# Report for 1959

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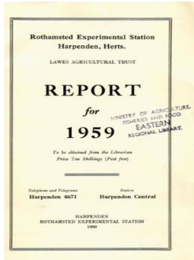
Rothamsted Experimental Station
Harpenden, Herts.

LAWES AGRICULTURAL TRUST

REPORT
*for*
1959

## General Report

### F. C. Bawden

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# GENERAL REPORT

F. C. Bawden

Broom's Barn Farm, about 200 acres of light land, at Barrow, midway between Bury St. Edmunds and Newmarket, was bought in September with money from the Home Grown Sugar Beet (Research and Education) Fund after it became obvious that tenure of the Dunholme Field Station could not be secured. As soon as laboratories have been built and other essentials provided, the staff now at Dunholme will move to Broom's Barn.

At Rothamsted some land was given up temporarily by the lease of Baldwin's Paddock to the Ministry of Agriculture for 99 years as the site of their new Plant Pathology Laboratory, which now graces the Hatching Green entrance to the farm. We extend a cordial welcome to our tenants, wish them every success in their new surroundings and add that we look forward with pleasure to even closer collaboration than before.

H. V. Garner retired from the post of Head of the Field Experiments Section on 31 March and was succeeded by G. V. Dyke. Fortunately we still benefit from Garner's wise advice and his unrivalled knowledge of the field experiments, for he continues to be employed part-time.

F. Tattersfield, who worked at Rothamsted from 1918 to 1956 and was Head of the Insecticides and Fungicides Department until 1947, died on 1 May. His influence was great and will long survive him, not only at Rothamsted, where he pioneered the study of insecticides, but the world over, for he can truly be called the father of the subject. The memory of him as a person will also long remain with the many of us to whom he was a valued friend. A true scientist, whose interest and curiosity in all natural history remained undimmed with age, he did productive research almost until he died.

J. M. Hirst had the signal honour of being the first recipient of the Jacob Erikkson Gold Medal, awarded at the International Botanical Congress for outstanding work of international importance in plant pathology and mycology. Unfortunately he could not be at Montreal, and we thank Mr. M. J. Marshall, the United Kingdom Trade Commissioner, for publicly accepting the medal on his behalf. P. S. Nutman was awarded the Huxley Memorial Medal, given to former students of the Imperial College of Science and Technology for their research in natural science. G. W. Cooke was awarded the silver cup for the best paper—" Fertilisers, Crop Production and Soil Fertility "—read to the Farmers' Club. F. C. Bawden was elected an Honorary Life Member of the New York Academy of Sciences.

Again we welcomed many visitors from home and overseas. How many we do not know, for not all are recorded, but our records show 3,140 individuals. Among those from overseas were the Director General of the Food and Agriculture Organisation, Mr. B. R. Sen; the Ministers of Agriculture for India, Mr. S. K. Patil, for the Western Region of Nigeria, Chief Akin Deko, and for Pakistan, Mr. Hafizar Rahmann; and the Minister of Research and Information for the Nigerian Federation, the Hon. Victor Mukete.

As the departmental reports show, several of our staff also travelled overseas for a variety of purposes. Our largest contingent was at the Botanical Congress, and we thank the Canadian organisers for the compliment they paid us in inviting so many of the staff and for their generosity in paying for four of the seven who attended.

*The weather and farming*

A greater contrast between 1958 and 1959 could hardly be imagined. Typical of the difficult conditions of 1958, we entered 1959 with only part of Broadbalk drilled and most of the other land destined for winter wheat still untilled. But with the new year things rapidly improved, and arrears were soon made up, with the spring corn drilled almost immediately after the delayed winter-wheat varieties. As things started, so they continued; conditions for harvesting all crops, hay, cereals and roots, were ideal, and the only major difficulties were a shortage of grass for the stock in the late summer and ground too hard to plough in autumn. A vivid comment on the two years is that all cereal experiments at Rothamsted were harvested in 1959 by the date when the first plot was cut in 1958. We enter 1960 with winter wheat well above ground on all Broadbalk plots and on many other fields, both at Rothamsted and Woburn.

We shared with the rest of the country the sunniest summer for years, but did not fully share the drought. At Rothamsted, and to a lesser extent at Woburn, many of the crops benefited from intense local storms. On 10 July, 2·3 inches of rain fell at Rothamsted, and further heavy falls brought the July total to 4·5 inches, 2 inches above the average, and the seven-months' total to 15·5 inches, 0·3 inch above the long-period (106 years) average. All months April to October inclusive had from 10 to 40% more sunshine than average, and mean monthly temperatures were from 1·6° to 4·7° F. above average. The wet July was the sunniest month since July 1935 and the warmest July since 1949.

Although the drought was less severe at Woburn than many other places, responses to irrigation there were large. Yield of sugar beet was increased by 50%, of spring wheat by 60%, of grass by 100% and of spring beans by 150%; the irrigated beans grew so high that they over-topped the spray lines!

At Dunholme, where only 6·5 inches of rain fell between January and October, the sugar beet suffered severely from drought, which also caused a few experiments at other centres to fail. Where soil moisture was adequate, however, yields were exceptionally high, 30 tons/acre of roots and 5·2 tons of sugar at Pondersbridge and 28 tons of roots and 4·5 tons of sugar at Holbeach. The weather favoured aphids and the spread of yellows, which would have caused great losses had not insecticidal sprays been used on an unprecedented scale. Warnings of the need to spray were issued from Dunholme as the number of aphids reached the danger level in different districts, and more than 95% of the total beet acreage was sprayed once, and much of it more than once. The response to spraying differed in different places (in some yield was doubled), but the results from widely scattered experiments suggest that average yield was increased by 25%. A remarkable achievement for a scheme initiated only in 1957.

*The range and aim of research*

The work on which we report this year covers an even greater variety of subjects than previously, ranging from attempts to derive an international language for computers to homely recipes for serving leaf protein, and from the isolation of " queen substance ", by which the queen bee largely controls the activities in the hive, to measuring the current value of manures added to land last century. The ultimate aim of agricultural research must, of course, be to increase the efficiency of agriculture, that is to lower unit costs of production by increasing yields per acre, per man or per sum of money spent, and to improve the quality of the produce. That the work summarised in the departmental reports on such things as fertiliser use and the control of pests and diseases has this as an immediate rather than ultimate aim is too obvious to be worth comment, but the practical implications of work that at first sight may seem to be academic or esoteric can also be considerable.

True, few farmers are themselves likely to use an international language for computers, but this does not mean that to develop one would not benefit agriculture. The success of our computer, which shows in the great annual increase in number of analyses made, makes it certain that more and more computers will be used to analyse the results of experiments and surveys. Unless an international language is developed, new programmes will have to be prepared for each type of computer, which will need much time and labour and delay the appearance of results.

Nor are many people likely immediately to abandon Mrs. Beeton's recipes in favour of ours for serving leaf protein. However, if the expected growth of the human population leads to protein becoming increasingly scarce and dear, we are now provided, not only with a method of getting much more per acre than from meat or milk, but with the knowledge that it can be served palatably.

To know the identity of such biologically important and specifically active materials as " queen substance " and eelworm " hatching factors " is information more than worth having for its intrinsic interest alone, but the knowledge could also lead to practical uses. Identification is a necessary step to synthesis, and a cheap synthesis of these substances could lead to new methods of handling bees or dealing with eelworms. Again, although most farmers are probably more interested in knowing what return they will get from fertilisers than in the status of their soils 100 years hence, agriculture is an industry that must continue indefinitely, and nothing could be nationally more important than to know what practices increase and what practices decrease the fertility of the soil. The long-term experiments at Rothamsted and Woburn provide a series of soils unique in the amount of information they now contain about the effects of different kinds of manuring, but much of the information is latent and will become apparent only when the experiments are

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modified, as they increasingly must be, to answer new questions of agricultural significance.

Our work has to be diverse, because agriculture is varied and raises an unending series of interacting problems, with each new practice bringing new consequences in its train. In other industries a discovery made anywhere is likely to apply everywhere, but this is far from being generally true in agriculture. Crops are grown on a great variety of soils and in widely different climates, and a practice proved to be beneficial in one place is by no means certain to be beneficial everywhere. The empirical approach can be very successful and sometimes quickly produces answers to practical questions, but alone is wholly inadequate for the needs of agriculture. To forecast whether a practice found beneficial somewhere has general use requires knowledge about how it works, which entails establishing principles. Until the principles that underlie the problems of soil fertility and the use of fungicides, pesticides and herbicides are much more firmly established than they now are, recommended practices will sometimes fail and will occasionally have undesirable consequences.

The value of the soil survey, which this year changed to a less detailed, reconnaissance type, so that much more land was mapped than in previous years, will also not be fully realised until knowledge increases about the soil conditions that determine whether potential plant nutrients move into or out of states in which they can be acquired by plants. The survey now provides many answers to practical problems, not only in agriculture but in other industries and in town-planning, but we look forward to the time when knowledge is such that a soil map used in combination with a knowledge of recent cropping and manuring will provide a sound basis for deciding fertiliser needs. It is to this end that the detailed structure and composition of soils are studied and better methods than current ones are sought to assess what proportion of the plant nutrients they contain will be usable by crops. We have this year made some advances, of which perhaps the new information on potassium is specially noteworthy. The amount of potassium that a soil can provide immediately to a crop is normally measured by the amount that will exchange with another cation when the soil is treated with a salt solution. However, many soils will provide much more potassium than this method measures, but the only method of identifying such soils has been to grow crops on them. The analysis of a range of soils shows that their content of useful but not exchangeable potassium is related to two qualities, the amount of fine clay (particles smaller than $0{\cdot}3\,\mu$) and the potassium content of these fine clays. Presumably the explanation is simply that fine clay exposes a larger surface area than coarse clay from which potassium can be released.

Research work is sometimes described as the asking of questions, with success depending on asking the right question. Sometimes, not only are the questions that need to be asked obvious enough, but so are methods of getting answers that may be practically useful. For example, when a crop is obviously sick, the first question must be, is it being attacked by something or does it lack something? When the cause is diagnosed, possible control measures, either cura-

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tive or preventative, may come directly from existing knowledge about comparable problems. But such a happy state of affairs is rare; although the right questions may be asked, and valid answers obtained, the answers often fail to have any immediate practical application. Even when a research worker considers a practical answer has been found, not all farmers will necessarily agree. For instance, although it may be established that a given rotation of crops will avoid or alleviate damage from a given soil-borne pest or disease, a farmer engaged mainly in cereal growing cannot readily change to other things, and one whose livelihood comes from potatoes cannot lightly abandon this crop. A problem has been solved for the farmer who can rearrange his plans so that susceptible crops are grown no more often than the research worker would advise, but such farmers may well be a minority. Research cannot stop at this stage, for although partial success is a good deal better than nothing, it is also partial defeat simply to withdraw in the face of the enemy. A maker of blankets troubled with moth in his wool would not consider his trouble solved by someone who advised him to change his business over to cotton sheets. Similarly, although advice to change crops is now often all that can be given, and in want of anything better valuable advice it is, the prominent part pests and diseases now play in determining crop rotations can only be regarded as temporary and as a challenge. The challenge is to find knowledge whereby farmers may safely grow the crops of their choice and not those forced on to them by the need to avoid pests and diseases.

The use of immune or resistant varieties is one response to this challenge, and our work with *Fusarium* wilt of peas suggests that growers troubled with this disease will gain relief by changing to other varieties. But before resistant varieties can be produced, the plant breeder must have a supply of resistant parents from which to breed, and for many of our pests and diseases there are no such things. Even when there are, the relief given by producing a resistant variety may be only temporary, for pests and diseases are variable things, and often soon change to forms that attack previously resistant varieties. It is idle to look for any panacea or for any permanent solution; the price of healthy crops is eternal vigilance, which means continuous study of the biology of pests and diseases and the physiology of the crop to know where and when the parasite can best be attacked, and what properties of the crops are likely to continue to protect them from damage.

Correct diagnosis of troubles does not lead automatically to remedial measures, even to those that might satisfy a research worker. Such measures may have to wait for new knowledge, which sometimes comes from unexpected quarters. For over 30 years King Edward potatoes have been known all to be virus-infected. Although there has been no evidence that infection with this particular virus affects yield (there could be no such evidence without any virus-free plants for comparison), it was obviously desirable to have a virus-free stock. But how to get one was less obvious until work on the distribution of viruses in infected plants suggested that the growing points of stems might contain no virus. Apical meristems were then excised from King Edward potatoes, nurtured on agar medium until one grew into a plant, which was indeed uninfected, and the progeny of which is now being rapidly propagated. Whether this clone will yield better than those now in commerce, only time will tell, but it shows promise. Again, sugar beet yellows has long been known to be caused by an aphid-transmitted virus with the clear inference that a suitable insecticide might control it, but this knowledge was in the academic category until there were suitable insecticides. After the great increase in yields this year from spraying, to criticise current insecticides adversely seems almost churlish, but it is true that yellows was still only partially controlled. Work must still continue, to find either more effective insecticides or another method of control, and meanwhile the practice of spraying such large areas with current insecticides also needs careful watching.

In doing research, particularly in the laboratory or glasshouse, conditions can often be simplified so that individual problems can be studied on their own, but this simplification is impossible in the field, where the consequences of any treatment put into practice must always be tested in the widest possible context. The chances of unwanted side-effects are perhaps most apparent with the use of insecticides, which carries with it the double hazard of mammalian toxicity and of killing insects beneficial to agriculture. However, the fact that these hazards are so obvious itself provides some safeguard, for they cannot be neglected. Insecticides, and other pesticides, will be increasingly used, because agriculture cannot forgo the benefits they confer, but this carries with it the obligation to know as much as possible about the ways in which they kill and their effects on animals other than those they are immediately directed against. Work on the mechanism of insecticidal action aims not only to increase the kill of pests but also to increase specificity, so that only pests will be killed. The effects of insecticides, too, provide part of the background to population studies of insects, both of pests and others, but only part, because insect ecology and biology also seeks knowledge that may help to defeat pests without the continued need to resort to chemical warfare.

The consequences of other agricultural practices are not necessarily fewer because they are less obvious than those of using pesticides. Whenever a new variety is grown on a large scale, or manuring, cultural practices or sowing dates alter, the environment of the growing crop changes and there is always the chance that a pest or disease previously trivial may now be favoured and become important. Good field experiments demand more than simply applying differential treatments to plots and measuring yields, even when the statistical design and analysis are excellent. They require repeated observation, with full knowledge of the soil conditions, of weather and of the incidence of pests and diseases. Without this information, there is simply a result, a measurement which may never be precisely repeated, whereas with it there might be a meaningful interpretation with general implications. Repeating experiments in many places or in many years is not only costly, but is no substitute for intensive research. It can give only average results, which are no doubt valuable for those who have to think nationally, but to the individual farmer may be no more use than are the average rainfall figures for telling him whether next August will be wet or dry. When a treatment can give widely different results at different times or places, there is little to be gained by testing it in repeated experiments that simply demonstrate this fact again. What is needed is a detailed study of the treatment to see how it works, to establish principles so that the conditions in which it will be beneficial can be precisely defined.

Forty years ago it was rare to record wheat yields of 1 ton/acre at Rothamsted, whereas we now sometimes record well over three. The difference has three main causes: better feeding, pests and diseases better under control, and higher-yielding varieties. The goal of a field crop optimally fed and watered and free from parasites has yet to be achieved, and potential productivity will remain uncertain until it is. However, there are clearly limits to the increases in yield possible simply by increasing health, and it is important to know whether there are other possibilities. Put as a question: what limits potential yields and can the limiting factors be overcome? The weather in winter is obviously important, because temperature and light intensity are for long periods below those needed for active photosynthesis. Also, frost-sensitivity or early maturation mean that some crops make little or no use of much favourable weather because their leaves are not yet developed or have already matured. But there are also other factors intrinsic to the plants, for different crops in the same conditions grow at different rates and different varieties of one crop yield differently. Until these factors have been defined precisely, it would be vain to forecast what may be done to alter them. Information about them, rich in scientific interest and practical implications, is sought in many ways, by detailed measurements of the physical conditions in crops, by growth studies on different crops and different varieties, and by studying the action of substances that affect leaf area. There is no simple approach to problems of this complexity, but when our greatly delayed constant-environment rooms at last come into use work will at least be simplified to the extent that effects of changing one factor in the environment can be studied while others remain constant.

My starting theme was "the range and aim of research", and I am conscious that I have not done it justice. The aim, at least, I hope I have defined; also that I have shown that the complexity of agricultural research demands workers with inquiring minds and a wide range of skills and experience. Diverse as are the various subjects I have touched on, I have wholly failed to give the full range of our activities, but my failure can be rectified by reading the departmental reports. These are already summaries, and I do not intend to summarise them again. From what I have written it will be obvious that they record much about fertiliser use and the control of pests and diseases in a range of crops, but it will be less obvious that they also contain information on subjects as varied as the viability of insects flying at 5,000 feet; the activities underground of organisms as diverse as slugs, earthworms, fungi, nitrogen-fixing bacteria and a previously undescribed eelworm that transmits a soil-borne virus, thus adding a new danger to the already formidable list carried by those that are direct pests; the internal structure of viruses and the relative infectivity of intact virus particles and their separated nucleic acids; the activities of enzymes in insects, bacteria and leaves; the biology of weeds and the use of pre-emergence weed killers; the effect of nutrition of bees on the incidence of their diseases and the best time to introduce pollinating bees into crops; the fungi in mouldy hay that cause " farmer's lung " and mycoses in cattle; the synthesis of clays; and another extension beyond our customary range, there is information on the incidence of diseases in dairy cows and the factors that affect the " S.N.F. content " of milk.