Report for 1970 - Part1

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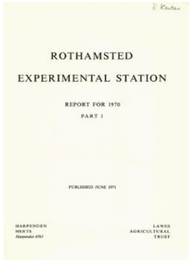
ROTHAMSTED
EXPERIMENTAL STATION
REPORT FOR 1970
PART 1

General Report

F. C. Bawden

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GENERAL REPORT

F. C. BAWDEN

The sudden death of A. Kleczkowski on 27 November robbed us of an unusually talented colleague, who during 30 years has done much to enhance the reputation of both the Plant Pathology and Soil Microbiology Departments. Born in Russia, he was educated in Poland and graduated Doctor of Medicine at Cracow University, where he also did his first research in the Department of Medical Bacteriology and Serology. From there, he went to the Department of Physiological Chemistry, University of Warsaw, and came to England in 1939 as a visiting worker in the laboratory of the London Hospital. This laboratory closed when the war broke out and he came to Rothamsted where his wife was a visiting worker in the Soil Microbiology Department. After a brief spell in the Statistics Department, he moved to the Plant Pathology Department to work on the serology of plant viruses, with support at first by research grants and later a Beit Memorial Research Fellowship, and after the war he was appointed biochemist to the department. Here is not the place to record his many achievements, which are as notable for their originality as for the diversity of subjects in which they were made, ranging from immunology to statistics and biochemistry to photobiology. Suffice it to say they gained him an enviable international reputation and were recognised by a Special Merit Promotion in 1961 and his election as a Fellow of the Royal Society in 1962. He will be greatly missed, not only because he still had much to contribute by his own research, but because we can no longer benefit from the wise and friendly advice he generously gave to the many who sought it.

Membership of Trust Committee. We suffered another grievous loss with the death of Professor A. Robertson, F.R.S., on 9 February. He had been a member of the Lawes Agricultural Trust Committee since 1954 and Treasurer since 1957. He was unusually well equipped to advise us, for it is given to few to be both eminent in chemistry and to farm on a large scale. He willingly gave much of his time to our affairs and we gratefully acknowledge his valuable services.

The Royal Society appointed Professor K. Mather, C.B.E., F.R.S., Vice-Chancellor of Southampton University, to succeed him as a member of the Committee, and Lord De Ramsey has succeeded him as Treasurer.

Head of Botany Department. Professor C. P. Whittingham, head of the Botany Department and Dean of Science, Imperial College, London, and Honorary Director of the Agricultural Research Council Unit of Plant Physiology, was appointed to succeed D. J. Watson as head of the Botany Department from 1 April, 1971.

Honours and awards. C. G. Butler was honoured by being made an Officer of the Order of the British Empire in the New Year Honours 1970 and D. J. Watson a Commander of the Order in the New Year Honours 1971. C. G. Butler and J. M. Hirst were elected to Fellowship of the Royal Society. J. M. Hirst was awarded the Research Medal of the Royal Agricultural Society of England. Under the scheme for Special Merit Promotion, M. Elliott and J. C. Gower were promoted to Senior Principal Scientific Officer. F. C. Bawden was awarded the degree of Doctor of Science (*Honoris causa*) of the University of Reading and was elected a Foreign Member of the Lenin All-Union Academy of Agricultural Sciences; he was appointed a Vice-President of the Royal Society and

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Chairman of the Board of the Council of Science and Technology Institutes. C. G. Butler was elected President of the International Union for the Study of Social Insects. R. Hull was elected Chairman of the Scientific Advisory Committee of the International Institute of Sugar Beet Research. P. H. Gregory gave the Leeuwenhoek Lecture of the Royal Society and F. G. W. Jones the John Curtis Lecture of the Royal Society of Arts.

Buildings and equipment. After much delay, the new building to house the statisticians and the new multi-access computer was finished and occupied. The computer, ICL System 4-70, was installed in July and passed its acceptance tests in September, but it would be vain to suggest that it has been satisfactory. Because of deficiencies in the Multijob operating systems, it will be some time before other institutes will have full access to the computer, and both the Orion computer and the link with the Edinburgh computer will need to be maintained for longer than intended.

On a happier note, the growth rooms and cabinets in the Controlled Environment building worked satisfactorily and promise to be rewarding in studying a wide range of problems. So, too, the Stereoscan electron microscope functioned well and gave much new information about the structure of various organisms and materials.

We won our appeal against the refusal of planning permission for the new laboratories to house the departments of Botany, Nematology and Physics, and at the end of the year had made a start on the temporary building to house the nematologists while their old one is demolished and the new one built.

At Woburn we were fortunately able to rent a little more land, which will compensate for the field largely made useless to us because it is contaminated with potato wart fungus.

A year of contrasts. A wet and cold spring, which delayed the sowing of crops and slowed the growth of winter wheat and grass, was followed by a dry May and June. Yields of most crops were less than in 1969, but yields of the same crop given similar treatment differed widely, depending on the soil type and past history of the fields. For example, in the Ley–Arable Experiment at Rothamsted, in which winter wheat on Fosters (old arable land) yielded slightly more in 1969 than on Highfield (pasture until 1949), this year yields on Fosters were about 20 cwt/acre less than in 1969, whereas on Highfield they were only 5 cwt/acre less. Late sowing, together with late top-dressings of nitrogen, were mainly responsible for the smaller yield of spring-sown wheat and barley than in 1969, and it seems that many crops, especially on land frequently cropped with cereals and where soil-borne diseases such as take-all were at all prevalent, failed to make use of the nitrogen they were given. Neither barley yellow dwarf nor mildew were very damaging, but European wheat stripe mosaic was much more prevalent than previously recorded. Seemingly, the weather favoured its hopper vector, and it is to be hoped this was only a temporary upsurge for the disease is crippling.

Early sowing of sugar beet failed to have its usual beneficial effects, and crops drilled at the end of April yielded as much as those drilled at the end of March. The late-sown crops grew rapidly and, with the top-soil dry during May, the free-living nematodes that cause Docking disorder were inactive, and this trouble was reported on only 1/20th the acreage affected in 1969. Consequently, there was little increase in yield from the nematicides that were applied to a large area of light land prone to the disorder. At Broom's Barn irrigation increased the yield of sugar by 11 cwt/acre, whereas on the heavy land at Rothamsted it produced a striking response in top growth but decreased root weight and sugar yield. With February and March colder than for several years, sugar-beet yellows was not expected to be severe; although summer weather favoured aphids and there were many flying during July and August, the expectation was realised and few

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crops had more than 1% of plants infected at the end of August. However, powdery mildew became unusually prevalent during late summer and undoubtedly affected yields.

Most potato crops grew well and even without irrigation their leaves remained turgid while nearby sugar beet were often wilted. Irrigation, however, was doubly beneficial. Given early while the tubers were first forming it prevented common scab, which otherwise was severe on susceptible varieties initiating their tubers in the dry soil of June. Given later, it increased yields of tubers by up to 5 tons/acre at Woburn and even more at Gleadthorpe. However, even without irrigation, a yield of 25 tons/acre was obtained at Woburn, by giving twice the usually recommended dressing of fertiliser and incorporating it deeply in the soil; the single and double dressing gave the same yield, 20 tons/acre, when it was worked only shallowly into the seed-bed. Such yields are not obtainable everywhere at Woburn because some land there is infested with potato cyst-nematode and *Verticillium dahliae*. The damaging interaction between the eelworm and fungus was clearly demonstrated on infested land which yielded less than 2 tons/acre without chemical treatment, nearly five when treated with a fungicide, more than six when treated with a nematicide and more than 14 when treated with methyl bromide, which is both a fungicide and nematicide.

In striking contrast to some of the large yields of potatoes, spring beans yielded pathetically little, many plots less than 10 cwt/acre, only a quarter of what we often achieve. The plants were stunted and yellow, their roots blackened by infection with fungi, and many wilted and died prematurely. Late sowing because of the wet spring and the later dry spell were partly responsible and irrigation almost doubled the yield. However, the main reason seemed an unusually damaging infestation by weevils, and where these were controlled by applying a carbamate (aldicarb) to the soil, yield exceeded 1 ton/acre. The weevils not only did much direct damage by destroying the root-nodules but also indirectly caused much further loss by spreading broad bean stain virus. Infection with this virus, which was first reported in broad beans in England only 5 years ago and was first noted in field beans on our farm in 1969, can halve the yield of plants, and more than 60% of plants in some of our crops were infected. It clearly represents a considerable threat to the bean crop and, as the virus is transmitted through a proportion of the seed set by infected plants, the first step in attempting to control it must be to ensure crops grown for seed are free from it.

Pests of pastures. Till now the pests that attack grass have received little attention, but with increasing use of fertilisers on pastures and leys it becomes increasingly important to know to what extent their productivity is being impaired by pests. The results of applying various pesticides suggest it can be considerable. Thus, the yield of an old pasture at Rothamsted started to increase within a few months of applying a mixture of pesticides, and after a year had increased by nearly a third. Similarly, newly-sown ryegrass at the Grassland Research Institute treated in 1969 yielded in 1970 a quarter more than untreated grass. The pests responsible have yet to be identified, but the yield of the old pasture was increased most by pesticides that mainly killed animals in the soil, and of the ley by those that killed animals living mainly in the foliage.

Synthetic pyrethroids. Two of our synthetic pyrethroids were marketed under the names resmethrin and bioresmethrin. Both are 5-benzyl-3-furylmethyl chrysanthemates, and although they are much more active against some insect species than the mixture of esters in natural pyrethrins, they have the slight disadvantage of acting more slowly and of not having their activity enhanced by compounds that enhance the activity of natural pyrethrins. A newly synthesised compound seems free from these disadvantages. Although

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less toxic to houseflies than resmethrin or bioresmethrin, it is more active than the natural pyrethrins, can be synergised to give the same activity as the resmethrins and has a quick action comparable to the natural pyrethrins. It is even less toxic than the natural pyrethrins to mammals. Other newly synthesised compounds also promise to be more selective in their action, that is, to be more active against some insect species than others.

Semi-dwarf wheat. The short varieties of wheat derived from the Japanese variety Norin 10, usually called semi-dwarf, have proved valuable in various parts of the world because, with their short, stiff straw, they do not lodge when given N-fertiliser or irrigated, and they greatly outyield the older local varieties when grown with modern methods of husbandry. We started studying them in 1967 because reports suggested that they differed from taller European varieties in several ways that were interesting physiologically. However, work with several spring varieties from Mexico, one from Australia, and Gaines winter wheat, shows that in many respects they resemble our taller European varieties. The short varieties yield as well but no more than the European ones and respond similarly to nitrogen fertiliser. Their grain yields are affected negligibly by large changes in sowing rate, as is usual with European varieties. Plots of short and tall varieties with similar leaf areas at and after flowering give similar grain yields, i.e. their leaves are equally efficient in producing grain. With similar plant populations, short and tall spring varieties produce similar numbers of ears but Gaines has more than Cappelle-Desprez. In crops with similar numbers of ears per unit area, ears of the short varieties have as many grains as the tall ones or fewer, not more as is sometimes claimed. Some lines derived from Norin 10, bred at the Plant Breeding Institute, Cambridge, had root systems as large as those of tall varieties.

The short and tall varieties differ consistently in two characters: the short varieties have a greater proportion of the final yield of dry matter as grain, and they have a larger ratio of ear to stem dry weight when the ears emerge, before the grains start to grow. These characters may be useful for breeding new varieties with large grain yield but less straw than those currently grown, provided such varieties are not as susceptible to fungal leaf diseases as many of the short varieties are in this country.

Work in controlled environments. The main purpose of the controlled environment rooms is to study how climate and weather affect crop growth and yield, and this requires spaces large enough to accommodate many plants in experiments that may continue from sowing to harvest. The smaller growth cabinets are suitable for shorter experiments, involving fewer and smaller plants, and on specific aspects of growth.

With the C.E. Rooms, the effects of environmental factors that are closely correlated in natural climates, for example, temperature and solar radiation, can be distinguished. Thus, although the grain yield of wheat increases with increase in radiation during the period while the grains are growing, because the green parts photosynthesise more, it decreases with increase in temperature within the possible range outdoors during the same period, because the leaves die sooner and produce less photosynthate, although a greater proportion of this reaches the grains. So, fine summers improve wheat yields because the weather is sunny rather than because it is warm.

The C.E. rooms can also measure effects of change in weather at different times during the growing season. For example, doubling the light intensity or increasing the temperature by 5°C for periods of two weeks before wheat flowers, increases growth but, in contrast to treatment while grains are growing, does not affect grain yields. Similarly, differences in temperature during the period between 4 and 12 weeks after sowing sugar

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beet has more effect on final yield of sugar than similar differences at earlier or later growth stages.

Soil structure and fertility. The year was punctuated by some alarmist statements about postulated ill effects of modern agricultural practices on soil fertility. The occasion was an inquiry into soil structure and fertility made by the Agricultural Advisory Council at the request of the Rt. Hon. Cledwyn Hughes, M.P., then Minister of Agriculture, Fisheries and Food. In the event, the Report of the Council, *Modern Farming and the Soil*, was anything but alarmist, and it is difficult to see how it could have been when the tables of average yields in the Report show increases during recent years rather than decreases, except for cereals in 1968. Indeed, although the Chairman of the Council writes, 'we embarked upon the Inquiry with no preconceived notions, neither were we induced to panic by the bad season 1968–69', it is difficult to escape the conclusion that a main reason for requesting the inquiry was the poor crops during that season. Also if the notions in the Report about the importance of organic matter, soil structure and drainage, were conceived during the inquiry, they matured rapidly, for they dominate the Report almost to the exclusion of other factors that affect soil fertility and crop yields.

In 1968 our cereal yields, both on the heavy land at Rothamsted and the light land at Woburn, were also small, on average more than a quarter less than in 1967, but this was neither because our fields need draining, nor that the soil organic matter had become dangerously little from repeated arable cropping. No—it was a direct reflection of the weather in 1968, when there was much less sunshine and more rain than average, and the cereals were severely mildewed, attacked by take-all and extensively lodged. The same modern methods applied to our fields in 1969 as in 1968 gave us cereal yields exceeding the previous records obtained in 1967. This year, as already noted, yields were less than in 1969, again because of less favourable weather. Many advances have been made in farming, and many of the hazards in growing crops diminished, but results are still greatly at the mercy of the weather. Lack of rain can be compensated for by irrigation, but there is no way to compensate for lack of sunshine; also, too much rain, at any time from before sowing to harvest, can set intractable problems. A modern development that may make these problems more frequent is the spread of cereal growing from the drier to wetter parts of the country. However, there is nothing new in the problems. It has always been possible to do harm by cultivating soil, or by moving over it, when it is too wet, and it always will be. Indeed, risks should be fewer than they were, because with modern machines larger areas than previously can now be cultivated, planted or harvested, during periods when the soil is fit, and more than one operation is possible with one passage of a tractor.

Official figures suggest that the increase in average yields of cereals characteristic of the last 20 years is slowing or has perhaps stopped. This increase has largely reflected the increased use of nitrogen fertilisers, although, as we show this year, perhaps a fifth of the increased barley yields may have come from the enrichment of the soil in phosphate from repeated fertiliser dressings. As our survey of fertiliser practice shows, most cereals now get as much nitrogen as they can use, so further increases in yield must come from other practices than giving more nitrogen. That there is still much scope for increase is evident, because official figures for average wheat yields are less than a half as much as we often get in experiments. Often, of course, crop yields are small for readily identifiable reasons, such as attack by known damaging pests or diseases, weed infestation, waterlogged soil or late sowing. However, it is not unusual for us to record differences of 1 ton/acre of wheat in experiments for which we have no satisfactory explanation. Similarly, a few years back we had no explanation for the poor growth of sugar beet (Docking

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disorder) some years in some fields, though bad soil structure and lack of organic matter were widely assumed to be responsible. With the main cause identified as attack on the seedlings by free-living nematodes, not only are the reasons now understood for the disorder being more severe in some fields and some seasons than in others, but also it can be prevented. Although the reasons for these differences in yields of wheat are obscure, it seems improbable that direct effects of soil structure on crop growth are of main importance, and we do know that fumigating some soils can lead to yields unobtainable otherwise. Hence it is reasonable to suspect undisclosed pathogens. We report this year a wide range of fungi, *Pythia*, *Olpidia*, *Polymyxa* and others, occurring in wheat roots; whether they play any important role has yet to be determined, but they were very common and, what may be significant, different ones were prevalent in crops in different places.

Modern Farming and the Soil is rather depressing reading for research workers, because the authors seem more impressed by hearsay than by the results of controlled experiments. Thus, they seem willing to attribute poor yields to bad soil structure without ever applying any of the tests for stability that have been developed, and they give no evidence for their assumption that organic matter is so important that soils with less than a critical, and determinable, minimum will disintegrate. Also, their plea for much more research on the effects of leys seems odd to us when, after 30 years of intensive work on our ley–arable experiments, we are stopping them. Both on the light land at Woburn and the heavy land at Rothamsted, these experiments show that yields of arable crops can be as good in an all-arable six-course rotation as in a 6-year rotation that includes 3 years of ley, provided the arable rotation is such that soil-borne pests and diseases do not become damaging and enough nutrients are given to make good what are removed in the crops. The benefits to arable crops from giving soil a period under grass lie in preventing losses from soil-borne pathogens of the arable crops and, with grazed leys, in accumulating nutrients, especially nitrogen; both of these benefits can be derived in other ways. After cut leys, the yield of arable crops may be small unless they are given enough phosphorus and potassium to compensate for the large amounts removed by cutting. Effects on soil organic matter also are brief, roughly lasting for a period equal to the one under ley. It cannot even be safely assumed that ley-farming will increase the soil organic matter. On Fosters field, long arable before the experiments began, the leys have increased the soil organic matter, but on Highfield, long pasture before the experiments began, the organic matter has steadily diminished, both with the continuous arable cropping and with the ley–arable rotations.

Soil fertility depends on many components, and is not indicated by any single measurement such as content of organic matter. Indeed, how could it be, when one soil may give good yields of one crop and miserable ones of another? This can be because the nutritional requirements of crops differ: for example, this year on Broadbalk, when yields of wheat after fallow ranged on different plots from 24 to 50 cwt/acre, potato yields ranged from 3 to 19 tons/acre, and the smallest yield of potatoes was not, as it always is of wheat, on the unmanured plot but on a plot that yielded 30 cwt/acre of wheat. However, differences in yield of this size in field crops can now rarely be explained by lack of major nutrients, for the specific nutritional requirements of different crops are recognised and met by fertilisers that contain the major nutrients in proportions needed by the crop to be grown. Where one crop does well and another not, the cause will more probably be found to lie in some other soil factor or in a pathogen that harms one crop but not the other. It perhaps needs stressing that soil type is not only important in affecting the supply of plant nutrients, the water-holding capacity, aeration and other physical and chemical features that directly affect the growth of plants, but equally so for the way it affects the ability of soil-borne pathogens to multiply, survive and move.

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