ROTHAMSTED RESEARCH

Report for 1969 - Part 1

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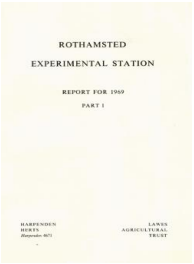

General Report

F. C. Bawden

F. C. Bawden (1970) *General Report ;* Report For 1969 - Part 1, pp 23 - 30 **- DOI: https://doi.org/10.23637/ERADOC-1-124**

GENERAL REPORT

F. C. BAWDEN

Two members of staff retired after periods of service, 58 and 51 years, that almost certainly will never again be equalled. H. Currant, who was born on the Rothamsted farm, where his grandfather and father worked before him, joined the farm staff in 1911, rose to be farm foreman, from which he resigned in 1955 to join the maintenance staff at the laboratories. The long family connection with the farm is still maintained by his son. Mabel Dunkley, who came in 1918 to work in what was then the Protozoological Laboratory, was a founder member of the Soil Microbiology Department when it was formed in 1941, and served it devotedly until her retirement.

Buildings and land. Items to be reported under this heading are mostly gloomy. Faults in the construction of the controlled environment rooms prevented their use, so a planned programme of experiments had to be postponed, but fortunately the cabinets for growing plants in controlled conditions worked satisfactorily.

The contractors for the new buildings to house the Statistics Department and the new computer did not meet their completion date of 30 October and the building was still unoccupied at the end of the year. Problems with the air conditioning may delay the arrival of the new computer until at least April. Meanwhile, in preparation for it and to gain experience with multi-access systems, links were established with computers elsewhere that use similar language.

Progress with the new laboratory block to house the departments of Botany, Physics and Nematology was delayed by the unexpected refusal by the Harpenden Urban District Council to grant planning permission, and at the end of the year we awaited the result of our appeal to the Ministry of Housing and Local Government against the refusal.

The new barn and cattle shelter on Scout Farm, with 70 tons of hay and straw, were destroyed by fire, probably started by children.

At Woburn, where we are already critically short of suitable land for experiments, we shall be even more cramped, because an outbreak of potato wart disease in one of the fields acquired when we rented the Dairy Farm means, in effect, we have lost much of its value. To avoid risk of spreading the disease, soil samples will not be allowed to be taken from the field. Also, it means replacing King Edward, the most favoured potato variety there, by varieties immune to wart.

Honours and awards. G. W. Cooke was elected to Fellowship of the Royal Society. F. C. Bawden was elected President of the Institute of Biology and appointed a Vice-President of the Royal Society; he was also awarded the degree of D.Sc. (*honoris causa*) by the University of Bath. F. Yates was appointed a Senior Research Fellow of the Imperial College of Science

https://doi.org/10.23637/ERADOC-1-124

and Technology, London, and made an Honorary Fellow of the British Computer Society.

Under the scheme for 'Special Merit Promotion', P. S. Nutman was promoted to Deputy Chief Scientific Officer and L. Bailey and O. Talibudeen to Senior Principal Scientific Officer.

Visitors and visits. The largest party of visitors from overseas was the visit of the American Society of Sugar Beet Technologists to Broom's Barn. At Rothamsted we received 18 parties from overseas, totalling 326. The other 160 individuals of whom we have record from overseas included Mr. Voroviev, Deputy Minister of Agriculture, U.S.S.R., Mr. Hani Akhad, Director General of Agricultural Research and Development, Saudi Arabia and Mr. R. J. Jordan, Minister of Agriculture and Natural Resources, Guyana. Parties of visitors from the United Kingdom were almost equally divided between farmers, scientific societies, university students and sixth-form school children, with about 300 in each category.

Several members of staff travelled overseas, some to do research, others to act as advisers or to attend conferences. In addition to the visits noted in the departmental reports, F. C. Bawden went to the Sudan in January to attend a symposium on Cotton Research held on the occasion of the Golden Jubilee of the Gezira Research Station, Wad Medani, and the last meeting of the Advisory Committee for Agricultural Research in the Sudan. In May he was an invited speaker at the opening of the new Plant Pathology Laboratories of Cornell University at Geneva, New York. In September, he went to Hungary under the scheme of exchange visits between the Royal Society and the Hungarian Academy of Sciences, and returned *via* Rome, where he attended a meeting of an FAO Panel of Experts on the Organisation and Administration of Agriculture. In December he attended a meeting of the Scientific Advisory Board of the International Sugar Research Foundation at Washington, U.S.A.

Some record wheat yields. Until 1968 our yields of winter wheat were increasing steadily, but then with the dull wet summer and harvest they fell with a bump. Happily this seems only a temporary interruption to the rising curve of yields, for this year yields again exceeded any previous ones. Especially noteworthy, in view of the current complaints that modern methods of intensive arable farming are harmful and inevitably lead to loss of soil structure and fertility, were yields of almost 3 tons/acre from some of the plots on Broadbalk, which has been in arable crops for 130 years and nothing but wheat until 2 years ago when other crops were introduced on some plots. The largest yields were on plots where wheat was not grown in 1968 and 1967, but plots carrying their 18th successive wheat crop since they were last fallowed yielded up to 47 cwt/acre, and plots with the 11th successive one 49 cwt/acre. Also worth comment is that these plots have received only mineral fertilisers since 1843. Several factors contributed to these yields exceeding past ones. One was the change from the variety Squarehead's Master to Cappelle; another was earlier sowing, made possible by the use of a weed-killer to control blackgrass (*Alopecurus myosuroides*), for previously sowing was delayed until seedlings of the weed

https://doi.org/10.23637/ERADOC-1-124

could be killed by cultivations. Mildew also was slight, though loose smut was unusually prevalent, there was no lodging, and the weather was good between flowering and harvest and during harvest.

Winter wheat in other experiments at Rothamsted also yielded well, averaging about 20 cwt/acre more than in 1968, and many plots gave 65–70 cwt/acre. These yields of plots are larger than would come from whole fields, but one field threshed out at 60 cwt/acre. In an experiment done to get information about the best way to grow semi-dwarf wheats, the American variety, Gaines, yielded up to 63 cwt/acre, equalling Cappelle, although it was severely attacked by mildew despite the use of a systemic fungicide.

However, it may be that Rothamsted especially favours winter wheat, because we do not get similar yields at Woburn, Broom's Barn or Saxmundham. Thus, in somewhat comparable experiments at Rothamsted. Woburn and Saxmundham, studying the effects of introducing crops not susceptible to take-all in sequences of cereals, the largest yield of Cappelle was only 31 cwt/acre at Saxmundham, was 44 cwt at Woburn, but 56 at Rothamsted. The smallest yields at Rothamsted, from plots where winter wheat followed three successive barley crops and more than half the plants had take-all, exceeded the largest at Woburn, from plots free from take-all. At all three places, there was more take-all where the wheat was the second or third successive cereal crop than where it was the fourth or more, and yields were smallest where take-all was most prevalent. However, yields were not wholly correlated with prevalence of take-all. For example, at Rothamsted the wheat after seven successive barley crops had about a quarter of its plants infected, but yielded as much (56 cwt/acre) as the wheat that was free from take-all after a fallow, although it needed more nitrogen fertiliser to do so. With such soils as at Rothamsted, there seems little risk in planting winter wheat after a long succession of barley crops.

The reason for the differences in yield between the places is obscure. It clearly is not because of take-all, and we have been unable to attribute it to any other pathogen. Mildew was more severe at Woburn and Saxmundham, especially on plants given most nitrogen, but nothing like enough to explain yields being so much smaller than at Rothamsted. Some difference during winter or spring seems responsible, and greater leaching of nitrogen at Woburn and Saxmundham may play a part. Certainly, leaching was greater than usual because of the amount of rain between July, 1968 and June, 1969, which may also have affected some soils adversely in other ways. However, if some of the small wheat yields were caused by compaction or other bad soil conditions, these conditions seemed not to affect other crops. Potatoes and sugar beet, which are sensitive to adverse soil conditions, yielded about the same amount on all three farms. Similarly, there is no comparable difference in yield of spring-sown cereals or beans on the farms. The contrast between Woburn and Rothamsted is simply summarised by stating that, whereas barley yields at the two were not greatly different, those at Woburn equalled or exceeded the yields of winter wheat, whereas at Rothamsted they were little more than half as much.

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Other crops. None of the other crops at Rothamsted resembled winter wheat in giving record yields. Barley, which mostly stood well, had only little mildew, but much loose smut, and although yields were about 10 cwt/acre more than in 1968, they were less than in 1967. With only a slight mildew attack at Rothamsted and Woburn, benefits from the new systemic fungicides that control it were inevitably small, but their use increased yield by an average of about 2 cwt/acre. Increases were largest on plots given most nitrogen, where mildew otherwise would have been most severe, and yields were slightly decreased on plots given little nitrogen, suggesting that the systemic fungicide may not be totally harmless to barley. However, its benefits where mildew was more severe were shown at Broom's Barn, with an increased yield by the variety Zephyr from 27 to 38 cwt/acre. The need for such fungicides has long been evident and their advent is timely when most of the varieties bred to resist mildew have already succumbed to new strains of the fungus. It is to be hoped their usefulness will be more enduring, but too little is known about their action for any confident forecast. The older fungicides, which do not become systemic, are fairly general poisons, so the chances were small that fungi would produce strains able to resist them, but the systemic ones are more specific, which increases the chances. Also, when applied as seed-dressings, there is the obvious possibility that they may encounter organisms in the soil able to degrade them before they are taken up by the growing plants. Hence, although they are a very welcome addition to the armoury for disease control, they still need much study and it is too soon to decide whether mildew has come into the category of preventable diseases.

Most bean crops yielded poorly, few much more than 20 cwt/acre, for unknown reasons, though they may have suffered from lack of water after flowering. A threatened attack by black aphids was prevented by spraying with a systemic insecticide, but this increased yield by only 2 cwt/acre. Although we have ample evidence that simazine, the weed-killer most widely used for beans, can affect their yields on land containing little organic matter, it was not responsible for the generally small yields; most of our crops were not obviously harmed by it, and yields on plots without simazine were less than two-thirds of those in 1968. The beans on Barnfield strikingly demonstrated the extent to which the effects of the weed-killer depend on conditions in the soil. Yields on the plots that have been manured differently since 1876 ranged only between 19 and 23 cwt/acre without simazine, but from 6·5 (no fertiliser) to 13 (mineral fertilisers only) and 21 (farmyard manure plus mineral fertilisers) with the weed-killer. Obviously, the results of experiments on the manuring of beans may be misinterpreted if simazine is used to control weeds, and on Broadbalk, where, as on Barnfield, there are great differences between plots in past manuring, we have reverted to mechanical cultivations to control weeds.

After the wet winter and spring, potatoes were planted later than usual; they also matured early in the fine weather of late summer and autumn. Hence, yields averaged about 3 tons/acre less than in 1968, which was also the amount they were increased by irrigation. Irrigating early, at the time stolons are swelling to form tubers, also prevented scab on susceptible varieties planted on land infested with *Streptomyces scabies*.

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Potatoes at Woburn did not die suddenly as they did in 1968. Our suspicion then that air pollution killed them was strengthened by the analyses of air samples, for there were very large concentrations of sulphur dioxide in samples taken shortly before the potatoes died in 1968. Fluorine, another effluent from the nearby brickworks, was also less in plants this year than in 1968.

However, there are still unsolved problems with potatoes at Woburn. Again in some plots of the ley-arable experiment yields of Maris Piper, a variety resistant to the potato cyst-eelworm, were increased by up to 7 tons/acre by fumigating the soil with chloropicrin. The nematicide 'Temik' also increased yields, though less than did chloropicrin, and the largest yields (about 22 tons/acre) were from using both. Some of the increase may reflect control of the cyst-eelworm, which can harm Maris Piper though less than susceptible varieties. The roots of this variety are invaded as are those of susceptible varieties but the eelworm fails to complete its full development or multiply in them, so the soil contains fewer cysts after than before growing it. However, the populations of neither the cyst-eelworm nor free-living nematodes in unfumigated plots seemed enough to account for yield losses of several tons per acre. Attempts to find other pathogens failed, but some were probably concerned, because although the extra nitrogen mineralised by treating the soil with chloropicrin may also have increased yield, its effects depended greatly on the past cropping of the plots and were greatest in the plots containing least organic matter. On other land at Woburn where large populations of cyst-eelworm have been deliberately created by growing potatoes repeatedly, fumigating the soil with dazomet increased the yield of the susceptible variety Majestic from 4 to 16 tons/acre.

Some promising results were obtained with fungicides in the control of tuber-borne fungi such as cause skin-spot. Especially, these promise to be helpful in keeping healthy the commercial seed stocks now being propagated from fungus-free tubers produced by the method we previously described of rooting stem cuttings in uninfested soil. However, it is too soon to forecast success, because it seems the effects of the fungicides may not be wholly beneficial: total yield of tubers was sometimes less with them than without, and they also increased the number of small tubers produced by some varieties.

Potatoes were lifted out of very dry ground, which gave nice clean tubers but, with little earth to cushion them, they were liable to bruising from handling during and after harvest.

The wet spring, which delayed the sowing of sugar beet, also favoured the activity of the species of free-living nematodes that, by feeding on the roots, slowed the growth of seedlings and produced the condition known as Docking Disorder, which was more prevalent than ever previously recorded. Many crops that were stunted early in the growing season recovered well when the soil became drier, and yielded reasonably. However, fumigating the soil, or using granular nematicides, increased yields at many places, increases reaching a ton of sugar per acre on fields where untreated plots yielded about 2 tons/acre and more where yields without treatment were smaller than this.

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The benefits from fumigation are not restricted to the crop grown immediately afterwards, or to one type of crop. Thus, at Herringswell, plots fumigated with 'D-D' in 1966 or 1968 before sowing sugar beet, this year yielded 36 and 40 cwt/acre of barley, whereas unfumigated plots yielded only 29 cwt. Similarly, at Woburn, rye yielded more on plots fumigated before planting potatoes in 1968 than on unfumigated plots. It becomes increasingly evident that there is much light land now yielding less of various crops than it could, or should from the amount of fertiliser it is given, and that the total returns from suitable fumigation would be considerable.

Sugar beet yellows was less than half as prevalent as would have been forecast from the winter weather. With only 3·5% of the crop infected at the end of August, it seems that the results of various control measures developed and applied during the last few years are having accumulative effects in lessening the importance of these virus diseases. Harvesting from the dry soil was difficult, but the dirt tare was small, and the sugar content was also unusually large.

Irrigation and salt each increased the yield of sugar at Broom's Barn by up to 4 cwt/acre. It is odd that the benefits from salt seem not widely appreciated and many growers give none for their sugar beet, though if they did they could save the cost by giving less potash. More interest seems to be taken in magnesium fertilisers, though they are not as generally useful as salt. However, with less farmyard manure being used than previously and heavier crops of all types being taken off the land, magnesium is being depleted in some light soils. Dressings of magnesium fertilisers are economically worth while on these soils and have enduring effects. The fields where yields of sugar beet can be expected to respond greatly can be identified either by soil analyses or by knowing what proportion of plants in previous sugar-beet crops have shown deficiency symptoms during summer.

We report results of many other experiments on crop nutrition, not only of the arable crops already commented on, but also of grass. Some evidence was gained that sodium can replace some of the functions of potassium in grass, and that agmatine accumulates in grass deficient in potassium. Many of the experiments, which must go without comment here, seek to improve the efficiency of fertilisers by finding the best ways and times to apply them, especially of the cheaper forms of nitrogen, such as anhydrous ammonia or ammonia solution.

The insect survey. The survey is in effect a monitoring system to show what insects are flying, and what numbers, at different times and places. Suction traps operating 40 ft above ground mostly catch aphids, and light traps night-flying insects, mainly moths. A prime aim of the work with the twelve suction traps now operating in the United Kingdom and Holland is to test their value in predicting aphid infestations; first results are promising, for in most places the traps caught cereal aphids before these were found by searching field crops, and in some places many days sooner. However, much more work will be needed before knowing whether catches in the traps can be related to damaging infestations of crops.

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One of the commonest species caught in the traps during spring and early summer is the leaf-curling plum aphid, *Brachycaudus helichrysi*. It sometimes harms clover a little, but otherwise is not regarded as affecting agricultural crops. This idea may need changing, not because it is a damaging pest, but because it does feed on crops as diverse as potatoes, sugar beet and lucerne and can transmit viruses of these crops. In comparative tests with six viruses, it transmitted only about a quarter as often as the peach-potato aphid, *Myzus persicae*, which is considered a main vector of the viruses, but it was many times more abundant on field crops. Its ability to transmit such viruses as potato virus Y might explain some of the occasions when this virus seems to have spread more than expected from the numbers of previously recognised vectors.

Synthetic pyrethroids. With increasing restrictions on the use of chlorinated hydrocarbon insecticides, the need for alternatives increases. To find something as cheap, as efficient in killing insects and as harmless to human beings as DDT, is a tall order, and our synthetic pyrethroids do not meet it. However, it is opportune that they are now being produced commercially, because their harmlessness to people should make them suitable replacements for various purposes, domestic, public health, veterinary, and for controlling insects that attack stored products; possibly, too, for fruit and vegetables when a safe spray is needed shortly before harvesting. Compound NRDC 104 is being developed in the U.S.A. and Japan with a view to commercial marketing and has already been cleared for certain applications in the United States by the United States Department of Agriculture. Compounds are also being developed commercially in France and in the United Kingdom.

Until their selling price is known, the uses of these compounds in agriculture and horticulture cannot be forecast, but they may not be stable enough to find many. However, there is reason to think that other compounds, at least as active against insects, can be prepared that are more persistent and may be cheaper to synthesise.

Examples of insects becoming resistant to pyrethroids are few, but they can become so when exposed repeatedly. Houseflies exposed similarly to NRDC 104 did not become so resistant to it, so it seems this compound is less affected than the natural pyrethrins by some resistant mechanism in the flies. Possibly it is also less readily degraded in susceptible flies, which would help to explain its greater activity against them.

The Soil Survey. The increase in numbers of staff has not only allowed more land to be mapped than in earlier years, but also some new developments. In a new mapping programme, areas to be surveyed, corresponding to the Ordnance Survey 10 km × 10 km Outline Edition 1 : 25 000 map series, are being selected for their geomorphological and agricultural interest. They will be used to compile county and regional maps, and the first, of an area of Norfolk, was published. Supplementing this map, there was also produced for this area the first of an experimental series of land capability maps, and a third one indicating areas most in need of draining.

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For the land capability maps, land is graded into seven classes according to its potentialities and limitations for crop growth.

The use of air photographs for rapid survey in uplands is being tested at Leeds and in lowlands at Cambridge. Most of the soil boundaries found by photo-analysis in two areas in the West Riding Pennines were confirmed by later field work, and the photographs saved up to 40% of the time usually spent on ground work. Five tonal patterns evident in oblique aerial photographs of lowlands, collected by the Department of Aerial Photography at Cambridge, reflected soil changes in East Anglia.

Using machines of the Natural Environment Research Council's Experimental Cartography Unit at Oxford, which record co-ordinates of a line in a map as digits on paper or magnetic tape, and a computer that replots the line at any chosen scale, boundaries on the 10 560 scale field sheets for a part of the Reading district were digitised on to magnetic tape, and the map redrawn at a scale of 1 : 63 360. Colour masks were also scribed and a colour map prepared. The drawing was both accurate and quick, but the method has additional benefits of improving map production because it allows information about soil to be retrieved rapidly and analysed for any required purpose.

Under a research contract with the Water Resources Board, the soils of the River Dee Catchment in Wales were surveyed, classified and the moisture release characteristics measured. The results will assist in preparing a flow model, one object of which is to minimise flooding of agricultural lowlands.

https://doi.org/10.23637/ERADOC-1-124