ROTHAMSTED RESEARCH

Report for 1939-45

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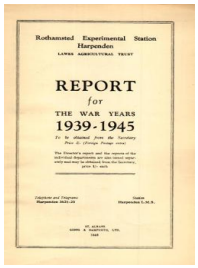

Field Experiments on the Rothamsted Farm

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E. M. Crowther ; H. V. Garner ; J. R. Moffatt ; D. J. Watson and F. Yates (1946) *Field Experiments on the Rothamsted Farm ;* Report For 1939-45, pp 233 - 239 **- DOI: https://doi.org/10.23637/ERADOC-1-87**

FIELD EXPERIMENTS ON THE ROTHAMSTED FARM

By E. M. Crowther, H. V. Garner, J. R. Moffatt, D. J. Watson and F. Yates.*

During the war years there has been a steady expansion of field experimentation. The number of plots was about 1,200 in 1939, and has increased each year to over 1,700 in 1945. The selection of suitable sites has become increasingly difficult, for it is the practice to allow an interval of at least three years between successive experiments on the same site, so that residual effects of treatments may be minimised, and the choice of site for many experiments is restricted by special soil requirements. Fortunately, the ploughing-up of many of the old grass fields has provided new areas for experiments on arable crops.

There are three groups of field experiments ;—

(1) *the classical experiments*, begun by Lawes and Gilbert. In all but one of these the cropping and manuring of the plots continues unchanged from year to year. The exception is Agdell, where a four-course rotation is followed.

(2) *the modern long-period experiments*, which are concerned either with the persistence or accumulation of treatment effects over a number of years, or with variation in the effect of treatment in relation to seasonal weather conditions.

(3) *the annual experiments*, in which treatment effects are tested only in one year, except that in a few of them the immediate residual effects in the following year are also measured. The annual experiments may be repeated a number of times, on a fresh site each year.

The problems investigated are listed below with cross references to the reports of the departments primarily concerned. Many of the experiments form part of series carried out at a number of centres on a co-ordinated plan.

The classical experiments

Broadbalk, continuous wheat. The hundredth successive wheat crop in this experiment was harvested in 1943. No recent changes have been made. The fallowing of one fifth of the field annually, begun in 1931, has been continued, and has justified itself as a method of weed control, although it is not effective against wild oat (mainly *Avena ludoviciana*), which is particularly abundant on the farmyard-manure plot. Slender foxtail is still prevalent over the whole field.

Hoosfield, alternate wheat and fallow. The modification of this experiment introduced in 1932, which provides a comparison of a one-year fallow with a three-year fallow, has been continued. Wheat bulb-fly has occasionally caused loss of plant on these plots.

Hoosfield, continuous barley. Weed infestation has become a serious problem on this field, the dominant species being charlock and wild oat (*A. fatua*). The infestation was so bad in 1943 that the

* These members of the staff constitute the Field Plots Executive Committee and are responsible for planning and carrying out the programme of field experiments.

https://doi.org/10.23637/ERADOC-1-87

plots were fallowed in the following year. This caused some reduction of the charlock population, but was quite ineffective against wild oat. In 1945 the crop was sprayed with D.N.O.C. to eradicate the charlock, and this treatment will be repeated annually when necessary.

Various methods of controlling wild oat on Broadbalk and Hoosfield have been considered, and the only one likely to be effective,which will not interfere with the continued cropping of the plots, appears to be hand-pulling at the time when the emergence of the panicles makes it easy to distinguish the oats from the wheat or barley. It is intended to make an effort in 1946 to clean the fields by this method, and, on Hoosfield, by intensive cultivation during the period between harvesting and sowing.

Barnfield, continuous mangolds. It was discovered in October, 1944 that beet eelworm is present on the plots of Barnfield. Where it came from, and how long it has been present on the field, are not known. There is some slight evidence that the yield on some plots is beginning to suffer. The infestation is more severe on the west side on and near to the farmyard-manure plots than in the rest of the field, and this suggests that it came in with the farmyard manure. If so, the original infestation probably entered the field before 1928, which was the last year in which London dung was used. Since that year dung produced on the farm has been used exclusively, and there is apparently no source of infection outside Barnfield, for a careful search has failed to reveal the presence of eelworm in any other susceptible crops on the farm. The present serious infestation is probably a recent development, for a search for eelworm made a few years ago gave negative results. Permission to continue cropping the field with mangolds has been obtained, and the future development of the infestation will be carefully watched.

Agdell, four-course rotation experiment. Parts of this field are now very acid, and heavily infected with club-root. For this reason the root crops in 1940 and 1944 were almost complete failures. In 1940 yellow turnips of the Bruce variety, and in 1944 a number of different strains of turnips and swedes were grown. Differences in susceptibility to club-root were detected, but none of the varieties was sufficiently resistant to withstand completely the very intense infection present in the field. The other crops in the rotation continue to give good yields.

Park Grass plots, permanent grass cut for hay. There have been no outstanding changes in the herbage on these plots in recent years. Early in the war, complete botanical analysis of samples of the herbage had to be discontinued owing to lack of staff, but partial analyses on a selection of the more interesting plots have been made annually.

Long-period experiments

Town refuse.—Cumulative and residual effects of various forms of town dust-bin refuse are compared with those of farmyard manure in an experiment begun in 1940. The cropping has varied from year to year, but not in a regular rotation, and has included sugar beet, mangolds, beans, barley and wheat. The manurial value of the town refuse was low, as in parallel experiments at Tunstall, Saxmundham and elsewhere. (Chemistry.)

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Four-course rotation experiment on residual values (see Rothamsted Annual Report, 1931, p. 129).—This experiment, started in 1930, tests the immediate and residual effects of three bulky manures—farmyard manure, straw compost and chaffed straw—and two phosphate fertilisers—superphosphate and Gafsa mineral phosphate—applied at intervals of five years to plots in a four-course rotation; wheat, potatoes, barley, rye-grass. One set of applications is made every year to appropriate plots for each crop, the treatments repeating on the same plot every fifth year. The farmyard manure and straw compost supply equal amounts of organic matter, and the chaffed straw is used in amounts equal to those required to make the straw compost. Fertilisers are added with the organic manures to raise the total nitrogen, phosphate and potash to constant amounts. The two phosphate fertilisers are applied every five years in amounts equivalent to the total phosphate given on the organic-manure plots, but for these treatments the nitrogen and potash fertilisers are divided so that one-fifth of the total goes on each year to each plot.

Farmyard manure and straw gave better yields of potatoes than straw compost, but the three organic manures gave similar yields of barley. For all three materials the yields fell off at first rapidly and then more slowly, the fall after the second year being shown more clearly in barley than potatoes. In the year of application the organic manures gave yields similar to those from superphosphate with one-fifth of the total amount of nitrogen and potash. Subsequently the yields from the residues of superphosphate with small annual dressings of nitrogen and potash greatly exceeded those from the residues of organic manures. Superphosphate gave consistently higher yields than mineral phosphate, which was probably ineffective on this neutral soil. The residual effect from superphosphate fell off very slowly after the second year, but was markedly less than the immediate effect in the year of application.

Three-course rotation experiment on methods of utilising straw (see Rothamsted Annual Report, 1933, p. 118).—This experiment, started in 1933, tests three methods of applying straw to land cropped in the three-course rotation; barley, sugar beet, potatoes. Each year half the plots receive a fixed quantity of fertilisers which is given in four ways; (1) in spring, without straw: (2) in spring, after straw ploughed-in in autumn: (3) divided between autumn and spring, after straw ploughed-in in autumn: (4) used to make straw compost which is applied in spring. In the following year the plots are treated uniformly, any additional fertiliser needed for the crop being applied equally to all plots. It should be noted that by contrast with the four-course rotation, losses of nutrients during the composting process are not made good by additional fertiliser. This experiment tests the value of straw as such, over and above that of fixed amounts of fertilisers.

The compost has consistently given poorer results than the fertilisers alone, as plant foods are locked up in unavailable forms during the composting process. Where constant amounts of fertilisers were applied in the spring, straw ploughed-in increased the yield of potatoes by about 10 cwt. per acre, but had no effect on sugar-beet roots or barley grain; straw reduced the yield of sugar-beet

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tops and barley straw. Residues of straw applied either as such or as compost improved the yields of potatoes in the second year but had little effect on other crops.

Six-course rotation experiment on seasonal variation in responses to fertiliser (see Rothamsted Annual Report, 1931, p. 131).—This experiment and an experiment of the same design at Woburn were begun in 1930. It gives information on the relative responses to fertilisers of the six crops of the rotation—barley, clover, wheat, potatoes, rye and sugar beet—on the variation in response from year to year, and on the relation between response and rate of application. The design is such that the effects of individual treatments are not cumulative, and it will, therefore, be possible to evaluate the effects of seasonal weather conditions on yield and fertiliser responses when a sufficient number of years has elapsed. A noteworthy feature of both the Rothamsted and Woburn experiments is that although no farmyard manure is given at any stage of the rotation, there is no evidence of a downward trend in yield of any of the crops during the course of the experiment.

Two-course rotation experiment on the immediate and cumulative effects of salt.—An experiment was begun in 1942 to test the effect of frequent heavy applications of salt on land cropped alternately with sugar beet and barley. So far there has been no sign of soil deterioration, and salt has given good returns, while the response to potash has been small. (Chemistry.)

Deep-cultivation rotation experiment.—The effect of deep ploughing (to 12 inches) at three stages in a six-course rotation, in comparison with ploughing to normal depth (6 inches), and its interactions with dung and fertilisers applied before or after ploughing are being investigated in an experiment started in 1944. All stages of the experiment will be established by 1946. (Physics.)

Grazing experiment.—Since 1937 an experiment on nine plots, each of 5 acres, of permanent grassland has been carried out, at the request of the Royal Agricultural Society of England, to assess the residual manurial value of cake fed to cattle. This question has an important bearing on the compensation payable in tenant-right valuations. The productivity of pasture on which cattle have been cake-fed is compared in the following two years with that of pasture receiving fertilisers applied at rates equivalent to the estimated residual value of the cake, as given in Voelcker and Hall's tables, and with that of pasture receiving neither cake nor fertiliser. The productivity is estimated from the maintenance requirements and live-weight increases of stock (cattle and sheep in a fixed ratio) grazing on the plots in the two years after cake-feeding. The results summarised below show that, over a series of years, very similar returns in starch equivalent have been obtained from the cake-feeding and from the assumed fertiliser equivalent of the cake residues:

Live-weight increase, lb. per acre	No treatment	Cake-fed	Equivalent fertilisers
1st year after cake-feeding :[1]			
Cattle	196	253	240
Sheep	88	92	93
2nd year after cake-feeding :[2]			
Cattle	210	232	196
Sheep	85	69	82

[1]Mean of 8 seasons. [2]Mean of 6 seasons.

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Starch equivalent, cwt. per acre	No treatment	Cake-fed	Equivalent fertilisers
1st year after cake-feeding[1] ..	13·9	15·8	16·0
2nd year after cake-feeding[2] ..	14·4	14·9	14·6
Increase in two years over no treatment		+2·4	+2·3

[1]Mean of 8 seasons. [2]Mean of 6 seasons.

No clear evidence has been obtained of any build-up in fertility due to the heavier stocking possible on the plots where cake is fed.

Annual experiments

Manurial value of bulky organic manures (1940 *to* 1945).—In each season experimental batches of farmyard manure were prepared from known amounts of feeding stuffs with different proportions of straw as litter. The earlier experiments included tests of the effect of storing the manures, and the later ones compared manures made in covered yards with those made in open yards of baled straw. A wide range of other materials was also included in annual tests on potatoes followed by barley, the potato plots being split to measure the responses to nitrogen, phosphate and potash fertilisers, in the presence and absence of the organic manures. In general there were only small differences between farmyard manures prepared with different amounts of straw. Good results were obtained from long, partially rotted manures. A large part of the merit of the farmyard manures in these tests must be ascribed to the potash they supplied, for whereas in the absence of farmyard manure dressings of muriate of potash increased the crop by several tons per acre, they had but little effect where the needs of the crop had been met by the potash in the farmyard manure. Open-yard manures which had been left exposed to rain for many months naturally lost potash and were somewhat less effective unless a potash fertiliser was given.

Excellent results were obtained in these experiments from bracken cut green in July and stacked until the potatoes were to be planted. Sewage sludges behaved essentially as sources of available nitrogen and phosphate, but not of potash. Town refuses had only small effects. Composts of straw and sewage sludge gave fairly promising results. (Chemistry.)

Experiments on *phosphate fertilisers*, *fertiliser placement*, *manuring of sugar beet* and *manuring of flax* formed parts of co-ordinated series carried out in different parts of the country. (Chemistry.)

Winter beans.—Beans are one of the few protein-rich feeding stuffs which can be produced on the farm, and therefore became of increased importance when the importation of feeding stuffs was greatly reduced during the war. Unfortunately, beans are an uncertain crop, and it has been suggested that in recent times the productivity of the crop has declined. One reason for disappointing results is the susceptibility of beans to aphis attack: another reason, shown by the Survey of Fertiliser Practice, is that many farmers are not aware that beans require a liberal supply of potash. Fertiliser experiments in 1939 and 1945 confirmed earlier work in showing that beans respond well to potash. Farmyard manure also gave good returns, probably because of the potash which it supplies. The response to superphosphate was smaller, and nitrogenous fertilisers had little effect.

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Experiments on winter beans in 1944 and 1945 showed the importance of early sowing on this soil. Beans sown by drill were severely damaged by birds during germination, but this was avoided if the seeds were sown at a greater depth by ploughing them in. Broadcasting the seed before ploughing, compared with sowing it in rows at the bottom of the ploughing furrow at varied spacing but the same rate per acre, had little effect on yield.

Kok-saghyz and krim-saghyz (Russian rubber plants).—Kok-saghyz is a species of dandelion, one of several which are grown in Russia for the production of rubber. When the loss of Malaya made it imperative to seek other sources of supply of rubber, the Royal Botanic Gardens, Kew arranged for trials at a number of centres to see whether kok-saghyz is a suitable crop for British conditions. An autumn sowing at Rothamsted in 1942 germinated well, but the plants were killed during the winter. The crop was resown in spring but grew very slowly, and much labour was spent on hoeing to control annual weeds. The yield of roots in September, 1943 was only 8 cwt. per acre, and in November 10 cwt., much below yields recorded in Russia, though the rubber content was satisfactory. Fertilisers had no detectable effect on yield, but sulphate of ammonia reduced plant number.

Another rubber-producing dandelion, krim-saghyz, was also tested. An autumn sowing failed, but a spring sowing gave a slightly higher yield of roots than kok-saghyz.

The cropping of newly-ploughed grassland.—Experiments on the cropping of land ploughed out of old grass, in relation to wireworm attack, were carried out in 1939-42. In the first year of each experiment, a variety of crops was grown, followed in the second year by uniform cropping with wheat or oats to compare the residual effects of the first year's crops. The yields of all crops were good and serious damage by wireworm occurred in only one experiment. Here the wireworm population was lower, and the yield of spring oats greater, after beans than after other crops. (Entomology.)

Eyespot disease of wheat.—The effect of "eyespot" disease, caused by infection with *Cercosporella herpotrichoides*, on wheat was investigated during the years 1941-1945. The loss of yield caused by the disease was measured by varying experimentally the intensity of infection. Varietal differences in susceptibility to infection and to lodging, and the effect of application of nitrogenous fertiliser at varying rates and times on the degree of infection and of lodging were studied. Spraying with sulphuric acid provides partial control of the disease, and experiments were made to determine the optimal time of spraying. (Plant Pathology.)

The effect of time of planting on the yield of potatoes, and on the spread of virus disease.—In a series of experiments carried out at a number of centres in the years 1940 to 1943[1] the yield of potatoes was found to be closely correlated with date of planting: one day's delay in planting apparently reduced the yield by over 3 cwt. per acre. An experiment was, therefore, made in 1945 to determine the effect of date of planting, within the period March to June, on the yield obtained from chitted and unchitted seed tubers. Stock seed was used, and tubers infected with leaf roll or with severe mosaic were introduced into each plot, to provide data on

[1] P. H. Gregory, J.Min.Agric., 1944, 50, 557-9.

https://doi.org/10.23637/ERADOC-1-87

the rate of spread of virus disease in relation to time of planting. (Plant Pathology.)

Cultivation experiments.—An experiment on a three-course rotation, started in 1934 to compare different methods of preparing a seed-bed, by ploughing, rotary cultivation or tine cultivation, to the normal ploughing depth or to a shallower depth, was discontinued after 1939. A new long-period experiment on the effect of deep ploughing was begun in 1944 (see above). During the intervening years the effect of varied intensity of cultivation, and its interaction with the level of fertility, on the yield of potatoes and of sugar beet, was investigated in a series of one-year experiments. (Physics.)

The effect of war gases on agricultural crops.—Experiments on the effect of spraying with mustard gas or lewisite on a variety of crops, and on the utilisation of the produce of contaminated crops, were made in 1940 and 1941. (Crop Physiology.)

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