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Report for 1956

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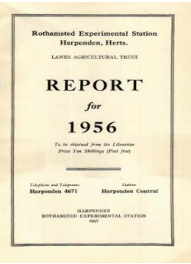
Rothamsted Experimental Station
Harpenden, Herts.
LAWES AGRICULTURAL TRUST
REPORT
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1956

Introduction

Sir William G. Ogg

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INTRODUCTION

BY THE DIRECTOR

We record with regret the death of a granddaughter of Sir John Bennet Lawes, Mrs. Donald MacAlister, née Everilda Creyke, who took a keen interest in the work of Rothamsted; also the death of Mr. F. K. Hawkins, a member of the staff for thirty-one years.

Dr. H. H. Mann, who has been deputy director at Woburn since 1928, retired at the end of the year and Mr. C. A. Thorold, until recently Principal Research Officer at Moor Plantation, Ibadan, Nigeria, succeeds him in January 1957, as Officer in Charge. Dr. F. Tattersfield, who has continued his research work in the Insecticides Department since retiring from the headship in 1947, retired in September, and Mr. B. Weston, Field Superintendent, retired in December after forty-six years' service. All three have given outstanding service to the Station. Dr. G. W. Cooke was appointed head of the Chemistry Department in March in place of Dr. R. K. Schofield, who has been appointed Reader in Soil Science at Oxford University.

Mr. M. J. R. Healy was awarded a Rockefeller grant to visit research institutes in the U.S.A. and Canada. Dr. I. Stephen accepted a temporary part-time appointment at the University of Illinois, and Miss S. G. Heintze has leave of absence for a year to work at Rukuhia Soil Research Station, Hamilton, New Zealand. Dr. P. W. Arnold and Dr. C. G. Johnson have been seconded to the West African Cocoa Research Institute, Tafo, Ghana, and Mr. B. M. Church to the Food and Agriculture Organization of the United Nations to work in Ethiopia, mainly on the setting up of agricultural surveys. Dr. D. W. Fenwick spent three months in Trinidad investigating Red Ring disease of coconuts, and Dr. F. T. Last has been seconded to the Research Department of the Sudan Department of Agriculture to study blackarm disease of cotton. Dr. D. A. Osmond visited Malta in connection with a soil survey of the island, and Mr. R. S. Seale and Mr. A. J. Thomasson have been seconded to Hunting Aerosurveys for six months for soil-survey work in Iraq.

Sir William Ogg visited potash mines in France and Germany and some of the centres at which research on potash fertilizers is being carried out. Dr. H. G. Thornton visited the U.S.S.R. with a delegation from the Royal Society, and Dr. F. Yates spent two months in India on a Technical Assistance Mission of the United Nations. Dr. H. Greene paid visits to British Guiana, Trinidad, British Honduras and Jamaica, and later in the year he went to Australia to attend the Symposium on Arid Zone Climatology organized by UNESCO, visiting North Borneo, Sarawak and Aden on his return journey. Mr. D. H. Boalch attended a meeting in Munich of the Executive Committee of the International Association of Agricultural Librarians, and Mr. F. G. W. Jones a meeting at Münster to discuss the formation of a European Nematology Society. Dr. Mary Glynne accepted invitations from the Departments of

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Agriculture for Eire and Northern Ireland to survey cereal crops for eyespot disease, and Mr. F. C. Bawden lectured at University College, Dublin.

Dr. H. F. Barnes, Dr. Marion Watson and Mr. M. J. Way attended the 10th International Entomological Congress in Montreal, and Dr. J. L. Monteith accepted an invitation from UNESCO to a Conference on Agricultural Meteorology in Australia. Mr. N. W. Pirie took part in a Conference on Chromosomes at Wageningen and a Symposium on Modern Ideas on Spontaneous Generation arranged by the New York Academy of Sciences. Several members of the staff attended meetings of the International Institute for Sugar Beet Research in the Netherlands, Belgium and France, and there was a large delegation from Rothamsted to the 6th International Congress of Soil Science in Paris.

Visitors

Visitors from abroad included Dr. Sonnemann, Staatsekretar, West German Ministry of Agriculture, Forestry and Food; Mr. Jamil Mualla, Director of Agriculture, Syria; H.E. Sayed Mirghani Hamza, Sudan Minister of Agriculture, Irrigation and Hydro-Electric Power, and Mr. Wadie Habashi, Director of Agriculture in the Sudan; Mr. Derwish El Haidari, Director General, Agricultural Division, Iraq Development Board; Dr. M. M. Hafez, Controller General of National Research Council, Egypt; Chief Akin Deko, Minister of Agriculture and Natural Resources, Western Region of Nigeria; Mr. Milan D. Smith, Executive Assistant to the Secretary for Agriculture of the U.S.A.; Dr. J. G. Harrar, Director for Agriculture of the Rockefeller Foundation; Professor G. Torstensson of the University of Uppsala and Professor O. Pohjakallio of the University of Helsinki. Amongst visitors from the U.S.S.R. were members of an agricultural delegation invited by Her Majesty's Government; Professor I. V. Tiurin, Director of the Dokuchaev Soil Institute, Moscow; Dr. A. V. Sokolov of the same institute; Professor V. A. Kovda of Moscow University and the Soil Science Institute of the Academy of Sciences; Professor Sukhorukov of the Botanic Gardens, Moscow, and Professor V. E. Shubin of Stalingrad University. Many parties visited the Station, including the International Union of Forest Research Organizations, the Biochemical Society and delegates to the 4th Congress of the International Potash Institute.

Buildings and Land

The work of certain departments has been seriously handicapped by unexpected delays in provision of additional glasshouses and laboratories.

Baldwin's Paddock and Lodge, comprising 6 acres near Hatching Green, were purchased during the year, together with 3 acres of woodland and 16 acres of agricultural land adjoining Redbourn Lane.

The Work of the Station

The work on soil structure and soil conditioners has been continued in the **Physics** Department, and a laboratory permeability

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test which gives a quantitative measure of soil structure has been improved and simplified. In a field experiment the effect of a ley in improving structure has been shown in better germination of beet and increased yields of carrots. Further studies have been made of the surface physics of clays, particularly on quantitative measurement of electric charges on kaolin crystals.

On the meteorological side, the recording of the environment (microclimate) in potatoes and wheat is proving valuable in the study of diseases and pests of these crops. Data on condensation and evaporation of moisture are particularly useful, and a special anemometer has been designed and built to give a continuous record of low wind speeds within the foliage of the crops. In the irrigation experiment at Woburn, water applied during the early summer drought gave increases in yield in the first two cuts of grass; on the barley there was a marked response in the early stages of growth, but wet weather followed, and there was only a moderate increase in yield of grain.

The current programme in the **Chemistry** Department on fertilizer placement is now being concluded. The experiments over the last few years on potatoes have demonstrated considerable benefits from placement of both ammonium sulphate and potassium sulphate close to the seed when the crop was planted from the flat by machine. The gains were greater with light than with heavy dressings, emphasizing that if the amounts of fertilizers are restricted for any reason, care should be taken to apply them properly. On barley, muriate of potash combine-drilled consistently gave higher yields than twice the quantity broadcast. In a three-year series of experiments on spring-sown cereals, combine-drilling ammonium sulphate gave at most centres larger yields than broadcasting, the average gain being nearly 2 cwt. grain/acre. Other experiments indicate that the top-dressing of spring barley with nitrogen in May should not generally be recommended, as in wet years it may cause serious lodging, uneven quality of grain and poorer yields. These investigations, however, have been confined to a limited area of the Eastern Counties, and should be repeated over a wider range of soil and climatic conditions.

Different nitrogen fertilizers are being compared on a variety of crops. Preliminary results indicate little difference between ammonium sulphate and calcium nitrate for spring-sown cereals, and the same is true for kale and potatoes at light dressings, but at heavy rates ammonium sulphate was the better fertilizer for potatoes. An imported granular urea containing 43 per cent nitrogen seriously damaged both potatoes and kale, possibly due to the presence of biuret. This emphasizes the importance of testing new materials thoroughly in the field before they are put on the market. Losses of nitrate nitrogen by denitrification have been investigated, but these are not likely to be serious if the water content of the soil is less than 60–70 per cent of the water-holding capacity. An account of the accumulation of organic matter and fertilizer residues in the soils of the long-term experiments has been prepared, and progress has been made with the laboratory work on the nature of soil organic matter. In the investigations on the nutrition of forest-tree seedlings at Wareham, copper-deficiency diseases have been

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diagnosed on poplar and Sitka spruce seedlings, and both can be cured by copper sprays.

One of the main lines of work in the **Pedology** Department concerns the parent materials from which soils are derived, and a detailed investigation is being made of the weathering of igneous rocks in Shropshire and of the soil types found in these rocks. The study of the clay minerals of sediments has been extended to a wide range of clays and limestones, and in the Chiltern area evidence from sand mineralogy shows the complex nature of the drifts overlying the chalk. Microscopic examination of thin sections of soils has thrown light on the morphology of soils and on problems of soil classification. Various investigations are in progress on the physical chemistry of soil minerals. Calorimetric methods are giving important information on the formation of soil aggregates and on the location of exchangeable bases. Work is also continuing on iron oxides, on water absorption by clay minerals and on the fixation of potassium by soils. On the spectrochemical side, further work has been done on the trace elements in Lower Lias shales, the parent materials of some soils in Somerset on which the cattle disease known as " teart " occurs. Samples from South Wales are also being investigated. Progress has also been made in the study of the effect of water extracts of various leaves on the constituents of soil profiles.

A considerable part of the work of the **Soil Microbiology** Department deals with biological interactions in the soil that encourage or control the growth of micro-organisms. These micro-organisms, and particularly the population in the immediate neighbourhood of the roots, can influence the supply of plant nutrients and may also include disease organisms. A group of bacteria resistant to certain antibiotics (streptomycin and chloromycetin) has been found to be abundant in the root surroundings but rare in soil away from the roots. A study is also being made of a factor or factors in fresh soil that inhibit the germination of the spores of certain fungi. This inhibitory action is destroyed by heating soil, and is also prevented or reduced by the presence around the fungal spores of certain sugars and in some cases by plant roots. Progress has been made with the investigation on the decomposition of herbicides and insecticides in soil, and a detailed investigation begun on the process of root-hair infection by the nodule organism. There are great differences in the number of infected root hairs on different clover species. This work should throw light on the roles of host plant and bacteria in controlling the numbers of nodules.

Investigations in the **Botany** Department have shown that the higher grain yield of Proctor and Herta barleys compared with Plumage Archer is due not to higher net assimilation rate, leaf area or total production of dry matter but to movement of a larger fraction of the total product of photosynthesis into the grain. Another and more striking example which suggests that the efficiency of the photosynthetic mechanism cannot be much increased, if at all, by breeding and selection for the improvement of yield is provided by a comparison of wild and cultivated beets. Some wild beets were found to have net assimilation rates identical with that of Kleinwanzleben E, the highest yielding strain of sugar beet.

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In the weed studies it was reported last year that there were indications that the population of viable wild oat seeds decreased rapidly under temporary ley. Although this is true in the first year or two, further work has shown that the decrease is not maintained. This raises doubts about the efficacy of temporary leys for the eradication of wild oats, although they reduce the population. It has been found that low temperatures favour germination of wild oat seeds, but short exposure to warm conditions tends to break dormancy and to increase germination on return to low temperature. Other lines of work deal with trace elements, nutrient uptake by excised roots, the physiological effects of virus infection and the effect of time of application of nitrogenous fertilizers to barley.

The main work in the **Biochemistry** Department is, as before, an examination of the nature of various enzyme actions that seem relevant to biological problems. The enzyme from bracken that destroys vitamin B, and so plays a part in bracken poisoning, can be made in a stable form, and improved methods for following its action have been devised. Two substances generally classified as alkaloids have been made enzymically by purified enzyme preparations, and other enzymes have been used for fractionating and characterizing phosphorus compounds of varied origin. Some parts of the enzymic process by which some plant viruses lose their infectivity when stored in the laboratory have now been unravelled, thus providing a rational basis for making stable preparations and for beginning the attack on the mechanism by which infection takes place in susceptible hosts. The same problem is also being approached from the other side by studies on the relationship between the photosynthesis activity of plants and the readiness with which they become infected. With tobacco mosaic virus, at any rate, the whole virus particle is not essential for infectivity, but a low and evanescent level of infectivity is associated with fragments of it. This activity can be stabilized, but judgement is reserved on the claims that have been made elsewhere that infectivity can be created by combining initially non-infective fragments. Progress has been made in characterizing the potato-root eelworm hatching factor. More equipment for making leaf protein has been built or installed, and the production of about 100 lb. a week of stable, palatable solvent extracted protein should now be possible.

In the **Plant Pathology** Department further progress has been made in researches on the constitution and properties of viruses. Disrupting tobacco mosaic virus so as to separate the nucleic acid from protein suggests that infectivity may reside in the nucleic acid fraction and antigenic specificity in the protein. Methods for counting virus particles with the electron microscope were improved and used to study the fate of particles during the early stages of infection.

Spraying potato crops with persistent insecticides again decreased the incidence of virus diseases, especially leaf roll. Combined with roguing, this treatment produced vigorous seed stocks in England at a cost comparing favourably with the cost of buying new seed. Excising apical meristems from Arran Victory potatoes, a variety that is wholly infected with potato virus S, and culturing them first on agar, produced virus-free clones.

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Five viruses infecting leguminous plants were identified, some of which were widespread in old stands of lucerne and long-established clover. Five viruses were also found infecting cereals and grasses; one does not appear to have been reported previously, but the others resemble viruses described in other parts of the world. How prevalent and important they are has yet to be established, but their existence raises the question whether some of the benefits from ploughing old leys and reseeding result from replacing virus-infected clovers and grasses with virus-free plants.

A new method of growing healthy sugar beet seed crops which economizes labour and gives scope for mechanization was designed and shows promise. Sugar beet was sown under barley and the stecklings left in the ground to seed in the following year. Weeds were controlled by spraying, and the seed plants were bigger and matured earlier than transplanted stecklings.

Potato blight was unusually severe in 1956, and copper fungicides increased yields at Rothamsted by 2 tons/acre; killing the haulm with sulphuric acid did not affect the proportion of tubers that became infected. Cultures of *Oospora pustulans* obtained from potato stems caused skin-spot when inoculated to tubers. Although this fungus can be contracted from the soil, the incidence of infection also depends on the extent to which the seed tubers are infected. In addition to surviving in the well-known skin-spot lesions, the fungus can infect eyes and sprouts, and is often present there on tubers showing no lesions. Despite the wet summer and exceptionally difficult harvest, wheat yielded well in experiments designed to control eyespot and take-all; by early sowing on uninfested land yields up to 56 cwt./acre were obtained. The yield responses to changes in certain agricultural practices, such as rate and date of sowing and manuring, depend greatly on whether the land is infested with the fungi that cause eyespot and take-all.

In the **Nematology** Department special attention has been paid to bud and foliar nematodes (*Aphelenchoides*), species of which attack mushrooms, and a wide range of higher plants. A new species of eelworm, also non-cyst-forming, which attacks oil palm has been described, and the knowledge of the host ranges and morphology of several species of root-knot eelworms has been extended by means of glasshouse tests. Cyst-forming eelworms have also received attention, and population studies of several types of these are in progress. A survey of experimental sites at Rothamsted and Woburn has revealed that there is a general infestation of potato-root eelworm at Woburn which has affected the potato yields of some field trials. Work, in collaboration with the Biochemistry Department, on the nature of the hatching factor given out by potato roots, is continuing. The existence of types of potato-root eelworm capable of attacking eelworm-resistant potatoes bred by crossing with the wild type, *Solanum andigenum*, has been confirmed. These biotypes occur in widely scattered localities and complicate the breeding of resistant varieties. Work has begun on the factors affecting the hatching of eggs from cysts of beet eelworm, and the movement and activity of larvae in soil. This study is of importance in that it is concerned with the first phase of attack upon plant roots. Work is also in progress on the morphology of

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the cabbage-root eelworm and upon certain insect predators that feed on the cysts. A visiting Canadian worker has reviewed the taxonomy of a family of nematode parasites of insects and has studied species of nematode parasitic in fruit flies.

In the **Insecticides** Department the various factors which affect the toxicity of insecticides are being studied. It is influenced, for instance, by temperature, and the effect of changes of temperature on speed of action differs for the various insecticides. Further work has been done on the mechanism of action of the important group of organo-phosphorus insecticides. It is known that they affect choline esterase, and a comprehensive study is being made of this enzyme as it occurs in insects. There is evidence, however, particularly from experiments on the poisoning of insect eggs, that other processes may also be involved. A study is also being made of what happens to insecticides in the soil and how long they persist. It was shown that BHC (benzene hexachloride) does not appear to penetrate the soil beyond the depth to which it is mechanically incorporated, and that it disappears rapidly in summer but not in winter. The effect of plant-protection chemicals on beneficial insects has been further investigated and techniques devised for diagnosing cases of poisoning in bees and the nature of the poison. In collaboration with the National Agricultural Advisory Service the control of wheat-bulb fly is being studied and a search made for promising chemicals. Improvements have been made in biological methods of testing insecticides, and methods of application are being studied. Some work has been done on fungicides, and it has been shown that the systemic fungicide griseofulvin applied to the soil reduces club-root in cabbage, but applied to the foliage it has no effect.

In the **Entomology** Department new developments include regular surveys of Rothamsted and Woburn farms for pest insects. This will enable those carrying out experiments either to make proper allowance for insect attack if it affects yield or to adopt control measures at the earliest possible stage. Work has also been started on the influence of climatic factors on insects, both in the field, where effects of microclimate on growth are being studied, and in the laboratory, where particular attention is being given to the relations between fat metabolism and temperature. The work of trapping aphids and other insects with suction traps at different altitudes has now reached a stage where the results have considerable importance in explaining general problems of the periodicity of insect attacks, and the results may also be applicable to animals other than insects. New work on the wheat-bulb fly includes laboratory experiments on the reactions of larvae to plant exudates, which may help to explain how the larvae locate host plants and why certain plants are preferred to others. In a field experiment the rate of emergence and survival of the flies was studied in a natural population confined in a large cage. Much of the other work, though no less important, is a continuation of investigations started in previous years. Broadbalk was sampled for wheat-blossom midges for the thirtieth year in succession; the relationships of the midges causing seed losses in red clover, and therefore of potential economic importance, continue to be investigated. The importance of earthworms in marginal land and orchards is being studied, and work

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continues on the effect of ants and of predators on aphid populations. The rate of decay of leaves and the production of litter is being studied in Knott Wood, using leaves marked with radioactive tantalum.

The work of the **Bee** Department has largely followed the lines of previous years. Further studies have been made on the nature of "queen substance" and on its collection and distribution by members of a colony. It has been shown that, despite suggestions to the contrary, the "queen substance" which worker bees receive in regurgitated food from other workers is sufficient to inhibit development of their ovaries, in the absence of a queen. Research has also been done on the process known as "queen supersedure" by means of which a colony replaces its queen without swarming. It has been concluded that shortage of "queen substance" is the only immediate cause of this, and that other factors such as disease or injury of the queen, which may initiate this process, do so by reducing the queen's output of this substance. It has also been shown that small quantities of mammalian hormones, such as androsterone and testosterone, as well as extracts of queen wasps and queen ants, when given to worker honeybees, inhibit development of their ovaries under conditions in which they would otherwise develop. In connection with swarming, comparative studies have been made of the salivary glands of worker bees both in and out of the swarming season, and changes have been noted in the degree of activity of these glands at different times of the year. Observations on the transmission of food throughout a colony indicate that workers receive food from bees older than themselves and give it to bees younger than themselves.

On bee diseases a very important advance has been made in the study of European Foul Brood. *Streptococcus pluton*, an organism suspected of causing the disease, has been isolated in pure culture, and it has been found that this organism and *Bacillus eurydice* have both to be present in a larva to cause the disease. By feeding a very small amount of the ammonium compound, di-*n*-decyldimethylammonium bromide, in syrup the disease has been controlled in small-scale experiments, and large-scale trials are now being made of this simple and economical treatment. Further work has also been done on Nosema and acarine diseases.

In the **Statistics** Department, the electronic computer is now working to full capacity. The capabilities of the machine have been increased by the provision of a high-speed tape reader and a punched-card reader. Programmes are now available for the routine analysis of all the commoner types of experimental design, and the number of variates analysed during the year has risen to over 1,700. Construction of these and other programmes has been facilitated by use of an automatic programming routine.

The results of several long-term Rothamsted experiments have been analysed. These include the four-course rotation on organic manures and forms of phosphate, the Woburn ley–arable and the large series of sugar-beet experiments. Close collaboration with the National Agricultural Advisory Service has been maintained on the design of crop and animal experiments. There has also been collaboration with the Galton Laboratory, the Blood Group Refer-

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ence Laboratory, the Institute of Animal Genetics and the Animal Breeding Research Organization on genetical problems. Ten counties or part counties were surveyed in the survey of fertilizer practice during the year, and a nation-wide survey of cattle diseases has been continued in collaboration with Weybridge. A survey of mortality in pregnant ewes has been completed and is being written up. Research work on experimental design and methodology has been continued.

The **Field Experiments** Section and **Farm** staffs again dealt with over 3,000 experimental plots at Rothamsted and Woburn. A very difficult harvest for cereal plots was greatly helped by the combine harvester, and no plots were lost, although the grain came in with very high moisture contents. The liming programme for the correction of acidity on certain parts of the classical experiments is now complete, and Hoosfield, in particular, showed marked benefit on some of the very acid plots. In the mangold and sugar-beet experiment on Barnfield the dry weather conditions at time of sowing led to a spectacular difference in plant establishment and early growth between the dunged and fertilizer plots, especially those receiving sulphate of ammonia. This is probably attributable to differences in organic matter and acidity. The recent short-period experiments include an examination of the relative responses of sugar beet and potatoes to several levels of farmyard manure. Dung from the same source is used for both crops, which are situated alongside in the same field. Dung × fertilizer interactions are also measured, as are residuals in the following barley crop. In another short-term experiment in co-operation with the National Institute of Agricultural Botany and repeated at Woburn, the cropping capacity of autumn- and spring-sown beans is compared; three levels of phosphate and of potash in all combinations are tested, and also insecticides against aphids. An account is given of the wheat and fallow experiment started in 1856, and from this it appears that a three-year fallow is practically no better than a single year. A short historical summary is also given of the clover plot (in the garden of Rothamsted Manor), which has been cropped continuously with red clover since 1854.

At Woburn the classical plots are being cleaned by fallowing reinforced with TCA (sodium trichloroacetate), which appears to be a promising treatment against the twitch that is such a serious weed on these old plots. The potato test crop in the ley–arable rotation has been changed to sugar beet on account of potato-root eelworm, and one of the fields at Woburn has been assigned to eelworm research. The farm is being used to an increasing extent for short-term experiments, chiefly on the light soil, but now for certain crops, such as beans, on the clay land. The season was unfavourable for the most sensitive exotic crops, such as maize, which gave only about half the yield of previous years, but sweet lupins, serradella and a new German variety of Jerusalem artichoke did at least as well as usual. In the wet summer the irrigation experiment gave small responses to watering, but during the spring drought there were marked benefits to the barley and the May cutting of the cocksfoot ley.

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