ROTHAMSTED RESEARCH

Report for 1956

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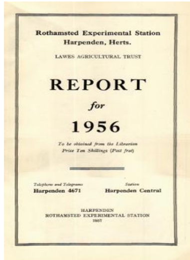
Rothamsted Experimental Station
Harpenden, Herts.

REPORT
for
1956

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, G. W. Cooke, H. H. Mann, J. R. Moffatt, R. G. Warren and D. J. Watson.

Four Working Parties 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 experimental plots carried out at Rothamsted and Woburn in 1956 were:

	Grain	Roots	Hay	Grazing	Total
Classical experiments:					
Rothamsted	162	14	48	—	224
Woburn	—	—	—	—	—
Long-period experiments:					
Rothamsted	514	392	191	96	1,193
Woburn	133	314	107	12	566
Annual experiments:					
Rothamsted	610	363	112	—	1,085
Woburn	162	128	—	—	290
Total	1,581	1,211	458	108	3,358

Some of these plots were put down for observation only, but 3,134 were harvested and weighed. In addition, some 390 microplots were carried out at Rothamsted, mainly on phosphatic fertilizers and fertilizer placement, but including a set of reference plots showing the effects of nutrients and dung on a series of farm crops. The Garden Plots Committee were also responsible for 210 small plots, mainly on plant pathology problems. At Woburn H. H. Mann had a number of observation plots 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 1956 to give a general background for an account of the year's experiments.

The main characteristics of the season were a favourable autumn and early winter, followed by an exceptionally cold February which gave excellent spring seedbeds. A spring drought then set in, affecting grass and seedling roots. The dry weather broke in mid-June to give a wet hay-time, followed by the most unpleasant August and early September for many years. The late harvest, with much poor-quality grain, will long be remembered. The weather then improved: there was good weather for potato lifting, and a dry, rather mild period from November to mid-December particularly favourable for clearing the mangolds and sugar beet. In spite of the lost time in late summer, the year finished with work well forward.

Broadbalk

The wheat was drilled on 2 November in a seedbed that was rather firm and sticky after the heavy rain of a fortnight before, consequently in the lower parts of the field the grain did not cover very well under the harrows. Nevertheless, a good plant was obtained, less good perhaps on the section immediately after bare fallow, especially on Plots 10 and 11, which are without potash. Growth was good in the rather dry, warmish weather of early winter, but the crop looked very brown and scorched during the continuous frost of February. It made a very good recovery in March and April, however, and there was promise of a good crop. The wet weather which started in June favoured weed growth, particularly where the treatments produced only light crops. Thistles (*Cirsium arvense*) were very conspicuous on the West end of the field, so much so that on certain plots in the strip set aside for continuous wheat these weeds had to be hand pulled. On the lower end of the field, near the drain, poppies (*Papaver rhoeas*) and mayweed (*Matricaria inodora*) were beginning to come back in quantity; the former being most prevalent on the section recently limed, the latter on the unlimed section.

Leguminous weeds, *Vicia* and *Medicago lupulina* continued to grain ground, particularly on the plots with minerals but no nitrogen. Plot 5, minerals without added nitrogen, which in recent years has carried a dense growth of leguminous weeds, grew a much better crop than the unmanured wheat alongside. The plots without potash showed a noticeable colour effect from the end of July onwards in the ripening straw. The straw and chaff had a dirty dull-brown colour quite different from the clean yellow of neighbouring plots which were fully manured.

Lodging was more or less general, and the plots looked twisted and miserable towards the end of summer, with much weed growing through. The crop had all to be cut one way in a very late harvest. Eyespot, *Cercosporella herpotrichoides*, was prevalent on Broadbalk, being least severe on the plots immediately after bare fallow. Take-all, *Ophiobolus graminis*, was scattered in sections following wheat, but was not found on plots after bare fallow.

Hoosfield

This field continued to show the good effects of the liming carried out in 1955. The dramatic change in the very acid Plot 5A (NPK annually) noted in the first year after liming, showed even more markedly in 1956. What was quite the worst plot on the field is now one of the best. For the first time the whole field, instead of only part of it, was thoroughly hand-pulled for wild oats. This was because Broadbalk, now nearly cleaned, makes very light work for the pickers, who are now free to concentrate on Hoosfield. The barley was sown in an excellent seedbed and made a good start well ahead of the weeds, which did not show up till late in the season. Harvest was very late, and by then some of the heavier yielding plots, including the dunged plot, were badly lodged. For the first time since 1951, when parts of the plots heavily infested with wild oats were discarded, the whole produce of every plot was harvested.

Barnfield

With the liming of Barnfield in 1956 the programme for the classicals has been completed. On Barnfield it was only Series A, sulphate of ammonia, and Series AC, sulphate of ammonia plus castor meal, which showed acidity, though on Series C, castor meal, the reserve of calcium carbonate was very small. The liming plan adopted was :

(i) A corrective dressing of 5 tons calcium carbonate per acre applied as ground chalk to Series A and AC only.

(ii) A maintenance dressing to be applied to Series A, AC and C at the rate of 1·5 cwt. calcium carbonate per 1 cwt. ammonium sulphate (23 lb. N) and 0·75 cwt. calcium carbonate per 23 lb. N given as castor meal.

The corrective dressing was applied in spring 1956 before the present crop was sown. The maintenance dressing was ploughed in after the mangolds were lifted, the chalk being given at five times the scheduled rate to last for five years. The TCA (sodium trichloroacetate) spray treatment tested on half plots in 1955 and found to be effective was applied to the remaining halves of the plots in March 1956.

The mangolds made a very bad start on a dry seedbed, and the germination and early growth was clearly related to the plot treatments. The dunged strips carried a good plant, which grew fast and was singled early. Series C, rape cake, which was not acid and in fairly kindly tilth, also gave a plant. Series N, nitrate of soda, lying in the valley and not acid, carried a fairly satisfactory plant. The remainder of the field, possibly still acid and certainly low in organic matter, carried so poor and irregular a stand that on 22 June it was decided to cultivate up all areas that had not been singled on this date. This left the dunged strips and the Series N, nitrate of soda.

Soon after the poor stands were ploughed up the weather broke and a very favourable root season set in, with the result that better yields of mangolds were taken from the surviving plots than for many years. Spraying against twitch was very effective. The dunged plots were almost cleared up, and carried a good crop of mangolds in consequence.

Park Grass

The season was a bad one for the permanent hay plots, the continuous frosts in February followed by the spring drought killed off the plants extensively on the acid plots. Those on which Yorkshire Fog (*Holcus lanatus*) was the main species reclothed themselves with seedlings in the latter part of the season, but the others, less acid and carrying a more varied population, still showed bare patches in autumn. Growth elsewhere was very slow to start in the spring, in fact there was very little growth till early June, thereafter when the rain came there was a flush which resulted in a rather light crop

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cut on 11 June. One feature of the wet summer was the large amount of wild white clover in the herbage. This was very conspicuous indeed on plots with mineral manuring without nitrogen, but was by no means confined to these. There was plenty of moisture in the second half of the season; the second cut taken on 19 November was therefore heavier than usual.

Agdell

This field is still being cropped without phosphate or potash. Since the old experiment was terminated in 195[illegible] at the end of the twenty-sixth cycle of the four-course rotation, it has carried three cereal crops with basal nitrogen, and in 1956 the crop was winter beans without fertilizer. The beans made a good start in the autumn and came through the very hard weather in February very well. The residual effects of phosphate and potash applied to roots in the old rotation were plainly visible in the growth of beans. Aphis attack was very slight, and the crop was not sprayed. It was harvested by combine, taking two cuts through each of the original six plots.

Long-period Experiments

Four-course rotation

This experiment, begun in 1930 and redesigned in 1955, carried its final crops in 1956. The potato crop was one of the best grown on this land for many years; wheat was, as usual, poor and barley good. Winter beans were badly thinned in the very hard weather in February and were resown on 12 April. They made very strong vegetative growth, and by waiting till 10 October a very good crop was combine-harvested, with a moisture content of 46 per cent. There was no aphis attack this year. All crops were visibly poorer on the old rock phosphate plots, and potatoes, wheat and barley gave big nitrogen responses and showed the residues of former organic manuring. The four blocks of the old experiment will each be sown with varieties of wheat and other cereals to provide material for the study of footrot diseases in relation to the preceding crops, wheat, barley, potatoes, beans.

Deep-cultivation rotation

The two blocks of this experiment which had terminated after completing their cycle were drilled with barley in 1956. In the spring the barley on certain plots showed a yellowing and browning of the tips of the young leaves which suggested potash starvation. The experimental treatments involve dung and muriate of potash, and on certain plots some poor subsoil has been brought to the surface; big differences in potash status between treatments could therefore be expected. Soil and crop samples have been taken for examination, and the results are to be found in the report of the Chemistry Department.

Deep ploughing for wheat gave an increase of 3·6 cwt. grain above that obtained by ploughing to ordinary depth. Dung applied to sugar beet increased the following barley by 1·8 cwt., seeds hay the third crop by 3·9 cwt. and wheat the fourth crop by 2·5 cwt.

Ley–arable rotations

These experiments have now completed one full cycle on every block. The season was not nearly so good for cereals as 1955, but very much better for potatoes. Excellent yields of potatoes were obtained from both Highfield and Fosters. Winter wheat, the first test crop, was somewhat below average on Highfield, nevertheless it was lodged. This occurred even after cut grass, when the crop was conspicuously poor and weedy and carried very small ears. This failure of cut grass as a preparation for wheat occurs every year on this field, and is now being investigated. In this wet season an extra 2 cwt. " Nitro-Chalk " top-dressing for the wheat was harmful after the leys but beneficial after arable crops. On Fosters, an old arable field, the wheat was not nearly so badly lodged, all leys gave better yields of wheat than the arable sequence, lucerne giving the best result. Extra nitrogen was always needed on this field, for the second dressing of 2 cwt. of " Nitro-Chalk " gave a mean increase of +4·1 cwt. grain. Potatoes, the second test crop, yielded 14·25 tons on Highfield without dung and 17·67 tons with 12 tons of dung. The test of additional phosphate and potash was continued for a second year to study the demands of the various rotations for phosphorus and potassium. Ley was by far the best preparation and cut grass the worst. Doubling the nitrogen and phosphate had little effect, but doubling the potash made a great improvement. After the grazed ley, however, the potash effect was greatly reduced. On Fosters the crop averaged 13·15 tons without dung and 15·39 tons with dung. In the absence of dung, grazed ley was decidedly the best preparation for potatoes, but when dung was given the best yield was after arable crops. Cut grass was again the least effective preparation for potatoes. Fosters was much less dependent on extra potash than Highfield, only after lucerne was the effect of doubling the potash at all noticeable.

The third test crop, barley, was badly lodged but gave good yields. An extra 0·2 cwt. nitrogen was harmful on both fields, for it put the crop down earlier. In contrast to the other test crops, barley did quite well after cut grass, but the grass was ploughed in three years previously in this case. Some of the main treatment effects in the test crops are given in Table 1.

The herbage crops in 1956 gave slow early growth without any marked flush; most of the crops held out well throughout the moist summer and the stock had a longer grazing period than usual. Highfield, on the whole, was faster growing and more productive than Fosters, particularly in the old grass, which stood up well against a full season's grazing with only a break of 2 weeks. The reseeded grasses on both fields carried a high proportion of clover which the sheep did not graze completely. The three-years ley on Highfield was particularly good in its seeding year; the second and third years of the grazing leys were almost as productive as the permanent grass on both fields.

Cut grass gave four cuts in its first year and six cuts in each of the later years. All lucerne looked well, but in mid-September large patches of wilted plants were observed in the third cut of the second- and third-year stands of lucerne on Highfield and to a

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TABLE 1

Rothamsted ley–arable experiment: Highfield and Fosters
Yield of test crops, 1956

	After 3 years' cropping with:				
	Lucerne	Grazed ley	Cut grass	Arable crops	Mean
First test crop:					
Wheat, grain, cwt./acre					
Highfield	34·2	36·2	20·[illegible]	39·7	32·6
Effect of 0·3 cwt. N ...	−1·1	−1·5	−1·[illegible]	+2·9	−0·4
Fosters	41·7	36·1	33·3	30·5	35·5
Effect of 0·3 cwt. N ...	+2·6	+3·0	+3·7	+6·9	+4·1
Second test crop:					
Potatoes, tons/acre					
Highfield	15·64	17·86	14·31	15·54	15·96
Effect of 12 tons dung ...	+5·09	+2·48	+2·35	+3·24	+3·42
Effect of 0·5 cwt. N ...	−0·98	−0·07	+0·13	+0·72	−0·04
Effect of 0·9 cwt. P_2O_5 ...	−0·21	−0·27	+0·57	+0·84	+0·26
Effect of 0·9 cwt. K_2O ...	+2·22	+0·78	+2·31	+2·27	+1·90
Fosters	14·23	14·76	13·37	14·70	14·27
Effect of 12 tons dung ...	+2·56	+0·96	+2·72	+2·66	+2·23
Effect of 0·5 cwt. N ...	+0·02	+0·72	−0·50	+1·04	+0·33
Effect of 0·9 cwt. P_2O_5 ...	−0·42	−0·06	+0·36	+0·34	+0·19
Effect of 0·9 cwt. K_2O ...	+1·16	+0·70	+0·48	+0·04	+0·59
Third test crop:					
Barley, grain, cwt./acre					
Highfield	31·5	33·2	35·[illegible]	36·8	34·3
Effect of 0·2 cwt. N * ...	−2·6	−1·4	+1·[illegible]	−5·7	−2·1
Fosters	36·7	38·8	40·3	39·8	38·9
Effect of 0·2 cwt. N ...	+0·3	−0·9	−2·5	−0·2	−0·8

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 nitrogen in this case.

lesser extent on Fosters. The wilt was caused by a fungus, possibly either a *Fusarium* or *Vertillicium* species, and the disease is being investigated in the Plant Pathology Department. Only the last cut of the third-year lucerne on Highfield was estimated to be seriously reduced this year. When the lucerne is ploughed up for wheat the plant is never completely killed, and the wheat always contains a number of lucerne plants. Starting in 1956, these volunteer plants have been killed in spring by spraying with a hormone weed-killer. This may help in reducing the carry over of the wilt infection from one lucerne crop to the next.

The yields of the herbage crops are given in Table 2.

Compared with the average of previous years, the output of dry matter was distinctly low for all the grazed plots in 1956, Highfield being rather more productive than Fosters. The small amount of extra nitrogen, given as 1 cwt. of "Nitro-Chalk", increased the dry-matter production of these plots by an average of 2 cwt. per acre. The season was favourable for cut grass on both fields, and yields well above average were obtained; in addition there was a response of 16 cwt. dry matter per acre for the extra dressing of 1 cwt. of "Nitro-Chalk" given for every cut. In spite of the fungus disease pre-

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TABLE 2

Rothamsted ley–arable experiment: Highfield and Fosters
Yield of treatment crops
(Dry matter, cwt./acre)

Year of leys	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				
First ...	41·7	25·8 *	61·5	22·9 *	20·3	59·4	46·2	56·6
Second ...	—	26·9	—	26·2	27·2	73·8	88·0	—
Third ...	—	31·6	—	33·0	30·2	75·7	96·6	—
				Fosters				
First ...	—	—	35·4	18·9 *	16·8	43·1	33·5	46·6
Second ...	—	—	—	22·9	24·0	63·7	90·1	—
Third ...	—	—	—	17·8	22·7	70·6	105·4	—

* Aftermath grazing.

viously mentioned, lucerne in its second and third years produced more dry matter than any other herbage crop.

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, Little Hoos. A repetition on a fresh site of the experiment started in 1955 testing "Nitro-Chalk" applied at three times: in the seedbed, as an early top-dressing and as a late top-dressing. All combinations of these three times are being tested, and the nitrogen is given at three rates of application 2, 4 and 6 cwt. "Nitro-Chalk" per acre.

(2) Spring wheat, Little Hoos. A comparison of eight varieties of spring wheat each tested at two levels of nitrogen: 2 and 4 cwt. of "Nitro-Chalk" per acre applied in the seedbed.

(3) Barley, Little Hoos. The same design as experiment (1) above using 1½, 3, 4½ cwt. "Nitro-Chalk" on Herta barley.

(4) Spring oats, Pastures Field. As experiment (2) above with levels of nitrogen 0·36 and 0·72 cwt. N per acre.

(5) Beans, Great Harpenden II. A comparison of autumn-sown and spring-sown beans, including a test of three levels of phosphate and three levels of potash in all combinations. Spraying against aphis was also tested.

(6) Potatoes, Great Field II. A test of four levels of dung, 0, 5, 10, 20 tons per acre, with all combinations of 0·9 cwt. N as sulphate of ammonia, 0·75 cwt. P_2O_5 as superphosphate, 1·5 cwt. K_2O as muriate of potash. Residual effects will be measured in barley in 1957.

(7) Sugar beet, Great Field II. Four levels of dung, 0, 5, 10, 20 tons, together with all combinations of 0·9 cwt. N as sulphate of ammonia, 0·75 cwt. P_2O_5 as superphosphate, 1·5

cwt. K_2O as muriate of potash, 5 cwt agricultural salt. Residual effects will be measured in barley in 1957.

(8) Lucerne, Great Harpenden II, second year. Three levels of potash, 1, 2, 3 cwt. K_2O per acre, given either in a single application in 1955 or in three equal annual doses in the years 1955–57.

(9) Ryegrass, Long Hoos I. Comparison of forms of nitrogen fertilizer: formalized casein, casein, urea, calcium nitrate, ammonium sulphate. N applied at 0·75 and 1·5 cwt. per acre. Casein products applied in single dressings, others in divided dressings before each of three cuts.

Placement experiments (F. V. Widdowson, Chemistry Department)

(1) Potatoes, West Barnfield I. Sulphate of ammonia 0, 0·5, 1·0 cwt. N; sulphate of potash 0, 0·75, 1·5 cwt. K_2O in all combinations: taken factorially with both constituents broadcast before planting, both constituents drilled in a side band at planting time, one constituent drilled and the other broadcast.

(2) Kale, West Barnfield I. Superphosphate 3 cwt./acre and muriate of potash 2 cwt. per acre in all combinations, broadcast on seedbed and harrowed in or drilled in band 2 inches to the side of the seed. A test of NPK broadcast or drilled is included.

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

(1) Ploughed up leys, Fosters Field. Effect of various five-year leys of pure species of grass and legumes measured in red beet and carrots (first test crops); wheat (second test crop); barley (third test crop).

(2) Ryegrass and cocksfoot leys, Long Hoos I. Second preparatory year of leys.

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

(1) Survival of wild oats under leys, Great Knott I, second year. Certain plots put down to ley in oat-infested land in spring 1955 have been ploughed up in autumn 1956 for examination.

Experiments on beans (J. R. Moffatt, The Farm)

(1) Spring beans, Great Field I. Control of weeds by cultivations and DNBP spray.

(2) Spring beans, Great Field I. Effect of hormone sprays on setting of flowers.

Plant pathology experiments

(1) Wheat, eyespot rotation experiment, Long Hoos II and III, third year (M. D. Glynne, Plant Pathology Department). Two varieties, two seed rates, two levels of nitrogenous manuring, sulphuric acid spray in early spring. All the above treatments are tested factorially on winter wheat in the final year after four different crop sequences. Detailed observations on eyespot (*Cercosporella herpotrichoides*) are made.

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(2) Wheat, Long Hoos VII, third year (D. B. Long, Entomology Department). Effect of plant density on incidence of wheat bulb fly (*Leptohylemyia coarctata* Fall.). Testing year under a uniformly treated crop of wheat, after four different degrees of ground cover in 1954 and 1955.
(3) Wheat, Pennell's Piece (R. Bardner, Insecticides Department). Test of four insecticidal treatments against wheat bulb fly.
(4) Wheat and winter oats, Highfield I (G. A. Salt, Plant Pathology Department). Plots of wheat and winter oats singly and in mixture in preparation for an experiment on spring wheat in 1957 studying weed control in relation to the incidence of take-all (*Ophiobolus graminis*).
(5) Spring beans, Great Knott I (M. J. Way, Insecticides Department). Testing four dates of spring sowing, February, March, April, May; with spraying against aphids, in mid-June, in early July and on both occasions.
(6) Potatoes, Great Knott III (G. A. Salt, Plant Pathology Department). Test of four fungicides applied by three methods against skin spot (*Oospora pustulans*).
(7) Potatoes, Great Knott III (J. M. Hirst, Plant Pathology Department). Effect of copper fungicide and burning off haulm with sulphuric acid on late blight (*Phytophthora infestans*).
(8) Potatoes, Great Knott III (L. Broadbent, Plant Pathology Department). Effect of spraying against aphids with DDT insecticides four times or six times, at high or low volume on the spread of leaf roll and virus Y.

Fertilizer experiments, Woburn

(1) Spring wheat, Stackyard C. A repetition of the nitrogen experiment of 1955. "Nitro-Chalk" at three times of application, in the seedbed, as an early top-dressing and as a late top-dressing. All combinations of these three times were tested at 2, 4 and 6 cwt. "Nitro-Chalk" per acre.
(2) Barley, Stackyard C. As experiment (1) above.
(3) Spring beans, Broadmead I. Three levels of phosphate and three of potash in all combinations.
(4) Potatoes, Butt Close. A repetition of the Rothamsted experiment testing four levels of dung with each of the three nutrients NPK in all combinations. Residues will be measured in barley in 1957.
(5) Sugar beet, Butt Close. A repetition of the Rothamsted experiment testing four levels of dung with each of the four nutrients NPK, salt in all combinations. Residues will be measured in barley in 1957.

Plant pathology experiments, Woburn

(1) Winter wheat, Road Piece, third year (G. A. Salt, Plant Pathology Department). Two varieties, two seed rates, two levels of "Nitro-Chalk" applied on four occasions: all early March, all mid-April, all end May, half in March and half in May. Observations on take-all (*Ophiobolus graminis*) were made.

Farmyard manure for sugar beet or potatoes

A new series of experiments was started in 1956 on both farms to compare the effect of dung on sugar beet and potatoes, two crops that often compete for the limited amount of dung available on arable farms. The dung, taken from the same yard, was used at several rates per acre in the presence and also in the absence of the three standard fertilizers; thus, in addition to providing a response curve for farmyard manure on both crops, the experiments were designed to give information on the interaction of dung with the inorganic nutrients. In the sugar-beet series agricultural salt was also tested. It is proposed to follow each experiment by at least one year under spring-sown cereals to measure the residual effects of the manures applied to the roots.

At Rothamsted the sugar beet and potatoes were grown side by side in Great Field II on land still showing some residual fertility after many years in grass. Field observations on the growing crops showed that with potatoes by far the most active fertilizer was superphosphate, which lightened the colour of the foliage and gave marked increases in vegetative growth. Dung was also effective up to 10 tons per acre, but the further increase in growth produced by the highest dose of 20 tons was small. In the sugar-beet plots superphosphate also produced a striking improvement, which was particularly marked in the early stages, though it persisted far into the season. The seedlings on the phosphate-treated plots made a much quicker start and were about twice the size of the others. In the early stages of growth even the heaviest dressing of dung, 20 tons per acre, although visibly beneficial was not nearly so effective as superphosphate. This spectacular result from superphosphate for sugar beet and potatoes is quite unusual at Rothamsted. Potash had no noticeable effect on the vegetative growth of the potatoes, but the final yield was increased except in presence of 20 tons of dung.

At Woburn neither superphosphate nor muriate of potash had any visible effect on potatoes. The main benefit came from sulphate of ammonia, both in growth and colour, and there was a steady improvement with each level of farmyard manure at the rate of approximately 1 ton of potatoes for 5 tons dung.

Alternate Wheat and Fallow, Hoosfield

In the autumn of 1956 the old "wheat and fallow" plots were reduced to half their former size to provide suitable land for field studies of the wheat bulb fly (*Leptohylemyia coarctata* Fall.), while still preserving the continuity of the classical experiment. The change provides a convenient opportunity to summarize the history and long-period results of the experiment.

The land on which the alternate wheat and fallow plots are situated has been completely without manure since 1851. In 1854 the whole area of 1 acre carried wheat, and in the autumn of that year the land was divided into two ½-acre strips side by side, one being drilled with wheat and the other bare fallowed. The crop of 1855 was preliminary, for the wheat followed a wheat crop and not bare fallow. From 1856 onwards one strip carried wheat after fallow while its neighbour was being bare fallowed for next year's wheat. The variety of wheat was the same as on the adjoining Broadbalk field to give a comparison between continuous wheat without manure on Plot 3 of Broadbalk with wheat after fallow on Hoosfield. Some evidence that the two fields were of approximately equal natural fertility was obtained in the preliminary year 1855, when wheat after wheat on the Hoosfield site gave almost exactly the same yield as Plot 3 on Broadbalk.

The experiment continued unchanged for 76 years; then in 1932 a modification was made to give a yearly comparison of the effect of a 1-year fallow and a 3-year fallow. The strips were each divided transversely into four quarters: when a strip came into wheat after fallow only three of the four quarters were sown, leaving one quarter to be again fallowed; next year this quarter was once more fallowed with the whole of its strip, making three successive bare fallows in all; this quarter was then drilled with wheat. A different quarter of the cropped strip was selected for fallowing every year, hence after a preliminary period of 2 years each phase of the rotation was represented yearly and the treatments followed an 8-year cycle.

The mean yields are taken over two periods. The first covers seven 10-year periods, 1856–1925, when the Hoosfield yields were comparable with those on Plot 3 on Broadbalk. There then followed an 8-year period in which the fallow cycle on Broadbalk and the cycle incorporating a 3-year fallow on Hoosfield were being established. This was completed in 1932, and it is now possible to present two complete 8-year cycles plus 6 years of the third cycle. The corresponding yields from Broadbalk Plot 3 are given 1 year after bare fallow and 4 years after fallow, the latter figure being the closest available estimate of the yield of continuous wheat.

TABLE 3

Hoosfield wheat after fallow, 1856–1925

(10-year means, cwt./acre)

	Grain		Straw	
Years	Hoosfield wheat after fallow	Broadbalk Plot 3 unmanured	Hoosfield wheat after fallow	Broadbalk Plot 3 unmanured
1856–1865	14·3	9·2	22·1	14·0
1866–1875	7·7	6·8	12·6	10·0
1876–1885	8·0	6·2	11·1	8·4
1886–1895	8·3	6·8	11·2	8·2
1896–1905	8·1	6·8	12·9	9·9
1906–1915	6·5	5·7	10·8	8·4
1916–1925	5·2	4·8	8·5	6·6
Mean	8·3	6·6	12·7	9·4

The figures for the original experiment show that the yields of wheat without manure are always low, whether grown continuously or alternately with bare fallow. Wheat after fallow yielded on the average about 25 per cent more than continuous wheat, but in order to justify the system, the yields would have to be at least twice as much as on the unmanured plot on Broadbalk. This was never obtained, even in the earliest years, when the fallowing effect was greatest. Cultivation, no matter how thorough or prolonged, is not an effective substitute even for continuous cropping without manure, much less for cropping with fertilizer. It is noteworthy that in the early years the advantage due to fallowing was large, +5·1 cwt. grain per acre in the first 10-year period. After that it dropped rapidly, and was only +0·4 cwt. in the last 10 years. If the benefit from fallowing is due, in part at any rate, to release of nitrogen from soil organic matter it might be expected that the early stages of the process, when the soil was better supplied with crop residues, would be more productive than the latest ones. The produce of the wheat and fallow plots differs from that of Broadbalk in the proportion of grain to straw. The Broadbalk experiment always gave a higher grain : straw ratio than the Hoosfield one, and the difference has become more pronounced with time. In the last 10-year period the grain : straw ratio of Broadbalk was 73 per cent, while on Hoosfield it was only 61 per cent.

TABLE 4

Hoosfield wheat after fallow, 1934–1955

(8-year means, cwt./acre)

Year	Grain: Hoosfield wheat, Years of fallow		Grain: Broadbalk Plot 3 unmanured, Years after fallow		Straw: Hoosfield wheat, Years of fallow		Straw: Broadbalk Plot 3 unmanured, Years after fallow	
	3	1	1	4	3	1	1	4
1934–1941 ...	10·6	9·7	14·6	8·6	16·8	14·1	27·1	14·8
1942–1949 ...	12·9	11·6	17·7	9·0	20·9	18·4	27·3	14·0
1950–1955 * ...	9·9	9·2	17·0	9·2	15·4	14·2	30·2	16·4
Mean	11·2	10·2	16·4	8·9	17·9	15·7	28·0	14·9

* 6 years.

Under the revised scheme, begun in 1934, yields rose considerably above the low levels recorded in the later years of the old experiment. Broadbalk yields also rose, and the best reference point obtainable from that field is the yield of Plot 3 when carrying its fourth successive wheat crop. On this basis the wheat after the 1-year fallow yielded on the average only 14 per cent more per acre than the practically continuous wheat. In contrast, the 1-year fallow on Broadbalk Plot 3 raised the yield on the average by +7·5 cwt. or 84 per cent. Here, however, the fallow is young in the sense that only 9 bare fallows have so far been taken on these plots, as compared with the 50 or more on Hoosfield. There is thus no justification for protracted bare fallowing on land already clean. The 3-year continuous bare fallow always gives higher yields than the 1-year fallow, but the difference is only 1 cwt. of grain, or about 10 per cent. Under the revised scheme the grain : straw ratio in the wheat-and-fallow experiment has altered very little, but under the fallowing system on Broadbalk this ratio for the unmanured plot has fallen from 70 to 60 per cent; thus the Hoosfield experiment is now giving a higher proportion of grain to straw than the corresponding plot on Broadbalk.

The wheat-and-fallow experiment has been under observation by the Plant Pathology Department for many years. Eyespot (*Cercosporella herpotrichoides*) occurs on all plots, but is less severe after the 3-year fallow than after the 1-year fallow. Take-all

(*Ophiobolus graminis*) is present in only negligible quantities, for it is controlled by fallowing. A disease called the "white straw disease" caused by the fungus *Gibellina cerealis* has been noted practically every year since it was first found by M. D. Glynne in these plots in 1935. The disease has been recorded from time to time in Italy since 1886, but the wheat-and-fallow experiment is its only known habitat in Britain. It causes severe damage to infected plants, but on the wheat-and-fallow plots so few plants are attacked that the yield is not appreciably affected.

ROTHAMSTED GARDEN CLOVER

In 1849 an attempt was made to grow red clover continuously with different manurial treatments on one of the ordinary farm fields. It was only in the first year that a really good crop of clover was obtained, and on 21 occasions the plots were not fit to weigh. When it was clear that red clover would not succeed year after year on farm land, a fresh start was made in 1854 on a very rich soil that had been under garden cultivation for at least two centuries.

The garden clover, as it is always called, was set down on a small plot only 8 feet by 12 feet in the kitchen garden near Rothamsted House. When the grounds round the house were freshly laid out towards the end of the nineteenth century the little plot found itself in one of the new lawns, and being included in the schedule of classical experiments, it was carefully railed off and preserved. There it has remained ever since, tended by hand at sowing and hay-time, but otherwise little visited, and in fact unknown to many of the Rothamsted workers.

In 1955 analysis of the surface soil showed that the plot, which had received no fertilizer for at least 60 years and had all its produce removed, was extremely deficient in potash. Consequently in May 1956 it was divided into two sub-plots to test annual dressings of muriate of potash at the rate of 2 cwt. per acre. Since the experiment will now be continued under this new scheme, it is perhaps appropriate to summarize its past history and performance.

The plot was sown in spring 1854, and no further seedings were made as long as the plants persisted. The first sowing lasted for 6 years and the second for 5 years. In the first 20 years the plot was resown on 5 occasions only, but thereafter either complete resowing, or more frequently patching, was almost a yearly operation. Thus in the last 55 years the plots have been resown 17 times and mended 27 times. Few individual plants survive more than two seasons.

In the early years the plot was divided into three parts to test cumulative dressings of gypsum and of mineral fertilizers. In 1896 a basal dressing of chalk and fertilizer was thoroughly incorporated with the soil to a depth of 18 inches. Since then the plot received no fertilizer till the present test of muriate of potash began in 1956.

The yields of green stuff averaged over 10-year periods since 1854 are given in Table 5 below.

The yields over the first 10-year period were very high indeed, averaging 22 tons green or about 4·9 tons reckoned as hay with 83 per cent moisture. The crop in the first year after sowing, i.e., when

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TABLE 5

Rothamsted garden clover, 1854–1956

(10-year means, green weight of produce, tons/acre)

1854–1863	22·37
1864–1873	10·09
1874–1883	11·32
1884–1893	11·44
1894–1903	4·56
1904–1913	6·09
1914–1923	3·48
1924–1933	2·04
1934–1943	2·06
1944–1953	3·02
1954–1956	1·12 *

* 3 years only.

red clover makes its biggest growth, was no less than 39 tons of green stuff as a total of three cuts, or 6·7 tons dry matter per acre. This is probably a reflexion of the fact that the surface soil contained 0·509 per cent N in 1857, and presumably was also well supplied with the other nutrients. Moreover, clover had not been grown there before. The next 10-year period gave on the average only about half the yield of the first, but 10 tons of green stuff would still be regarded as a fair crop by agricultural standards, and this level of production was maintained over 30 years. During this period yields varied considerably from year to year, but there were 4 occasions when really high figures of over 20 tons of green stuff per acre were reached; the last of these occurred in 1889 after 35 years of continuous cropping. After 1893 production showed a marked decline; no more large crops were grown, but there were several complete failures. As late as 1951 a yield of green stuff of 5 tons per acre was recorded. In the last few years the crop has been of the order of 1 ton green stuff/acre, and little more useful yield information could be expected from the original scheme. Although the fact that clover would grow at all under continuous cropping was a matter of great interest, the pronounced deterioration in the later years of Lawes and Gilbert presented a problem. Several measures appear to have been tried: in 1896 mineral fertilizers were thoroughly mixed with the soil to a depth of 18 inches; in the following year the plot was "microbe-seeded" with a water extract of a good garden soil, and in 1898, when *Sclerotinia trifoliorum* was confirmed, the diseased plants were burnt, sclerotia were carefully removed from the surface soil and the plot was disinfected with carbon bisulphide. The same treatment was repeated in the following year. About the same time stem eelworm was found attacking the plants.

The first year's result of the potash dressing applied in spring 1956 is:

TABLE 6

Rothamsted garden clover, 1956

	Dry matter, cwt./acre			Potassium in dry matter per cent	
	1st cut	2nd cut	Total	1st cut	2nd cut
Unmanured	0·4	0·8	1·2	1·0	1·1
2 cwt. muriate of potash	0·4	3·8	4·2	1·1	2·4

The potash was applied only two months before the first cut was taken and affected neither the yield, which in any case was negligible, nor the composition of the produce. The second cut, however, which was taken four months after application, showed some improvement in yield and in potash content. The effect of further yearly potash dressings will be measured.