ROTHAMSTED RESEARCH

Report for 1949

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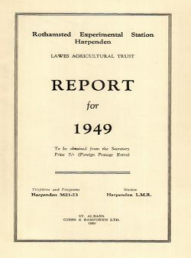

Introduction

Sir William G. Ogg

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INTRODUCTION

Staff

A few members of the staff left during the year but several of the vacancies have been filled and a few new appointments made. Dr. F. M. L. Sheffield, cytologist in the Plant Pathology Department, who had been seconded to Zanzibar for fifteen months for work on " Sudden Death " in cloves, has accepted a permanent appointment in the East African Agriculture and Forestry Research Organization. Dr. F. M. Roberts has also gone to Zanzibar recently to work for a year on the same problem. Dr. Herbert Greene has been appointed to the new post of Adviser on Tropical and Sub-tropical soils which is being financed mainly by the Colonial Office. Dr. Greene was formerly Chief Chemist and Assistant Chief of the Research Division of the Department of Agriculture and Forests, Sudan. Since 1945 he was on the staff of F.A.O.

Mr. F. C. Bawden and Mr. N. W. Pirie were elected Fellows of the Royal Society.

The Station was represented at the following conferences : United Nations Conference on the Conservation and Utilization of Resources (U.S.A.), International Conference on Bacteriology (Belgium), International Congress on Beekeeping (Holland), Congress of French Beekeeping Associations, Meeting of the Electron Microscope Society (Holland), British Commonwealth Scientific Conference on Plant and Animal Nutrition in Relation to Soil and Climatic Factors (Australia), Fifth International Congress on Comparative Pathology (Turkey), Meetings of the Biometric Society and International Statistical Institute (Switzerland), Conference on Phosphorus and its role in Biology (France), and a Conference of the International Superphosphate Manufacturers Association (Denmark).

Dr. Muir spent several months in the United States and Canada studying soil survey methods, and the Director, in addition to attending the United Nations Conference, visited a number of research institutions in the United States and Canada.

Dr. D. M. C. MacEwan gave a course of lectures in Spain at the invitation of the Spanish Soil Institute.

During the year there were 13 long-term and 25 short-term temporary workers at the Station. Even more applications than usual had to be refused because of lack of accommodation. This is to be regretted for many of those for whom no room can be found go to other countries for their post-graduate training and, apart from that, our own workers lose a certain amount of benefit.

Visitors

The number of visitors to the Station continues to increase. The overseas visitors included the Under-Secretaries for Agriculture of the United States and Persia, a Canadian mission of agricultural scientists and administrators, the Lambert Mission on the way to Africa, and several parties of Canadian and American farmers.

Facilities were provided for various conferences, including a meeting of the Biometric Society and a meeting under the auspices of the Colloid and Biophysics Committee of the Faraday Society. Visits were paid by the Second International Congress on Crop

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Protection, the Fertiliser Society, a group from the Council of the Royal Agricultural Society, and the Guild of Agricultural Journalists.

The Work of the Station

The work of the Pedology Department is concerned with the way in which rocks weather to form soils and the nature of the processes and products involved. The study of rock weathering in the Malvern Hills area has provided valuable information on changes undergone by rock minerals and some new types of clay minerals have been discovered.

An important clay mineral (montmorillonite) which occurs in soils and which has also considerable industrial use has been studied in detail. By X-ray methods its structure and the way in which the plant nutrients, such as potassium, are held on it have been determined.

Other lines of work include a study of water-logged soils, particularly in relation to the iron compounds and it has been shown that the processes are to some extent due to micro-organisms. An investigation of the distribution of the trace element molybdenum in soils has been commenced.

The Chemistry Department is engaged mainly on problems of soil fertility. Fertilizers have been in use for over a century but there are still many unsolved problems connected with their use. We know relatively little about their fate in the soil and how they are taken up and used by the plant. For experimental purposes fertilizers can now be made radio-active and their movements followed. Preliminary work with radio-phosphorus as an indicator showed that the phosphate held on the surface of some preparations of calcium phosphate was much more active than that within the crystals. Attempts are being made to control the rate of action of nitrogen and phosphate fertilizers to suit different needs. Phosphate fertilizers are being tested in pellets and also dispersed through bulky organic manures in attempts to keep them available to plants whilst protecting them from too rapid inactivation by the soil. About 80 per cent. of the phosphate applied as soluble fertilizer is not recovered in crops in the first few years but a little of the phosphate in fertilizers and farmyard manure may remain available for long periods. This is well illustrated on Hoos field at Rothamsted where plots which have received no farmyard manure or fertilizer except nitrogen since 1901 sometimes show the effects of phosphate applied annually for many years previous to that date. The dry spring of 1949 accentuated the differences in the barley crop—the farmyard manure plots and the superphosphate plots standing out very clearly during the month of May. At that time the crops on the better plots contained only two or three pounds of phosphoric acid per acre but those on the most exhausted plots had less than 0·5 lb. of phosphoric acid per acre.

Particularly for horticultural crops there is need for a slow-acting nitrogenous fertilizer to supplement the inadequate supplies of organic manures such as hoof and horn. Various new materials, including urea-formaldehyde products, are being tried. Although some of the results are promising, none of the materials has yet reached the stage for commercial production.

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Fertilizer placement experiments have been continued and it has been found that heavy dressings of fertilizer placed an inch to the side of the seed damaged germination of sugar beet, mangolds and peas, but bands at 3 inches from the seed were safe. There was, however, no advantage from placed over broadcast fertilizer for sugar beet but a marked improvement for peas.

In work on the chemical nature of soil organic matter it has been shown that at least a third of the nitrogen is present as protein. The kinds and approximate amounts of amino-acids in different kinds of soil have been determined.

Field experiments in relation to soil analyses were continued and amongst other things it was found that peas receiving broadcast fertilizers responded to potassium only on soils deficient in readily soluble potassium and gave neglible responses to nitrogen and phosphorus.

Fertilizer experiments have been in progress for some time on rubber in Malaya and oil palm in Nigeria and the Belgian Congo. Recent measurements showed marked increases in tree girth and yield of latex from rubber trees manured experimentally from 1934 to 1939. The oil palm gave only small responses to fertilizers but there were slow progressive improvements from potassium fertilizer in most of the experiments and some benefit from nitrogen. Response to phosphate fertilizer occurred only on a single kind of soil at one estate.

The results over five years in investigations on nutrition problems in forest nurseries are summarized in a separate report. There were striking benefits from fertilizers on very acid soils and from so-called "partial sterilization" by steam or formalin, especially in old nurseries. The latter problem is being examined jointly with the Microbiology Department.

Soil reaction measurements at intervals from 1934 to 1947 in a chalking experiment at Tunstall in Suffolk showed that good yields of sugar beet were maintained as long as the pH of the soil was above 5·5, but it is generally advisable to keep well above that figure for sugar beet. In the same experiment, a war-time change of nitrogenous manure from sodium nitrate to ammonium sulphate without application of lime, soon led to a disastrous increase in acidity and loss of yield.

Work was continued on the forms in which manganese and other trace elements are held in soils. In a pot experiment on a fen soil low in available manganese addition of small amounts of molybdate led to the occurrence of " Marsh Spot " in peas.

Theoretical and experimental work by the Physics Department has shown that there is an upper limit to the amount of water that can be transpired by green vegetation. This amount depends only on the weather ; hence it is possible to estimate from simple weather data just how much irrigation is required. Field experiments on sugar beet in Surrey and Suffolk have strikingly demonstrated the accuracy of these estimates. Large increases in yield were obtained by employing the calculated amount of irrigation, but no further increase was obtained by doubling the amount.

The same principle has been applied in a detailed study of the water resources of the catchment area of the Suffolk Stour. Since the evaporation from this area can now be accurately estimated,

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and the rainfall and river discharge are on record, it has proved possible to calculate the month to month change in ground-water storage. This kind of information is of great value to authorities responsible for water supplies.

In the six-course experiment at Rothamsted on deep and shallow ploughing, wheat and potatoes again yielded slightly better on the deep-ploughed plots and sugar beet again benefitted from deep incorporation of phosphate. It is still not clear why these effects are more consistent at Rothamsted than at other centres where similar experiments were carried out.

A study is being made of the physical processes which occur in the swelling and shrinking of clay ; this and other work will be helped by a recent improvement in our method for measuring the volume of solids, water and air as it exists in the field.

Apparatus specially designed in the Physics Department has enabled the Botany Department to study the germination of seeds in a series of constant temperature chambers in each of which the humidity is accurately controlled at a chosen level close to saturation. Under these conditions the seeds behave with remarkable consistency. One outcome of this work should be exact information about the soil moisture and temperature desirable in a seed bed.

The chemical tests applied to soil in advisory work are not wholly satisfactory, and a new approach is being made by physico-chemical methods to get a better measurement of what plant roots can take from the soil.

In the Soil Microbiology Department further work has been done on methods for estimating the numbers of micro-organisms in soil and a survey of the main groups of microbes in plots, manured with organic and inorganic manures, on Broadbalk field has been continued.

In the course of work on nitrification a pure culture was obtained of *Nitrosomonas*, an organism that produces nitrite from ammonia. Progress has also been made in the study of soil amoebæ and with mycorrhiza on crop plants. The antagonistic behaviour of certain soil micro-organisms towards the root disease fungus *Fusarium* has also been studied and it is intended to expand this study of microbial antagonism in soil.

The work on nodule bacteria and leguminous plants has been continued. This includes a survey of the areas where types of clover nodule organisms that are ineffective in fixing nitrogen are prevalent in the soil and attempts are being made to introduce effective strains. It has also been found that in certain soils effective strains of nodule bacteria tend to become ineffective. In most cases this is related to soil acidity and can be checked by liming. The problem of ineffective nodules has been found to be further complicated by the discovery that their formation can be induced not only by the strain of bacteria but also by hereditary factors in the clover plant.

The work of the Botany Department is mainly concerned with the physiology of plant growth in relation to the yield of agricultural crops. One aspect of this is the investigation of the effects of plant nutrients required in very small amounts—the so-called trace elements. The interrelation of one of these, molybdenum, with nitrogen nutrition has been studied in lettuce and red clover.

Another investigation dealt with factors affecting the rate of

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uptake of nitrogen, phosphorus and potassium by roots. Work was also commenced on the uptake of mineral nutrients from solutions sprayed on the leaves of plants and it was found that appreciable amounts of nitrogen, phosphorus and potassium can be taken up in this way, but the investigation has not proceeded far enough to show how this affects subsequent growth.

In collaboration with the Physics Department, experiments have been made to define precisely the conditions of moisture supply in which germination can take place, and to study the relation between water-uptake and moisture potential.

In view of the increasing prevalence of wild oats as a weed on arable land, the biology of the two species common at Rothamsted is being investigated. In a field experiment on potatoes there was evidence that wild oat seeds had survived in the dung in a viable state or that the dung had broken the dormancy of seeds already present in the soil. These possibilities are being tested in the laboratory.

Another line work deals with the physiological effects of infection with leaf-roll virus on the potato crop. One purpose is to determine whether the intensity of the leaf symptoms depends on the conditions of growth. It was found that increased nitrogen supply and reduced light intensity both tended to mask leaf-rolling and yellowing symptoms but did not completely suppress them. The chief object of the experiment was to investigate the changes in growth due to virus infection that are responsible for the reduction in yield.

The studies on the effects of manuring on the grass and clover species in permanent pasture cut for hay were continued and also the routine observations on the weeds in the Classical fields.

The scope of the Plant Pathology Department covers both basic studies on plant viruses and fungi, and work on specific plant diseases, mainly those affecting arable crops. Improvements to the electron microscope have made it possible to determine the sizes and shapes of virus particles in the sap of infected plants, and with an improved technique the electron microscope has been used in collaboration with other departments in the study of insect cuticle and clay minerals. The transmission of viruses by aphids is being studied by using plants containing radio-active phosphorus. Work on extraction and purification of viruses continues in close association with the Biochemistry Department, and an undescribed virus on broad bean with unusual properties has been isolated. Potato tubers infected with leaf roll virus have been cured by heat treatment, and field experiments confirm the impracticability of controlling leaf roll by roguing potato crops in the South-east of England. Work on virus and fungus diseases of sugar beet continues at Rothamsted and at the field laboratory at Dunholme, Lincoln, where the desirability of raising stecklings in isolation in the North and East for sugar beet seed production, was demonstrated ; spraying with systemic insecticides or planting under a cover crop was also found to be beneficial. Laboratory studies on the survival of resting spores of the club root fungus in the soil have continued and field experiments have shown that eyespot of wheat is reduced by spraying with sulphuric acid and a spring application of nitrogenous fertilizers. A small wind tunnel has been built to study the dispersal of airborne plant disease organisms.

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In the Biochemistry Department several years' work on leaf components has been completed, and a study made of the rôle of manganese in plant respiration and of the extraction of manganese from organic soils.

The Nematology Department has developed a number of new techniques for the microscopic examination of eelworms in plants, *e.g.* for measuring the vertical migration of larvæ in the soil, and for determining the proportion of living cysts of potato eelworm (*Heterodera*) in the soil. The department has acquired apparatus for collecting large quantities of eelworms from plant tissues for use in inoculation experiments. Biological studies include a sorting out of the species and strains of eelworms causing plant infestations in potato tubers, oats, bulbous iris, strawberry, and black currant. An eelworm found in roots of Sitka spruce seedlings (*Hoplolaimus uniformis*) is new to Britain. Work on root infesting eelworms has included pot studies (using clay mixed with sand, peat, compost and fertilizers) on potato plants infested with root eelworms and on the effect of adding various nematocides. Tests with the substance known as D.D. have been made in the field against potato root eelworm and sugar beet eelworm, and the effects of humidity and of repeated annual applications of D.D. to the soil are being studied. The factors which cause eelworm cysts to hatch are being studied with a view to inducing them to hatch and die before a susceptible crop is planted.

The work of the Entomology Department continues to be focussed on insect ecology and migration and the fluctuation of insect populations. Systematic trapping over a period of years has demonstrated that, in general, insects are more abundant after wet weather in summer and warm weather in winter. From this a method of forecasting insect abundance has been developed. Other methods of sampling insect and plant populations to determine relative abundance have also been studied. Records of insect migration showed no great influx into this country during 1949. A comparison of the efficiency of aerial tow-nets and suction traps operated from balloons at the R.A.F. station at Cardington has led to an improved method of studying the drift of insects in the upper air. Another side of the department's work is connected with terrestial insects, and new surveys have been started on the fauna of forest soils. Changes in the wireworm population under a variety of ley rotations are being made in connection with the new ley and arable rotation experiment on the farm. In addition tests of chemical treatment for wireworm control are in progress with the Insecticides Department. Studies on the biology of slugs have been facilitated by a method of marking individuals, and a study has been made for over 200 successive nights of the changes in a population of the grey field slug. In addition to ecological studies, the department continues to serve as the centre for identification of gall midges, and Vol. 6 of Dr. Barnes' work on " Gall Midges of Economic Importance " has now been published.

The foraging behaviour of honey bees is one of the main interests of the Bee Department, providing as it does the basis for correct management of bees for pollination and honey. Recent investigations have been summarized in Dr. C. G. Butler's book on " The Sense Physiology and Behaviour of the Honey Bee." Experiment has

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shown that a bee leaving the hive without a preconceived idea will seek food in the crevices of any small coloured moving object. Prolonged observations on individually marked bees, offered a choice of experimental crops, showed that in subsequent foraging the individual bee is continually exercising both choice and memory. The technique of artificial insemination of queen bees has been developed further, and differences between colonies headed by different matings were well marked during the 1949 seasons. Other studies of bee-keeping included analysis of stores from autumn-fed syrup, the effect of winter weather on the humidity within the cluster, and work on the European foul-brood disease.

The Insecticides and Fungicides Department is concerned with the mode of action of toxic substances, and factors affecting the susceptibility of insects to toxic materials. Knowledge of these may lead to a rational choice of new toxic substances and to the more efficient use of existing insecticides and fungicides. This aim has been followed in work on the solubility of D.D.T. and rotenone in the wax layer of the insect cuticle. Studies have also been made on the susceptibility of insects at different stages in their life, on the development of resistant strains of insects and on the effect of systemic insecticides as contact and stomach poisons. Analytical work on established insecticides has continued, together with the testing of certain new materials as possible insecticides including some amides related to herculin, and synthetic materials related to pyrethrins. In response to the Colonial Insecticides Committee's request, experiments have been carried out on the persistence of D.D.T. sprayed on foliage. Analysis showed no loss of D.D.T. from films on cabbage leaves during the period of a month unless exposed to rain or short wave ultra violet light. The deposit might be attenuated, however, by expansion of the leaf. Field experiments have tested the effect of soil treatments against wireworm in the year of application and in the following season, and work has been done in collaboration with the Plant Pathology Department, on control of aphids transmitting potato viruses.

The Statistical Department has continued its work on the design and analysis of experiments and has given assistance to the other departments at Rothamsted and to many research workers in this country and the Colonies. Co-operation with the National Agricultural Advisory Service in the design and analysis of experiments has steadily increased, and is leading to more joint planning and co-ordination of experimental investigations. Assistance and advice is given both to the separate provinces, and to the Experimental Husbandry Committee of the Agricultural Improvement Council, which is responsible for the planning of experiments on the Ministry's experimental husbandry farms.

The principle sample surveys carried out during the year were the Survey of Maincrop Potatoes and the Survey of Marginal Land. The 1948 Survey of Maincrop Potatoes gave an overall yield estimate which exceeded the official estimate by 1·2 tons per acre. It was shown that late planting was associated with low yields. The Survey of Marginal Land is aimed at investigating the increase of production obtainable from this type of land and the expenditure necessary to obtain it. Other projects include a continuation of the

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Survey of Fertilizer Practice and the pilot Survey of Methods of Milk Production.

The computational facilities of the department have been increased by the installation of Hollerith equipment. With these machines the data are recorded on punched cards, which can then be sorted and tabulated mechancially. This equipment is particularly suitable for analysis of certain types of survey data, but its possibilities for the more complicated types af analysis encountered in experimental work are also being explored.

At Woburn Dr. Mann has continued his work on the growing of hybrid maize, soya beans, serradella and birdsfoot trefoil and encouraging results have been obtained. Other work includes investigations into clover sickness, weed competition and nutrition of crops under very acid conditions.

The large programme of field experimantal work on the farms at Rothamsted and Woburn is dealt with fully in this report. An elaborate new ley-arable experiment has been laid down to compare the productivity of various rotations based on different types and durations of leys. There are now over 2,000 experimental plots and as in the past very efficient co-operation has been obtained from the farm manager and his staff.

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