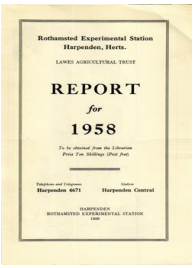
ROTHAMSTED RESEARCH

Report for 1958

Full Table of Content



General Report

F. C. Bawden

F. C. Bawden (1959) *General Report ;* Report For 1958, pp 23 - 32 **- DOI: https://doi.org/10.23637/ERADOC-1-91**

GENERAL REPORT

F. C. BAWDEN

Sir William Ogg retired on 30 September. This is neither the time nor place to assess his directorship, but it is appropriate to record some changes during his period of office. When he came in October 1943 the total staff was 140, and when he left it was 471. Three new departments, Biochemistry, Nematology and Pedology, were formed, and the Station's activities were increased by the addition of the Soil Survey of England and Wales and of the work done for the Sugar Beet Research and Education Committee, which has developed into the Dunholme Field Station. The estate was increased by about 50 acres; other acquisitions were Rivers Lodge, which houses most of the Statistics Department, Rothamsted Lodge, which houses the Bee Department, and several smaller buildings. The West Block, which houses the departments of Entomology, Insecticides and Fungicides and part of the Plant Pathology Department, was the main new building, but others were a laboratory for the Nematology Department, one for the field experiments of the Chemistry Department and the leaf-protein work of the Biochemistry Department, a building for the electronic computer, an extension to Red Gables for a canteen, six farm cottages, additions to the farm buildings, and new glass-houses for the departments of Entomology, Plant Pathology, and Insecticides and Fungicides. Another major development, in which Sir William took great pleasure and of which he was justifiably proud, was the conversion of the Manor House into the magnificent hostel that adds so much to the Station's amenities.

Sir William was awarded the Rapphaele Piria Gold Medal of the Italian Chemical Society shortly before he retired, and soon afterwards was honoured again by being made an honorary member of the Royal Agricultural Society of England.

F. C. Bawden was appointed director from 1 October; he was succeeded as deputy director by F. Yates and as head of the Plant Pathology Department by P. H. Gregory. The expansion of work at the Dunholme Field Station to include the manuring and study of pests in addition to diseases of sugar beet was recognized by giving the Field Station the status of a department with R. Hull as its head.

Two deaths saddened the year. Lord Bledisloe, who was Chairman of the Lawes Agricultural Trust Committee from 1920 to 1924 and was actively interested in the Station for the rest of his life, died in July at the age of ninety. A. H. Bowden, a faithful and respected servant of Rothamsted for almost fifty years, was killed in a road accident in August. His was the only name of the existing staff that appears in the Station's first *Annual Report*, published in 1909. We deeply regret he did not achieve his ambition of a Golden Jubilee, at which it would have been our great pleasure to do him the honour he deserved.

https://doi.org/10.23637/ERADOC-1-91

H. V. Garner's many services to the Station and to agriculture were recognized by the award of the O.B.E. in the Birthday Honours List. Another event that gave great pleasure was the promotion of H. F. Barnes to the grade of Senior Principal Scientific Officer for his outstanding research. I. F. Long's winning a Darton Prize for his paper on " Instruments for Micro-meteorology " was also a notable achievement.

We gratefully acknowledge the generous support given us by the Rockefeller Foundation, which provided grants to expand the work on leaf protein, to buy an infra-red gas analyser and to pay for two members of the staff to visit the U.S.A.

Visits and visitors

Were science not already recognized to be international, our visitors' book and the travels listed in the departmental reports would show that it is. We welcomed visitors from most countries during the year, and the number of countries visited by members of the staff to attend conferences, symposia, to serve on committees or working parties, to give advice or to do some research was also considerable. The largest single influx of overseas visitors was for the successful colloquium on Research Methods in Soil Zoology organized by the Entomology Department immediately before the International Zoological Conference in London. Other visitors from abroad included Mr. Kedish Luz, the Minister of Agriculture, and Mr. Ben-David, the Assistant Director General, from Israel; Mr. Balaceanu, the Rumanian Minister in London; and Mr. Slavko Komar, Secretary for Agriculture of the Federal Executive Council of Yugoslavia. British visitors included the Minister of Agriculture, the Rt. Hon. John Hare, P.C., O.B.E., M.P.; the Chairman of the Agricultural Research Council, the Duke of Northumberland; and the Parliamentary Secretary to the Minister of Agriculture, Mr. J. B. Godber, M.P.

An exchange arrangement with the Russian Ministry of Agriculture allowed R. Cooper and A. Newman to work in Moscow for a year and brought Messrs. G. Naumov and B. Pleshkov here. A third Russian scientist, Mr. Y. Rusko, came as a British Council scholar. The compliment paid to us by the American Phytopathological Society in inviting five members of the staff to contribute to their Golden Jubilee Meeting was much appreciated.

The year's work

Whatever the weather, farmers are apt to complain, but there can be few years when complaints were more justified than in 1958. The year started well, and in May cereals promised bumper yields, but June, with twice the normal rainfall, altered the picture, and from then on things went from bad to worse. Hay was spoiled and cereals lodged badly; when combining was possible, the grain came in with a water content that taxed the new grain drier to the utmost. Fortunately, satisfactory methods for combining harvesting experimental plots of cereals and beans had been developed, for without these many experiments would probably have had to be abandoned.

The continued dull, wet weather favoured fungus diseases, and

potato blight was more severe than in human memory; repeated spraying with modern fungicides did little more than delay the epidemic. The only redeeming feature was the growth of the root crops, with sugar beet giving record yields and sugar content increasing unusually late in the year, but lifting was tedious and dirty. The soil continued wet, so that autumn ploughing was difficult and getting good seedbeds was impossible. Little winter corn has been sown, and rarely has field work been so far behindhand. Broadbalk typifies the autumn difficulties; it was ploughed in poor conditions, and drilling started early in December as soon as it became possible, but rain fell before it was finished, and at 31 December plot 2 was still not sown.

Soils and fertilizers

In some light soils organic matter seems necessary to maintain a structure, but at Rothamsted there is little evidence that it affects the growth of crops except through the supply of plant nutrients. Even with sensitive crops, such as carrots and beetroot, differences in soil structure seem to have any effect only during germination and for a little while after seedlings emerge. Results from the original three-course rotation experiment, which tested the effects of accumulated applications of straw and composted straw, suggested that the applications mainly affected yield by supplying potassium and withdrawing nitrogen from circulation. Results since 1952, when the experiment was redesigned specifically to test this point, confirm the earlier conclusion. Ploughing in straw at 53 cwt./acre decreased the yields of sugar beet and barley, neither of which responded to potassium in this experiment, by amounts compensated for by giving 0·2 cwt. nitrogen. Potatoes responded to both potassium and nitrogen, and straw, given with a compensating dressing of nitrogen, increased yield by the same amount as did its potassium equivalent given as potassium chloride. The effects of past dressings of straw also seem to derive solely from the residues of nitrogen and potassium.

The ley–arable experiment provides information on the way in which organic matter and plant nutrients change when old grassland is ploughed and when leys are introduced into an arable rotation. On Highfield, previously permanent grass and rich in humus, one-seventh of the organic matter was lost after 6 years of arable cropping, and the loss was not lessened by growing a ley for 3 of these years. On Fosters Field, old arable land containing much less organic matter than Highfield, 3 years under ley followed by 3 years arable cropping raised the organic matter by one-seventh, twice the increase obtained by ploughing in 26 cwt. of straw/acre annually for 18 years. In this experiment, too, responses of arable crops reflect the way treatments affect the amounts of plant nutrients in the soil, especially of potassium. Continued cutting and removing grass or lucerne seriously depletes reserves of this element, and yields of arable crops fall unless it is replenished.

Work on the failure of sugar beet, known as " Docking disorder ", emphasized the much greater importance of organic matter in some light soils. This trouble, characterized by slow growth caused by the main roots dying, was unusually prevalent in 1958, and invariably

https://doi.org/10.23637/ERADOC-1-91

occurred on light, alkaline soils containing little or no clay or organic matter. Mineral fertilizers do not control it, but organic manures and the taking of leys do. It may now become possible to test whether inadequate aeration is one cause of poor growth in these almost structureless soils, for methods that promise to give meaningful measurements on aeration were developed during 1958.

The value of reserves of potassium and phosphorus built up by manuring last century were tested by growing in 1957 and 1958 six crops on the Exhaustion Land Experiment, with and without new dressings of the two elements. The residual phosphate from manures applied between 1856 and 1901 was enough to give full crops of cereals, sugar beet and swedes in 1957, but not in 1958; in neither year was it enough for potatoes or kale. The residual potassium was enough for cereals, sugar beet and swedes in both years, but not enough for potatoes in either year or for kale in 1957. Even the land unmanured for over 100 years contained enough potassium for cereals, sugar beet and swedes in the conditions of 1957, but in 1958 swedes and beet responded to the fresh dressings. The long-term experiments at Rothamsted provide unique material for testing the value of fertilizer residues, and the experiments on Agdell and Barnfield are being adapted for this purpose.

Most current methods used to measure " available " phosphate are unsatisfactory with calcareous soils, and measuring the amount of exchange between soil phosphate and a solution of phosphate labelled with ^{32}P gave better results. "Available" potassium is measured by finding the amount that exchanges with another cation, usually ammonium, but the relevance of this to plant growth is open to question, because some of the potassium in many soils that is unexchangeable by this method can be used by crops. Grass growing in pots removed this type of potassium in amounts equal to those extractable by a hydrogen-saturated cation-exchange resin. Natural sources of potassium contain a constant fraction of the radioactive isotope ^{40}K, and measuring the radioactivity of soil promises to provide a method of estimating soil potassium less tedious than the chemical methods now in use. Results from chemical analyses and measurements of radioactivity agreed well, except with some soils that contain traces of other radioactive materials.

A series of fourteen experiments on the nitrogen manuring of spring-sown wheat and barley ended in 1958. Both crops gave profitable increases in yield with 3–4 cwt. " Nitro-Chalk "/acre at Rothamsted and up to 6 cwt./acre at Woburn. Wheat at both farms, and barley at Rothamsted, responded most when all the dressing was given before drilling, but at Woburn barley did slightly better with an early top dressing. Dividing the dressing, or giving a late top dressing, gave no benefit. Other experiments showed that heavy dressings of ammonium sulphate could be combine-drilled with the seed without affecting germination, and this method gave higher yields than broadcasting the fertilizer at sowing time. Except when lodging occurred, winter wheat responded better to nitrogen given in March than when given to the seedbed or in May. As nitrogen given in autumn was washed into the sub-soil by spring,

https://doi.org/10.23637/ERADOC-1-91

but nevertheless increased yields, inorganic nitrogen in the sub-soil must be used by wheat. Whether applied as solids or in solution, ammonium sulphate, ammonium nitrate, calcium nitrate and urea all greatly increased yields of old pasture and newly sown ryegrass. An aqueous solution of ammonia, however, damaged permanent grass and failed to increase yield; when applied before sowing ryegrass, it also increased yield less than did the other sources of nitrogen. All the fertilizers increased the amounts of water-soluble ammonium- and nitrate-nitrogen in grass, which may be important in affecting the health of animals that eat it.

Pedological studies on an increasing number of soils from at home and abroad make it increasingly clear that simple descriptions of soil profiles do not give a sound basis for soil classification. Valuable additional features are coming from examining thin sections of soils, a technique that promises to help elucidate soil genesis and to indicate relations between soils from different places. In some soils developed in loess-like material it provides evidence that clay has migrated down the profile and changed the structure of the profile. Mechanical analysis had previously suggested that soils from the Chiltern area commonly have a loess-like layer on the clay-with-flint deposits, and this was established by studying thin sections. Oxford Clay showed the same correlation between the content of trace elements and organic matter as previously found for Lias shales. A clue towards understanding the curious behaviour of molybdenum in " teart " soils may lie in the behaviour of this element in the presence of iron oxide. In water-logged soils molybdenum is strongly fixed to iron oxide, but is readily released on incubation with decomposing remains of plants.

Demands on the soil surveyors to examine experimental or demonstration farms, sites of open-cast mining, forestry land and to make surveys for town planners are considerable, but despite these, the primary survey made progress in eleven districts, and some sheets were finished. A soil map of the United Kingdom was prepared for inclusion in the map of the soils of Europe to be issued by the Food and Agriculture Organization; it will also be used by the Clarendon Press in a forthcoming atlas.

Soil microbiology

New chemicals are now constantly being introduced into agriculture, and it is important to know whether or not they will accumulate in the soil. Hence, to the older microbiological studies on nitrogen fixation and similar problems have been added tests with some of these new substances. Fortunately, most seem to be susceptible to microbial attack. The sex hormone stilboestrol, now widely used, disappears from soil, although rather slowly compared with the weed-killer, 2 : 4-D. A small dose of 2 : 4-D added to soil changes the flora to one better able to decompose it, and large doses increase the numbers of active bacteria. Species from three genera of bacteria that attack it in pure culture were isolated.

A considerable step towards understanding the anaerobic decomposition of cellulose was made by achieving the difficult task of getting a pure culture of a bacterium, provisionally identified as *Clostridium cellobioparum*, able to do this in pure culture. It breaks

https://doi.org/10.23637/ERADOC-1-91

down cellulose and produces organic acids, sugars, hydrogen and carbon dioxide, but not methane.

We reported in 1952 that clover grown on agar media in which clover seeds had already been germinated produced nodules quicker than when grown on fresh agar, and the effect was tentatively attributed to a stimulant secreted by the first plants. This interpretation is wrong; the effect occurs because the first plants remove traces of nitrate or nitrite from the media, which otherwise inhibit nodulation. The inhibition seems specific, because ammonium salts, asparagine and urea in similar minute amounts did not affect the formation of nodules. A start was made to estimate the importance of nitrogen-fixation in soil by free-living bacteria.

Crop growth

There is much evidence that differences in yield between individual crops of one kind depend on differences in leaf area, so substances that affect leaf area could affect yield. Gibberellic acid is such a substance, and last year it increased the yield of potatoes. However, although it consistently increases leaf area, it increases yield only within a restricted range of conditions. When potatoes were sprayed frequently with it, and particularly when nitrogen was limiting, photosynthesis was so affected that yield was decreased despite the increase in leaf area. Extracts of expanding French-bean leaves were found to contain a substance behaving like gibberellic acid on paper chromatograms and in its ability to accelerate the growth of discs of etiolated leaf. Its amount was correlated with the rate at which the leaves were expanding, so it seems to be a normal growth regulator of this plant.

An attempt is being made to measure the movement of carbon dioxide into a field crop by day from photosynthesis, and out by night from respiration, and to relate this with the yield of dry matter in the crop. The biological and physical measurements agreed reasonably well in August and September, but in October a flux from air to crop was detectable only in bright sunshine, and there is a suggestion that at some other daytime periods the crop may have been getting its carbon dioxide from the soil. Leaf areas were measured, so that the flux of carbon dioxide can be related to the size of the assimilating system; measuring the areas of leaves has become less tedious since an instrument has been developed that does it directly and quickly by a light-scanning method.

Seeds of wild oats persist under temporary leys much longer than when arable crops are grown; many seeds survive for more than 4 years, so short-term leys are evidently no answer to heavy infestations. No evidence was found to support the idea that couch grass exudes substances into soil that are toxic to crops, although it was confirmed that dried roots and rhizomes contain substances that inhibit germination and growth of seedlings. The seventh consecutive wheat crop on section 1a of Broadbalk, which has been returned to continuous wheat and is sprayed with weed-killers, looked much better, particularly on plots 3 and 5, which get no nitrogenous fertilizer, than did the second wheat crop after fallow on section 1b. These plots are heavily infested with leguminous weeds; killing these in spring probably led to the response, which

https://doi.org/10.23637/ERADOC-1-91

almost doubled the yield of grain. Only time will tell whether this effect will continue, or whether the repeated use of weed-killers on section 1a will eliminate leguminous weeds and make yields of plots 3 and 5 decline from lack of nitrogen.

Biochemical work on the blackening of potato tubers supported the idea that the pigment responsible is a complex of ferric iron and dihydroxy phenols, produced when colourless ferrous complexes oxidize in air. Blackening is also affected by the amount of citrate in tubers; this and other substances that form colourless iron complexes prevented blackening when added to water in which the tubers were boiled. Potatoes from Woburn blackened less than those from Rothamsted, where blackening varied more with the kind of manuring.

Methods of extracting and preparing leaf protein for human consumption were improved, and encouraging yields were obtained from a range of plants; of spring-sown cereals, oats were the most productive and gave 471 lb. of protein/acre when cut in June. However, plants that now contribute nothing to human nourishment may find a use through this process, for nettles growing wild, except for a small dose of fertilizer, yielded 546 lb. of protein/acre.

Pests and diseases

The year favoured fungus diseases but not pests; virus diseases also spread much less than in 1957, for although early in the season it seemed that aphids might again be abundant, the weather later turned against them, and their predators were also plentiful. After the great losses from sugar beet yellows in 1957, a regular survey of the crop was organized from Dunholme, and warnings of the need to spray were issued when aphids averaged one per four plants in any district. As a result, 100,000 acres were sprayed, and in September yellows was much less prevalent in sprayed than in comparable unsprayed crops. In some districts yellows was not serious enough to affect yields, but in others spraying increased yield by amounts up to 5 tons of roots/acre.

It was reassuring to find from the health of seed tubers saved from the 1957 potato experiments that, despite the unprecedentedly early and heavy aphid attacks that year, spraying with insecticides completely stopped the spread of leaf roll. Spraying did not prevent the spread of rugose mosaic, but this, fortunately, is less important than leaf roll. The practical value of insecticides in controlling the common virus diseases of sugar beet and potatoes now seems established, and preliminary experiments suggest that applying them to beet seed and potato tubers, or to soil at planting time, may protect crops soon after they emerge and add to the benefits gained from spraying the growing crops.

Organophosphorus insecticides are generally considered to act by affecting cholinesterases, and most of them do affect these enzymes. However, that it may not be the only way all of them act was suggested by the fact that poisoning house flies with " Diazinon " had no effect on the cholinesterase activity of their brains. The mechanism whereby flies become and remain resistant to " Diazinon " seems to differ with different strains: one resistant strain remained resistant from generation to generation without being continually

https://doi.org/10.23637/ERADOC-1-91

exposed to the poison, whereas another remained resistant only when each generation was exposed. Continuing work on pyrethrins and related compounds gave further information on the relation between chemical structure of molecules and their insecticidal activity, and suggested that crude extracts of pyrethrum contain insecticidal substances other than those previously recognized. Some substances were found to enhance the valuable " knock-down " action of pyrethrins.

Much evidence was obtained compatible with the idea that infection by tobacco mosaic virus entails the dismantling of the virus particles and the separation of the nucleic acid from the protein. The protein undoubtedly stabilizes and protects the nucleic acid, and differences between the susceptibility of different plants to infection are conveniently explained by postulating differences in their ability to inactivate the nucleic acid when it becomes free; but the explanation remains in doubt until it is proved that infecting particles are dismantled in host cells. The action of some of the agents found to inactivate fragments of tobacco mosaic virus was difficult to interpret if the minimal infective unit has the simple structure of a sequence of nucleotides now generally assigned to nucleic acids. Infective fragments consisting mainly of nucleic acid were also obtained from viruses other than tobacco mosaic. Tobacco rattle, a soil-borne virus, resembles tobacco mosaic virus in being a hollow rod and, possibly, in having its protein units spirally arranged along its long axis. Rods of two lengths occur in infected plants; both are nucleoprotein, but only the longer ones are infective.

The common virus disease of cereals, yellow dwarf, which is particularly damaging in oats, seems to be caused by at least two viruses, each of which occurs in strains of different virulence. Leafhoppers infected with wheat striate mosaic virus produced fewer young than uninfected ones, and many of the eggs they laid failed to hatch; this is the first unequivocal evidence of a plant virus harming the insect that transmits it. Further evidence was obtained that strains of potato virus Y normally not transmitted by aphids can become transmissible as a result of multiplying in plants simultaneously infected with strains that are aphid-transmitted.

In the favourable conditions for spread of potato blight there was little difference between the dates at which four potato varieties, reputedly of different susceptibilities, became defoliated. However, varieties did differ in the extent to which their stems became invaded by the fungus and to which lesions on their leaves produced spores. Blight outbreaks are generally thought to start only from lesions that develop on shoots produced from infected tubers, but in this wet year the fungus also spread through soil from diseased tubers that produced no shoots and directly infected the lowest leaves of nearby plants growing from uninfected tubers.

Eyespot and take-all of cereals were also unusually severe in 1958. The high incidence of eyespot made lodging even more serious than it otherwise would have been and contributed to the low yields; on the Rothamsted six-course rotation experiment, for example, the wheat was 100 per cent infected, lodged early, and the yield was 18·7 cwt./acre compared with the previous 20 years' average of 30·4. Take-all was particularly severe when winter

https://doi.org/10.23637/ERADOC-1-91

wheat followed another wheat or barley crop, but was negligible after oats. The incidence of mildew on Broadbalk was clearly correlated with manuring and was least on plots getting potash as well as nitrogen and phosphate.

As the growing of peas increases, fusarium wilt becomes increasingly common and important. Field trials with ninety pea varieties on infested land showed that more than half of them, including many that are popular and widely grown in the United Kingdom, are highly susceptible. Some of these are described as resistant in other countries, suggesting we have strains of the fungus not yet in those countries. Fortunately, many varieties were resistant, and there seems ample material for the plant breeders to use in producing desirable varieties resistant to wilt. The fungus, however, varies, and no single variety can be relied on to resist the disease indefinitely.

Most kinds of pathogens show this type of variability, nematodes no less than fungi. Strains of potato-root eelworm that infect potatoes at first thought to be resistant are now known to occur commonly, and some beet eelworms develop in *Beta patellaris*, previously considered not to be a host of this pest. Thus, although resistant varieties should be sought, this cannot be relied on to control eelworms, and other ways of decreasing damage are being sought, such as by varying crop rotations, or methods of cultivation, and by soil treatments. Much new information about the factors affecting the movement of eelworms through soil and over plants was obtained, and considerable progress was made in isolating the substance exuded by potato roots that causes cysts of the root eelworm to hatch. The " hatching factor " was consistently correlated with a single fluorescent spot on chromatograms, and although the chemical composition of the " hatching factor " was not determined, some progress was made towards its identification.

Bees

Improving methods for assaying " queen substance " led to much new information about this important material. It is produced in the queen's mandibulatory glands, from where she apparently distributes it over her body while grooming and makes it obtainable by her workers. It inhibits workers from raising queens, and, when given to queenless workers, inhibits the development of their ovaries. Queens that have been superseded or have swarmed from uncrowded colonies contain less of the substance than those in colonies of the same size with only one queen, a clear suggestion that the substance could have important applications in colony management. Workers at the National Institute of Medical Research are collaborating with us to try to identify the active material in queen substance.

No evidence was found to support the claims of workers in other countries that bees can be directed to pollinate given crops by incorporating pollen from these crops in nectar fed to the colonies.

Observations in years with very different nectar-flows show that acarine disease is inversely correlated with amount of nectar. Antibiotics suppressed European Foul Brood, and fumigating comb with formaldehyde or acetic acid promises to be valuable in freeing it from contaminating bacteria.

https://doi.org/10.23637/ERADOC-1-91

The increasing use of insecticides on crops is obviously dangerous to bees, and tests on dead bees sent to us indicated that some had been killed by parathion, some by DDT and some by arsenic. "Metasystox" was not found in bees suspected as having been killed by it, but this may be because the insecticide had decomposed.

Statistics

Statistical work again was concerned with far more than Rothamsted's experiments, and results were analysed for many other research stations and organizations, both at home and in various Commonwealth countries. A major task was the summarizing of 230 fertilizer experiments, each of twenty-seven plots, made on rice farms in Bihar, India. The survey of fertilizer practice was continued and extended, and other large surveys organized were of the growing of maincrop potatoes and of diseases in dairy cows. The enormous amount of computation involved in analysing the results from experiments and surveys is possible only by the electronic computer and by steadily improving its performance and hours of operating. This year the number of variates analysed was one-third more than in 1957, and the number of experiments analysed was nearly five times as many as in 1951.

https://doi.org/10.23637/ERADOC-1-91