ROTHAMSTED RESEARCH

Rothamsted Experimental Station Report for 1965

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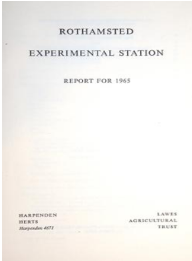

General Report

F. C. Bawden

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GENERAL REPORT

F. C. BAWDEN

Sir John Russell, who was appointed to Rothamsted in 1907 as Goldsmith's chemist and was director from 1912 to 1943, died on 12 July, surviving Lady Russell by only three months. Although in his ninety-second year, he was still active and had just finished his history of agricultural research. Here is not the place to review his remarkable career or to comment on the unique place he held in world agriculture, but it is relevant to note how greatly he influenced the development of Rothamsted. When he came, the work was restricted to the study of soils and crop nutrition, and the comprehensive programme of research that now characterises the Station, embracing most problems of arable agriculture, was fashioned during his directorship. Also, it was by his initiative and energy that the Estate and Manor House were bought and their use by the Station ensured. All those now at Rothamsted owe much to him, as will those still to come.

Sadly, too, we have to report the death of two valued members of staff, A. Crompton, of the Soil Survey, and J. B. Goodey, of the Nematology Department. Goodey, a world authority on the taxonomy of nematodes, died at sea while travelling to New Zealand, where he had been invited to work for a year.

We suffered another loss by the retirement of R. G. Warren, who joined the Chemistry Department in 1923. We shall greatly miss his wise advice and his unrivalled knowledge of the classical experiments, which he applied so shrewdly to make them rewarding in the context of modern agriculture.

The Lawes Agricultural Trust Committee. Sir Lawrence Bragg retired after serving for 12 years on the Committee, and we are much indebted to him for sparing so much of his time to advise us in our affairs. In his place, the Royal Society appointed Sir Gordon Sutherland, Master of Emmanuel College, Cambridge, who was previously director of the National Physical Laboratory.

Awards and appointments. Two members of the staff received Honours from the Queen. Marion A. Watson was appointed an Officer of the Order of the British Empire in the New Year Honours, and A. E. Hall a Member of the Order in the Birthday Honours. B. Kassanis was awarded the Research Medal of the Royal Agricultural Society of England for his work on the therapy of virus diseases, especially for producing a virus-free clone of the potato variety King Edward. J. M. Hirst was promoted to the grade of Senior Principal Scientific Officer under the scheme for special merit promotions. F. C. Bawden was appointed a member of the Natural Environment Research Council and elected President of the Association of Applied Biologists and of the British Insecticide and Fungicide Council.

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Visits and visitors. Although visitors were fewer than in 1963 or 1964, more than 3,000 came to Rothamsted, and many hundreds to Broom's Barn. The winter is no longer the close season it used to be, and visiting scientists now seem almost as abundant then as during summer. Visitors from overseas included a party from the Soviet Academy of Sciences, the Hon. D. D. Nelder, deputy Prime Minister and Minister of Agriculture, Western Australia, and H. E. the Minister of Agriculture of Afghanistan (to Broom's Barn). Two Ministers of State for Education and Science, Lord Bowden and Mr. R. E. Prentice, J.P., M.P., were among our visitors from the United Kingdom.

As is evident in the departmental reports, many members of the staff travelled abroad, to attend conferences, to lecture or to advise on various matters. In addition to visits recorded in these reports, F. C. Bawden went to Trinidad in January for a meeting of the Advisory Technical Committee for the Regional Research Centre, University of the West Indies, to Zambia in March for a meeting of the Agricultural Research Council of Central Africa and to Uganda in October at the request of the Empire Cotton Growing Corporation.

Appointments for research overseas. J. K. Coulter, of the Chemistry Department, was appointed to the post of Tropical Soils Adviser, vacant since H. Greene died. He will continue to work at Rothamsted, although the post is now on the establishment of the Land Use Section of the Department of Overseas Surveys, which also assumed responsibility for the "Pool of Soil Scientists", whose members were previously attached to the Soil Survey, although they were appointed to work overseas.

To provide "home-based" appointments for specialists working overseas, additional posts were created to provide two entomologists, two nematologists, one mycologist, one virologist, one soil chemist and one statistician. R. Kenten was appointed as the virologist, and returned to work at the Cocoa Research Institute, Ghana, where he was previously working on secondment from the Biochemistry Department. The other posts were being advertised at the end of the year.

Land and buildings. Scout Farm, which adjoins the south-west end of Rothamsted Farm, was bought by the Trust Committee. Most of its 224 acres are suitable for field experiments and, though many of the fields are now very weedy, it will greatly ease our current problem of choosing suitable sites for experiments. We shall now be able to adapt our crop rotations so as to fit the needs of individual experiments and, especially, shall be able to lengthen the period between cereal crops.

With our large programme of field experiments and few farm staff, we are always dangerously dependent on favourable weather to complete the programme, and this autumn the weather was anything but favourable, so it was not completed. We hope to be less dependent in future and to have more farm workers, for, after many delays and frustrations, permission was obtained to build four cottages, which by the end of the year had their roofs on.

A new workshop was built for the maintenance staff, who now, for the

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first time, have reasonable working conditions. A field laboratory for the Physics Department was also built, the library was extended and some of our older laboratories were modernised.

A cheerless year for crops. In strong contrast to 1964, which was more favourable than most to arable farming, 1965 was near disastrous; only grass did well, and this only if not required for hay. The total rain exceeded the average by only 1·9 in., but there was rain on many days, and the months April to September all had much less than average sunshine (July less than half), with a total deficit of 251 hours, 50 more than the average for June. The year started well, and indeed threatened problems from water shortage, for with January and February both drier than usual, this gave a succession of 8 such months and rain since June 1964 was 10 in. less than the average. Open weather in February also allowed land work to start, but this promise of an early season was denied by snow and rain in March, and not all the spring crops were planted until early May.

The weather in June and July made a mockery of the hay harvest. Most of the grass was laid, and when it could be cut it could not be carried, so was leached by rain and made useless. Cereals, barley especially, lodged early and never recovered; weed grasses that would have been smothered by upright crops grew through the flattened ones and flourished. Recommended nitrogen dressings were too much in the conditions of this year and, because of lodging, yields in many experiments were decreased by increasing the amount of nitrogen fertilisers. This was not simply an effect of the wet summer but also reflected the unusually dry winter, and so could partly have been anticipated. With so much less rain than usual during the 8 months before March, nitrogen was not leached from the soil, which therefore contained more than usual in spring. It is to be hoped that their troubles with lodged crops this year will not persuade farmers to use less nitrogen in 1966, for after the wet autumn and winter of 1965 more than usual instead of less will be needed to give full crops in 1966. Take-all and eyespot were also prevalent and lessened yields, but the biggest problem was the harvesting. Grain ripened so slowly that the first crop was not cut until 26 August and, with more than 4 in. of rain in September, harvest took on the nature of a salvage operation, cutting whenever the combines could work regardless of the moisture content of the grain, but even so, it was not finished until well into October. Birds took a large toll from the lodged crops, and much grain was shed, but despite all this the largest yields of winter wheat still exceeded 50 cwt/acre; both wheat and barley averaged about 35 cwt, but the quality was poor.

Our experiments testing effects of sterilants applied to soil, and those comparing cereals grown continuously and in various crop rotations, continue to provide evidence of the extent to which soil-borne pests and diseases limit yields when cereals are grown intensively. Thus, at Woburn formalin nearly trebled the yield of spring wheat, and at Rothamsted, where these pests and diseases are less serious, it also increased yield considerably on a field where cereals have been grown frequently, but not on a field recently ploughed from grass. Similarly, barley after beans at Rothamsted yielded 40 cwt/acre without any nitrogen, whereas barley after barley

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yielded only 24 cwt, which increased to 37 cwt with 0·9 cwt N/acre: the maximum yield (44·5 cwt) was with 0·3 cwt N after beans. Spring barley is now the main crop for intensive cereal growers, partly because winter wheat suffers so much more from soil-borne diseases, but the fact that it is profitable to grow barley repeatedly should not obscure the fact that it, too, is being affected.

Like cereals, beans also lodged and were difficult to harvest. The cool wet summer favoured the spread of chocolate spot so much that not only were the winter beans so affected that they yielded little, but spring beans, which yielded about 26 cwt/acre, were also considerably damaged, which is unusual.

Potatoes grew rapidly and yielded well, nearly 20 tons/acre, although the haulm was burnt off early because of blight. This year blight was not controlled by four sprayings with fungicide, although spraying delayed the attack, and in some experiments greatly increased total yield of tubers. The variety King Edward had many blighted tubers unless the haulm was killed by acid very early in the attack. However, in this wet year scab was less than usual, and was lessened further by watering at the end of June. This was the only benefit derived from irrigation at Rothamsted; at Woburn yield of spring wheat was slightly increased, but yields of clover and sugar beet were decreased.

A rare spell of fine weather in October allowed all the plots in potato experiments to be harvested in reasonable conditions, but thereafter the weather prevented lifting, and at the end of the year there were still more than 100 tons in the ground. A previously unrecognised virus, which has been named "mop-top" because of the way it changes the shoots of some varieties, was prevalent in our stocks of potatoes and of many others examined. It is soil-borne, but not apparently transmitted by nematodes. Some varieties show no obvious signs when infected, and others have characteristic corky arcs in the flesh of the tubers.

Sugar-beet harvest was also difficult and protracted, and was not finished at the end of the year. Root yields averaged well, but sugar contents were small, especially of those lifted late. Downy mildew was more prevalent than usual, but yellows viruses caused little loss, for although aphids flew early and some spray warnings were issued, later weather did not favour them, and spraying did not increase yields. By contrast, carrot yields, although large without any insecticide treatment to control the aphid vector of motley dwarf virus, were considerably increased by such treatments.

Herbicides. The use of hormone weedkillers in cereal crops is now almost routine farming practice, and has changed the appearance of the countryside, for the traditional flowering weeds no longer add their vivid colours to these crops. Their use has been an important factor in allowing cereal growing to be intensified, one consequence of which is the increasing prevalence of wild oats and of the weed grasses they do not kill. When broad-leaved weeds are limiting crop yields there is no need to question the value of spraying, but it is worth questioning it as a routine, because there is little evidence about how this affects yields. We have now measured

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effects over 4 years, and find that spraying decreased the yield of wheat on average by about 2 cwt/acre and did not measurably affect the yield of barley. Of course, crop yields are not the only consideration. Routine spraying prevents susceptible weeds from reaching damaging populations and obviates the problems that can be set by weeds in a year when harvest is difficult. Also, the appearance of sprayed crops has considerable psychological value, because no good farmer likes to see weeds in his crops; it may be a pity to risk diminishing this value by suggesting that it may be the only benefit to be derived from the spraying, but it is perhaps well that he should ask himself whether his pleasure was enough to justify not only the cost of spraying but possibly also a smaller crop of grain.

New herbicides are continually being produced, either to control individual weed species or as unspecific general killers. The general killers are of two broad types, one that persists active when applied to soil and for some weeks kills young seedlings that emerge, and the other that kills all plants on which it is sprayed but is inactive in soil. No one who has seen the near miracle of a weed-free bean crop, traditionally one of the dirtiest crops, because however thoroughly they are cultivated between the rows, weeds remain unharmed in the rows, can but marvel that this can be achieved by a single passage of a sprayer immediately after sowing the beans. More than 30 years ago we showed, contrary to general belief then and still to the belief of some, that cultivations in excess of those needed to control weeds did crops no good and could harm them. Then the information was of academic interest only, but now when there are other methods than mechanical ones of dealing with weeds it comes into the practical category.

With farm workers becoming fewer and labour costs increasing, the use of persistent herbicides is certain to increase greatly, and their faults and values therefore call for thorough testing. Their persistence and lack of specificity clearly implies risks not carried by most hormone weedkillers, which are rapidly inactivated in soil. Their use calls for care, as was vividly portrayed by some areas of our farm that received gross overdoses, and for some years grew neither crops nor weeds. But even recommended amounts are not always safe, and some sugar-beet crops at Broom's Barn and elsewhere were ruined this year by a weedkiller that for 4 years previously had proved satisfactory. Only our crops that were sown during the first week in April were seriously harmed, and the damage developed when a few hot sunny days followed an unusually wet spell.

As crops plants, no less than weeds, are susceptible to these chemicals, it is necessary to know whether they affect yield when not obviously causing harm and whether they will accumulate in soil and be damaging where used frequently. Obviously, long-term effects can be studied only in long-term experiments, and it would be vain to suggest that our results obtained over four years are conclusive, but at least they are reassuring. In an experiment with the four crops beans, wheat, potatoes and barley, grown in rotation with three different main methods of cultivation, ploughing, rotary cultivation and cultivation with deep tines, persistent weedkillers were applied every other year to control weeds in the beans and potatoes and compared with mechanical weed control. Yields of all the

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crops were the same with all three main methods of cultivation, though weeds were fewer after ploughing. Beans and potatoes yielded the same whether weeds were controlled mechanically or by herbicides, so if they were adversely affected by herbicides it was no more than they were by the cultivations. The yields of cereals were unaffected by the herbicides applied to control weeds in the bean or potato crops, and there is no evidence that the herbicides are accumulating in the soil.

The general herbicides that kill plants but are inactive when they enter soil offer the promise of cheapening labour costs still further by eliminating the need for ploughing and the customary seedbed cultivations, because seed can be drilled directly into a sprayed grass sward or cereal stubble. Unlike ploughing, which buries the organic matter, this method leaves it on the soil surface, and the change in practice could affect both crop nutrition and the behaviour of the soil fauna and flora. Unfortunately our attempts to study any such effects have been frustrated by the failure in 2 years of very different weather to get good cereal crops by this method on our soil. In 1964 we drilled into a treated grass sward, but too many grasses survived the treatment, perhaps because the land had been badly poached, and the wheat was smothered with grass weeds. In 1965 we drilled into sprayed stubble, but the ground was so hard that the grain did not go in deeply enough, and much was taken by birds, so again the result was a crop near smothered with weed grasses. An indication that the practice may influence the incidence of take-all came from observations on an experiment at Jealott's Hill Research Station, where direct seeding after spraying with paraquat gave a good wheat crop, for the disease was five times as prevalent in plots cultivated by traditional methods as in sprayed plots. The practice is one of promise for the future rather than for immediate recommendation, because until more is known about the conditions to ensure its success, the risk of failure is too great.

Seed inoculants. More than 40 years ago we demonstrated the benefits of inoculating seed of leguminous plants, particularly lucerne, with appropriate symbiotic nitrogen-fixing bacteria, and developed the agar culture–skim milk method of inoculation. For some years we supplied farmers with free cultures, but the demand became too large for us to meet, and in 1926 Allen and Hanburys Ltd. undertook to prepare and market cultures under an arrangement whereby we supplied parent cultures and tested every thousandth culture sold. As many as 40,000 have been sold in a year, mostly for lucerne. However, from being a pioneering country in this matter, the United Kingdom later lagged behind other agriculturally advanced countries, and sales of cultures have dwindled more than the acreage of lucerne has declined. In 1963 Allen and Hanburys stopped the sale of all cultures except those for lucerne. Since then we have given cultures to growers wishing to inoculate clovers or any leguminous plant other than lucerne; in 1965 we supplied more than 300 such cultures, which is the most we can manage without being equipped for the purpose. The future of lucerne cultures also is now uncertain, because in 1965 Allen and Hanburys gave up the sale of all cultures, and unless some action is taken farmers in the United Kingdom will only be able to buy cultures from

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abroad. We have examined some samples of a peat-based inoculant recently imported from Belgium, and found that most samples contained too few *Rhizobia*, and all were grossly contaminated with other micro-organisms. At present there are no regulations for the control and testing of imported inoculants.

Only in Russia and eastern Europe are seeds of other plants than legumes inoculated, but there it is much done, and yields of various crops are said to be increased by *Azotobacter* or other "bacterial fertilisers". We have occasionally noted benefits from inoculations with *Azotobacter*, but few crops respond consistently, and it has never proved possible to define the conditions in which yields were increased or to determine the cause. However, it is certainly not because of nitrogen fixation, for, unlike *Rhizobium* in legumes, *Azotobacter* fixes only trivial amounts. Tomato responds more consistently to inoculation than other plants we have used, and the effects on its growth resemble those caused by growth hormones of the gibberellin-type. Cultures of *Azotobacter* contain hormones of this type, so these may explain effects on tomato, but whether they also explain the inconsistent responses of other plants remains in doubt.

Seed dressings. The practice of treating seed with pesticides originated to control seed-borne fungi, but has extended far beyond this, and is now not only also used to control soil-borne pests, such as wireworm and wheat-bulb fly, but also some that are not soil-borne, such as the aphid vectors of viruses. It is the cheapest and simplest way of controlling pests and diseases, and uses less pesticide than would be needed either to treat the land or to spray a growing crop. It also relieves the farmer of responsibility, because he can buy seed of cereals and sugar beet already treated with specified materials.

Seed dressings can be very effective, but to be so they need to be properly applied, which means more than simply mixing a pesticide and seed in the correct proportions; the pesticide must not only be distributed uniformly over the seeds but must adhere to them in amounts enough to control the pests but not harm the plant. Our tests with some proprietary pesticides and on commercially dressed seed suggest that these requirements are not always being met. For example, the proportion of the active ingredient in four proprietary insecticides that adhered to dressed sugar-beet seed ranged from 11 to 100%, and the relative efficiencies of the different insecticides in protecting seedlings from damage by wireworm reflected the percentage that adhered to the seed. Also, insecticide was very unevenly distributed in the samples of commercially dressed wheat we examined. In only one sample did the average amount per seed equal that expected from the recommended dressing, and three samples contained little or none. The variability seems plenty to account for the inconsistent results reported on the ability of such seed dressings to control wheat-bulb fly. Obviously the formulations of seed dressings and the methods of applying them urgently need improving; the need is particularly great with sugar beet, for the current tendency is to sow less and less seed, to avoid the labour of singling, and losses of seedlings that would have been unimportant with past methods will now be unacceptable.

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Synthetic pyrethrins. Work with seed dressings is only one out of very many items of interest and importance reported from our studies on a wide range of insecticides. All except one must go without comment here, but the synthesis of new esters of chrysanthemic acid that are more toxic to houseflies than any other pyrethrin-like ester, natural or synthetic, calls for mention. The pyrethrins are very valuable insecticides, not only because they do not harm mammals but because they kill quickly, and insects rarely seem to develop resistance against them. However, their use is limited because they are expensive. That chemicals with their desirable qualities and enhanced insecticidal activity can be synthesised offers the possibility of using them more extensively. The synthesis of these more active derivatives was achieved only because long study of the relation between chemical structure and activity made it possible to predict which compounds that could be synthesised would be active. Different synthetic compounds differ considerably in their ability to kill different kinds of insects.

Computation. The Orion computer got through its teething troubles, and its reliability steadily improved. We now have a set of programmes for analysing most types of replicated experiments and surveys, and 60% more analyses were made in 1965 than in 1964. The computer is now used directly by some workers at other institutes, using either our general programmes or ones they write in Extended Mercury Autocode. A line printer was ordered to prevent the delays now occasioned by printing results on flexowriters from paper tape. Demands on the computer can be expected to increase greatly, particularly as workers here and at other institutes are showing interest in installing instruments that will automatically record results in forms that can be read and analysed directly by the computer.

This general report makes no attempt to summarise the year's work; indeed, the few items commented on do not even begin to indicate the range of subjects dealt with in the departmental reports and articles that follow.

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