitro-Chalk " at three rates and in all combinations. The field was in such high fertility that all nitrogen effects were small. There was no lodging.

(3) Spring wheat, Great Field I. Varieties and two levels of nitrogen. The experiment showed clear differences between varieties but no advantage this season for high levels of nitrogen.

(4) Barley, Great Field I. Seed rates and levels of nitrogen applied in the seedbed. With a very heavy crop the yield effects were small and non-significant. Heavy seed rates combined with high levels of nitrogenous manuring produced lodging. Records of incidence of eyespot and take-all were made by the Plant Pathology Department.

(5) Barley, Great Field I. Seedbed applications compared with early and late top dressings of " Nitro-Chalk ", at three rates and in all combinations.

(6) Barley, Great Field I. Varieties and nitrogen. The newer varieties, Herta and Proctor, were compared with Plumage Archer, with and without nitrogen. Intensive plant observations were made during the growing period by the Botanical Department.

(7) Barley, Great Field I. Varieties and nitrogen. Plumage Archer was out-yielded by each of the seven modern varieties with which it was compared. High nitrogen dressings were harmful this season.

(8) Barley, Highfield V. Residual effects of phosphate and potash applied to lucerne in 1952. A heavy crop of barley which showed a small residual effect of potash.

(9) Spring beans, Fosters Field. Control of weeds by spraying with DNBP and by cultivations.

(10) Lucerne, Great Harpenden II, first year. Levels of potash given either all in the first year or distributed equally over 3 years.

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Placement experiments (G. W. Cooke, Chemistry Department)

(1) Potatoes, Little Hoos. Three levels of nitrogen and of potash, broadcast or placed in a side band, in all combinations.
(2) Kale, Great Harpenden II. Combinations of nitrogen, phosphate and potash, broadcast or placed near the seed.

Experiments on soil structure (W. W. Emerson, Physics Department)

(1) Fosters Field. Effect of 5 years under various leys measured in spring beans followed by wheat.
(2) Long Hoos I. First preparatory year of new experiment. Ryegrass ley, cocksfoot ley and bare fallow have been established.

Experiment on wild oats (J. M. Thurston, Botany Department)

(1) Survival of wild oats under ley, Great Knott I, first year. Ley established in spring 1955 in oat-infested land and some plots ploughed up in autumn 1955 to test effect of one summer under grass. Further plots will be ploughed up yearly.

Plant pathology experiments

(1) Eyespot rotation, Long Hoos II and III, second preliminary year (M. D. Glynne, Plant Pathology Department). Winter wheat, two varieties, two seed rates, two levels of nitrogenous top dressing. Grown after wheat or after potatoes.
(2) Winter wheat, Long Hoos VII, second preliminary year (D. B. Long, Entomology Department). Effect of plant density on incidence of wheat bulb fly. Four different degrees of ground cover were obtained in 1954 and again factorially with the first year, in 1955.
(3) Winter wheat, Pennell's Piece, first year (M. J. Way, Insecticides Department). Test of four insecticidal treatments on wheat bulb fly.
(4) Spring beans, Fosters Field (M. J. Way, Insecticides Department). Test of spraying against aphids in relation to four times of sowing the seed.
(5) Potatoes, Little Hoos (L. Broadbent, Plant Pathology Department). Effect of spraying against aphids on spread of leaf roll and virus Y. Plots sprayed with DDT emulsion 0, 2, 4, 6, 8 times during the summer.
(6) Potatoes, Stackyard Field (J. M. Hirst, Plant Pathology Department). Effect of copper fungicide on late blight (*Phytophthora infestans*).
(7) Potatoes, Little Knott (J. M. Hirst, Plant Pathology Department). Effect of copper fungicide and of burning off haulm with sulphuric acid on late blight.
(8) Broccoli, Great Knott I (L. Broadbent, Plant Pathology Department). Effect of dung and levels of nitrogen on spread of cauliflower mosaic virus.

The results of the experiments carried out for workers in the scientific departments are usually reported by the departments concerned.

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Broadbalk Fallow

Under the original scheme of continuous winter wheat weeds were always a serious problem. In Lawes's and Gilbert's time much hand labour was expended on keeping the plots clean, but in wet years this was quite ineffective. Various methods of reducing the weeds were tried. In 1889 half the field was drilled in 16-inch rows to allow thorough inter-row cultivation; in the following year the other half was similarly treated. In 1904 each strip was divided lengthways into halves so that one-half of each plot could be bare fallowed, the remainder was fallowed in 1905. For the next 20 years the wheat was grown on 12-inch rows to facilitate hoeing. In 1914 the whole of the western half, i.e., nearest the farm buildings, was bare fallowed, and in 1915 the whole of the eastern half. The field was then cropped in the normal way till the harvest of 1925, when it was divided transversely into five equal sections in preparation for a regular cycle of crops and bare fallows. In 1926 and 1927 the three western Sections, 1, 2, 3, were fallowed, and in 1928 and 1929 the three eastern Sections, 3, 4, 5. Section 3 therefore received four consecutive bare fallows. In 1930 the whole field was drilled with wheat, and in the following years a sequence of 4 years wheat and 1 year bare fallow was built up on each section in turn, so that by 1935 the experiment was in full cycle, each section carrying one phase of the sequence: bare fallow, first, second, third and fourth wheat crops after fallow. The actual operations of bare fallowing vary from year to year according to the weather, but they usually conform fairly closely to the following scheme: The first operations on the plots due to be fallowed are the same as on plots being prepared for wheat, i.e., a single ploughing in September followed by from one to three strokes with the spring-tine cultivator about a month later. A second ploughing follows on a favourable occasion between December and March, and frequently a third between June and August. Each ploughing is followed by one or more strokes with the spring-tine cultivator to disturb successive crops of seedlings, and from May to July the thistle bar is used as necessary to cut strong perennial weeds. The fallow section is once more ploughed with the rest of the field for the next wheat crop.

Four complete 5-year cycles are now available covering the period 1935–54, and in Table 3 the average yields of grain and straw are given for each treatment, as well as the long-term average over the period 1852–1925, when the field was in continuous wheat. The figures for the final 10-year period under continuous wheat are also included.

The broad result of the fallowing of Broadbalk has been greatly to raise the productivity of all plots, particularly in the year immediately after the fallow. This may be seen in the last line of the table. The mean yield of all the plots has been increased by 3·1 cwt. grain and 9·3 cwt. straw above the long-term yield when under continuous wheat. The effect is no less than 6·7 cwt. of grain and 14·5 cwt. of straw when compared with the average production of the last 10 years before fallowing started. Fallowing has a big effect on the first year's crop and an appreciable one on the second year's crop, but the residual effects in the last two crops are small. Thus, taking the yield in the fourth year after fallow as the point of

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TABLE 3

Effect of fallowing, Broadbalk Field, 1935–54

Means of four complete cycles

Plot		Grain, cwt./acre: Years after fallow 1st	2nd	3rd	4th	Mean	Means 1852–1925	Means 1916–25	Straw, cwt./acre: Years after fallow 1st	2nd	3rd	4th	Mean	Means 1852–1925	Means 1916–25
2A	D	25·1	20·0	19·3	16·9	20·3	16·3 *	13·8	55·7	44·2	41·5	40·7	45·5	32·1 *	25·5
2B	D	25·7	22·6	21·2	19·1	22·2	19·4	15·5	57·8	48·4	45·6	45·4	49·3	34·2	30·1
3	O	16·1	9·0	8·7	8·7	10·6	6·7	4·8	28·1	15·1	14·6	14·7	18·1	9·8	6·6
5	C	19·0	10·3	9·5	10·3	12·3	7·8	5·2	34·2	19·1	17·8	20·1	22·8	11·5	7·4
6	N_1C	22·0	13·9	12·3	12·9	15·3	12·5	8·7	42·1	26·7	24·5	26·9	30·0	20·3	13·9
7	N_2C	24·1	18·8	17·1	17·3	19·3	17·6	14·0	49·4	39·5	35·3	36·4	40·2	32·1	26·1
8	N_3C	24·8	22·1	20·0	20·0	21·7	20·1	15·3	54·3	50·9	47·4	47·4	50·0	39·8	33·3
9	$N_1'C$	21·7	15·7	14·1	14·9	16·6	13·9 †	11·2	42·4	30·8	27·9	29·3	32·6	24·6 †	20·5
10	N_2	17·2	18·6	15·0	14·4	16·3	10·9	8·0	33·2	32·5	27·0	26·3	29·8	17·8	14·9
11	N_2P	17·1	16·8	14·9	14·1	15·7	12·3	7·7	34·0	31·2	27·5	27·1	30·0	21·4	17·7
12	N_2PS	20·3	18·5	16·6	16·4	18·0	15·7	10·2	39·3	34·8	30·4	30·6	33·8	26·8	20·8
13	N_2PK	24·3	18·0	16·0	16·4	18·7	17·0	12·9	48·6	37·7	32·7	33·8	38·2	30·6	25·6
14	N_2PM	21·5	18·7	16·9	16·3	18·4	15·5	10·6	41·9	36·1	30·9	31·2	35·0	26·8	21·5
15	$(N_2)C$	23·3	16·1	15·1	15·7	17·6	16·1	11·1	44·6	31·4	28·9	31·1	34·0	28·2	20·9
16	$N_2'C$	25·1	21·2	19·6	19·5	21·4	17·8 †	14·8	52·1	42·9	40·8	40·3	44·0	35·2 †	30·3
17 & 18	N_2	22·8	17·7	17·5	18·1	19·0	16·1	11·7	43·8	33·4	33·6	33·8	36·2	28·1	20·9
17 & 18	C	18·8	9·3	7·6	7·5	10·8	8·1	6·2	34·5	16·8	13·9	14·6	20·0	12·3	8·4
19	R	22·6	17·4	14·9	15·5	17·6	12·6 ‡	8·3	42·0	31·5	27·0	28·3	32·2	22·0 ‡	15·2
	Mean :	21·8	16·9	15·4	15·2	17·3	14·2	10·6	43·2	33·5	30·4	31·0	34·5	25·2	20·0

Notes : Manures per acre applied to every wheat crop, but not in the years of bare fallow:—D farmyard manure, 14 tons (2A since 1885, 2B since 1843); O unmanured; C superphosphate, 65 lb. P_2O_5 (P), sulphate of potash, 98 lb. K_2O (K), sulphate of soda, 100 lb., sulphate of magnesia, 100 lb.; N_1, N_2, N_3 sulphate of ammonia, 43 lb., 86 lb. and 129 lb. N; N_1', N_2' nitrate of soda, 43 lb. and 86 lb. N; S sulphate of soda, 366 lb.; M sulphate of magnesia, 280 lb.; (N_2) sulphate of ammonia, 86 lb. N in autumn; R castor bean meal, 1889 lb.

* 1900–25. † 1885–1925. ‡ 1893–1925.

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reference, there is a mean effect of 6·6 cwt. grain per acre in the first year, a residual effect of 1·7 cwt. in the second year but of only 0·2 cwt. in the third.

The results for the individual manurial treatments show differences. The three treatments with the lowest mean yields 3, 5, 17–18C, all no-nitrogen plots, give the greatest first-year response to bare fallowing: an increase of 9·1 cwt. grain and 15·5 cwt. straw per acre, the crop being practically doubled. Fallowing, however, is beneficial even to the best treatments; thus the three plots in highest fertility, 2B, 8, 16 are improved in the first year by 5·7 cwt. grain and 10·3 cwt. straw. A series of plots all having PK but with increasing levels of nitrogen show that the immediate effect of fallow declines as the direct addition of nitrogen increases.

		First-year fallow effect (cwt.)	
Plot number	N lb./acre	Grain	Straw
5, 17–18C	0	10·0	17·0
6, 9	43	8·0	14·2
7, 13	86	7·4	13·9
8	129	4·8	6·9

These facts suggest that the effect of fallowing is, at any rate in part, an addition to the available nitrogen in the soil.

The treatments may be divided into four groups differing slightly in their responses to the fallow.

TABLE 4

Mean yield, cwt./acre, and (in brackets) as per cent of mean yield

		Grain				
Treatment	Plot numbers	1st year	2nd year	3rd year	4th year	Mean
Farmyard manure	2A, 2B	25·4 (119)	21·3 (110)	20·2 (96)	18·0 (85)	21·2
Complete fertilizer 86 lb. N	7, 13, 15, 16, $(17–18)N_2$	23·9 (124)	18·4 (96)	17·2 (89)	17·4 (91)	19·2
No nitrogen	3, 5, (17–18)C	18·0 (161)	9·5 (85)	8·6 (77)	8·8 (78)	11·2
No potash, soda or magnesia	10, 11	17·2 (107)	17·7 (111)	15·0 (94)	14·2 (89)	16·2

The two high-yielding series given by dung and complete fertilizer respectively differ in the last year of the fallow cycle, for the yields with fertilizer practically reach their lowest level in the third year, whereas the dunged plots show a further marked decline in the fourth year. The poorest crops are those without nitrogen; in this series the fallow effect of +9·2 cwt. or 83 per cent of the mean yield in the first year is outstanding, both actually and relatively. The two treatments without potash are unusual in that the yield in the first season is no better than that in the second.

Effect of fallow on weed population

The effect of the Broadbalk fallowing operations on the weed population has been studied in the Botany Department in two ways: (1) by identifying and counting the number of seedlings of annuals produced in surface soil samples when kept for 3 years in good conditions for germination; (2) by estimates made in the field. Much of the data have already been published, and the work still continues. The following notes do no more than illustrate a few of the results obtained.

Of the annual weeds, poppy (*Papaver rhoeas*) and slender foxtail (*Alopecurus agrestis*) were the most conspicuous under continuous wheat. Fallowing affected them quite differently. Poppy was only slowly reduced, but failed to re-establish itself; slender foxtail was greatly reduced in the year of fallow, but quickly built up again. The enormous population of weed seeds and the effect of the fallowing system at each stage in the cycle is seen in Table 5.

TABLE 5

Reduction in weed seed population by periodic bare fallowing, Broadbalk, 1930–40

Mean of plots 2, 7, 18

Relative numbers, year before fallow = 100

	Year before fallow: Actual per sq. foot	Year before fallow: Per cent	Year of fallow	Years after fallow: 1st	2nd	3rd	4th	Year of next fallow
All annuals ...	2960	100	49	69	77	85	81	35
Alopecurus ...	645	100	19	89	125	132	131	19
Papaver ...	800	100	67	56	49	49	55	33

Comparing the populations in 1925, the last year of continuous wheat, with those found 20 years later, the species may be classified as follows:

Changes in weed population due to fallowing, 1925–45

Soil sample data

Species showing reduction of: 85–90%	Over 75%	Over 60%	Species showing little change	Species showing increase
Papaver rhoeas	*Aethusa cynapium*	*Scandix pecten-veneris*	*Alopecurus agrestis* *	*Medicago lupulina*
Atriplex patula	*Galium aparine*		*Bartsia odontites*	*Stellaria media*
Caucalis arvensis	*Myosotis arvensis*		*Capsella bursa-pastoris*	
Polygonum aviculare	*Veronica arvensis*		*Veronica hederaefolia*	

* But very big reduction in first year.

The field observations were in general agreement with the above. In addition, they revealed an increase of *Vicia sativa*, *Matricaria inodora* and *Ranunculus arvensis* since fallowing was introduced. The field observations covered the perennials also, chiefly *Convolvulus arvensis*, *Cirsium arvense*, *Tussilago farfara* and *Sonchus arvensis*. The intensive fallowing of the period 1926–29 materially reduced these species, *Sonchus* being practically eliminated. *Convolvulus* and *Cirsium* are probably increasing again under the rotational fallow system.

With 1 year's fallow in 5 Broadbalk is much cleaner than it used to be, the heavier and denser crops of wheat that are now grown probably helping to reduce weeds.

Wild oats, *Avena ludoviciana*, were frequent on Broadbalk by 1931, and became serious during the Second World War. Bare fallowing every 5 years has very little effect on this weed, but systematic hand-pulling, begun in 1945, has almost eliminated it.

Effect of bare fallow on eyespot and take-all

Every year the incidence of eyespot, *Cercosporella herpotrichoides*, is lower in the section following bare fallow than in the sections after crop. Observations made on eight plots over the 18-year period, 1938–55, show that the deep lesions on the straw which cause serious loss of yield are reduced from 45 per cent on wheat after wheat to 21 per cent on wheat after fallow.

Take-all, *Ophiobolus graminis*, is common on plots which received no nitrogenous fertilizer. The disease is severe enough to cause loss in yield in some years in sections after crop, but is generally absent or relatively slight after fallow. One of the ways in which the fallow has increased the yield of the less-fertile plots is by control of take-all.

Wheat bulb fly

The sequence of wheat crops and bare fallows on Broadbalk provides suitable conditions for the establishment of a permanent infestation of wheat bulb fly (*Leptohylemyia coarctata* Fall.). From 1930 onwards damage from this pest was noted, mainly on the crop immediately after bare fallow. In most years the plant, although thinned in the winter and early spring, filled up again and the effect on yield was judged to be slight. In a few seasons the loss of plant was so great that there could be no doubt that yields were affected. Thus in 1936 the mean yield of the whole section after bare fallow was less than that of the neighbouring section carrying the second crop after fallow, and less than that of another adjoining section carrying the fourth crop after bare fallow. Other bad years were 1950 and 1953. When the plant is seriously thinned by wheat bulb fly, weeds quickly come in, and the crops after fallow may be much more weedy than the rest.

Counts of larvae on the wheats after fallow show that the population varies widely from year to year. There is not yet sufficient evidence to judge how far the different manurial treatments effect egg laying and the subsequent larval infestation.

Staff

C. R. L. Scowen transferred from the Farm Staff to replace Kathleen Ogborn who left the Section to go to the Aden Protectorate. Mr. J. L. Hammerton, Department of Agriculture, Reading University, spent the long vacation on the farm assisting in the work of the Section. H. V. Garner spent three weeks in Holland, West Germany and Denmark studying field experimental methods, and also attended the meeting of the International Institute of Sugar Beet Research at Brussels.