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Introduction

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INTRODUCTION

BY THE DIRECTOR

STAFF

Dr. E. M. Crowther and Mr. F. C. Bawden, F.R.S., have been appointed Deputy Directors of the Station responsible for the Soil and Plant Pathology Divisions respectively. There have been no major changes amongst the senior scientific staff, but a few of the junior members have left to take up posts elsewhere and several new appointments have been made. Mrs. M. J. Way resigned her position as Librarian and was succeeded by Mr. D. H. Boalch, M.A.(Cantab.), F.L.A. Dr. T. Goodey, F.R.S., was awarded the O.B.E. in the 1950 New Year's Honours.

The Director was elected a Foreign Member of the Royal Academy of Agriculture of Sweden.

Dr. A. H. McIntosh, of the Insecticides and Fungicides Department, has spent the year at the Connecticut Agricultural Experiment Station on an exchange basis with Mr. Neely Turner, the senior entomologist of that Station. Mr. M. J. Way has been seconded to Zanzibar for entomological work on Sudden Death of Cloves, and the secondment of Dr. F. M. Roberts on the same scheme has been extended. Mr. W. W. Emerson spent three months at the University of Madrid, assisting in the preparation of the English translation of Professor W. Kubiena's new book on the Systematics of European Soils and studying his micro-pedological technique.

Rothamsted was represented at the following conferences: the 4th International Congress of Soil Science, Amsterdam, the 7th International Botanical Congress, Stockholm, and the 5th International Congress of Microbiology, Rio de Janeiro. Dr. E. M. Crowther was Chairman of the Soil Fertility Section of the Soil Science Congress and Mr. F. C. Bawden was Vice-President of the Phytopathology Section of the Botanical Congress. He was also President (*in absentia*) of Section VII (Plant Pathogenic Microorganisms) of the Congress of Microbiology. The Brazilian Government generously provided the travelling expenses for a delegate from Rothamsted and Dr. P. H. Gregory was chosen to represent the Station.

Mr. F. C. Bawden gave a course of lectures on Plant Viruses and Virus Diseases for six weeks at Yale University; he also attended a conference on viruses at the California Institute of Technology, Pasadena, and visited other Universities and Research Stations in the United States and Canada. Dr. F. Yates attended the Fourth Session of the United Nations Sub-Commission on Statistical Sampling at Lake Success. Whilst in the United States he represented Rothamsted at the 75th Anniversary of the Connecticut Agricultural Experiment Station, the oldest agricultural experiment station in the United States, and one with which Rothamsted has for many years had close links.

The Director spent two months in Canada as leader of a United Kingdom Agricultural Mission. The Mission were guests of the Canadian Government and visited all the leading agricultural teaching and research centres throughout Canada.

VISITORS

Several thousand visitors from 30 countries came to the Station in 1950. These included many foreign or Dominion scientists who spent some time at Rothamsted in the course of their journey to or from the International Congresses held at Amsterdam and Stockholm. The visiting parties included the Parliamentary and Scientific Committee, and a Parliamentary delegation from Iceland. There were parties of farmers from Norway and the United States, and agricultural students from Norway, Denmark, Belgium, Eire and the United States. In July a visit was paid to Rothamsted by delegates of the Commonwealth Agricultural Bureaux Review Conference.

BUILDINGS

A new field laboratory was completed for the Bee Department, which relieved the congestion in that department. During the year a start was made with the conversion of the Manor House as a Hall of Residence, and the old Sample House near the main laboratory buildings is being fitted up as a library annexe and institutional store. Plans have been prepared and estimates obtained for a new building which will house part of the plant pathology group of departments. It is also hoped to provide a new building to house the Statistics department which has expanded considerably with the creation of the Statistical Research Service.

THE WORK OF THE STATION

A considerable amount of work has been done in the Pedology department during the year on the clay mineralogy of soils from a wide range of conditions. The interdependence of soil clays and soil parent material has been clearly brought out in the study of the Malvern Hill soils and also in a series of soils from Syria. An examination of the clays from soils of the groundnut areas in Tanganyika gave no clue as to the curious physical behaviour of the soils. In the study of waterlogged soils it has been shown that the reduction of iron oxides can be effected by sterile fermented grass extracts so that the process is not entirely microbiological.

Increases in the prices of fertilizers make their efficient and economical use more important than ever, and in particular restrictions in the supply of sulphur render it necessary to economize in the use of superphosphate, and to test other phosphatic fertilizers. For many years much of the work of the Chemistry department has been directed to these ends. In a series of experiments mostly on very acid soils, silico-phosphate proved to be just as effective as superphosphate for swedes and reseeded grass, but not so good for potatoes and cereals. In the fertilizer placement experiments it has been confirmed that placement is advantageous in the case of quickly growing crops with shallow roots, e.g., peas, beans and spinach, but not for deeply rooting crops with long growing seasons, e.g., sugar beet and carrots. The search for a slow-acting nitrogenous fertilizer has been continued and so far the most promising results have been obtained with formalized casein, a plastic waste product. Progress has been made with nutrition problems in forest nurseries, and the value of fertilizers, properly

used, has been established. Steam and formalin treatments gave striking results in certain cases and these are being investigated. Part of the effect is probably due to control of soil fungi and other organisms but there are indications that most of the benefit may arise from the maintenance of high ammonium concentration in the soil. The study of soil organic matter has been continued and in a range of contrasted soils it has been found that the protein materials were very similar in composition. The long-term residual benefit of farmyard manure on Hoosfield appears to be largely due to its inorganic constituents, since superphosphate had similar effects. The radio-active tracer technique has been used to study the behaviour of added phosphate in soil and it has been shown that in a Broadbalk plot which has received superphosphate annually for over a century about one-fifth of the total phosphorus was in a readily exchangeable form whilst it was negligible in a plot without superphosphate. Work on manganese deficiency has been continued. The state of oxidation of manganese in the plant depends on the production of hydrogen peroxide and in the Biochemistry department two enzymes, an amine oxidase and an aldehyde oxidase have been studied in this connection.

There can now be little doubt that the weather is the dominant factor determining the water requirements of all kinds of vegetation. Using the method worked out in the Physics department, the Agricultural Meteorological Branch of the Meteorological Office issued fortnightly estimates of the inches of water evaporated from green vegetation at stations throughout England and Wales during the summer of 1950. These estimates serve as a guide to irrigation, since if the inches of evaporation exceed the inches of rain the difference is the inches of irrigation that must be applied to replace the moisture drawn from the soil. As a further check, calculations have been made of the mean annual evaporation at one hundred stations in the British Isles, and the results have been compared with the excess of rainfall over river discharge in forty catchment areas. The agreement is very satisfactory. The results may also be used to estimate the surplus of rainfall over evaporation available for meeting the water needs of the country. A theoretical study of the processes of diffusion of water vapour through the stomata of the leaves of plants has further substantiated the validity of the principles underlying the calculations. The physico-chemical approach to the study of soil fertility is giving interesting results. It has been found that on shaking up a soil sample with water containing about as much calcium salt as is normally present in soil water, a very small but quite definite concentration of phosphate is established in a few minutes. This test applied to soil known to be deficient in phosphate gives concentrations so low that they can only be measured with the aid of special equipment, and for this reason solvents giving higher concentrations for analysis have been preferred in advisory work. The use of acid solvents appeared to be justified by the older view that acids are secreted from plant roots; but as there is no real foundation for this view the results obtained by the use of acid solvents may be misleading. Other substances beside phosphate—some desirable and others undesirable—are also present at very low concentrations in the soil solution, and techniques for studying them are being developed. If it can

be shown that the soil solution remains in physico-chemical equilibrium with the solid substances this will facilitate the interpretation of the results of laboratory tests.

One of the aims of soil microbiology is to learn how to change the microscopic population of soil in a useful direction. In the Soil Microbiology department in co-operation with the Chemistry department, the effects of treating soil, in the field, with steam and formalin have been studied. Striking changes in composition of the soil micro-population resulted from these treatments and have lasted in some cases for over a year from the time of soil treatment. An abundant group of soil microbes, the actinomycetes, include many species that secrete antibiotic substances of which streptomycin is an example. This suggests that such organisms might be used to control those that produce root diseases. For this to be possible it is clearly necessary that the actinomycetes to be used should grow actively in the soil and should produce an antibiotic that is active and lasting in it. Actinomycetes that produce secretions active in laboratory culture against a root disease fungus have been found and the conditions under which they will grow and produce active antibiotic secretions have been investigated. Since it is important to know how far the actinomycetes exist in the soil in an active state or as spores, a method for finding this out has been developed and is under test. Many plants have specific fungi associated with their roots (mycorrhiza) and in some cases there is evidence that the fungus benefits the plant. Such associations are found in crop plants such as clover and wheat but there has been no evidence as to whether the crop benefits from them. Experiments have been made in which clover was grown in sterilized sand supplied with a series of diluted suspensions of fresh soil. In some pots mycorrhizal associations were found to have developed and in others there were none, but no corresponding difference in growth of the clover was observed. The factors in the clover that influence the appearance of nodules on its roots have been further studied and there is evidence that nodule production and numbers are controlled by some substance secreted from the roots.

Work done in the Botany department during the year followed the same lines as described in 1949. The micro-nutrient investigations were on the interaction of molybdenum and manganese and no evidence has yet been found to support the claim made elsewhere that increased molybdenum supply mitigates the toxic effect of excess manganese. Further progress has been made in the studies of nutrient uptake by excised roots and by leaves. In the case of excised roots it has been shown that the rates of uptake of nitrate, phosphate and potassium all depend on the total soluble carbohydrate content of the roots but not specifically on sucrose or reducing-sugar content. The rate of uptake of each of these nutrients decreases with increase in the concentration of the same nutrient in the root. The uptake of appreciable amounts of nitrogen, phosphorus and potassium from nutrient solutions sprayed on leaves has been confirmed for cabbage, sugar beet, french beans and barley. Similar amounts of nitrogen were taken up from solutions containing ammonium or nitrate ions in equal concentrations. The growth and yield of sugar beet plants was increased by spraying the leaves with nutrient solutions. In a study of the manner in which germina-

tion of seeds depends on water supply, it has been found that in the first phase of water uptake the seed behaves as a physical system, the course of water uptake being similar in living and dead seeds. In living seeds there is a second phase associated with growth of the embryo. Fairly simple mathematical formulae have been found to express the variation of water content with time. In the investigations on wild oats it has been shown in laboratory tests that farmyard manure hastens the germination of dormant seeds, and this is being tested on a field scale. Further work has been done to find out how infection with leaf-roll virus affects the growth of the potato plant. Reduction in yield would appear to be due mainly to decreased assimilation by the leaves that are rolled, but leaf area is also smaller in infected plants.

In the Plant Pathology department studies on the nature of viruses were continued. Further work has been done on the proteins specific to virus-infected plants, and it has been shown that only part of them can bring about infection. Investigations have been made on a number of crops including potatoes, sugar beet, lettuce, cauliflower, cabbage, groundnuts and cacao. Techniques were devised for using radio-active phosphorus to study the feeding and movements of the aphids concerned in virus transmission. As a result of six years' experiments it was concluded that roguing potato crops in south-east England did not reduce virus diseases sufficiently for the practice to be worth while, but preliminary experiments in co-operation with the Insecticides department indicate, that spraying with "systemic" insecticides reduces the spread of leaf-roll. There has been a great increase in sugar beet yellows since the production of sugar beet seed was started in this country during the war. Control measures on steckling beds have been developed and a health certification scheme introduced in 1950 when more than half the stecklings for the seed crop of the country were raised in isolation, under cover crops or sprayed. The mycological work was mainly on cereal diseases and a new disease of oats was discovered, caused by the same fungus (*Corticium solani*) as that causing sharp eyespot of wheat. Work on clubroot was continued and experiments on potato blight and cereal mildews started. A study has been made of the new disease attacking sycamore trees in the East of London and the fungus which appears to be responsible has now been identified as *Coniosporium corticale*, hitherto known only on maple in Canada and the United States.

In the Biochemistry department work has been continued on normal and virus-infected leaves. Normal tobacco leaves contain an unstable nucleoprotein which is sedimentable on the ultracentrifuge; the amount separated can be as much as 10 per cent of the protein of the leaf, and probably more remains attached to the fibre. This is a regular contaminant of all plant virus preparations made by methods designed to keep the virus in its original state. Using the experience gained with this material, progress has been made in understanding the changes that a tobacco necrosis virus undergoes in the process of isolation, and it has been suggested that much of the infectivity of a preparation is acquired after the virus has been liberated from the cell, as preparations made from sap that has stood for some time are more infective than those newly

extracted. This possibility becomes important when one is thinking about the mechanism of virus infection and the possibilities of control. Work on the large-scale separation of leaf protein continues. A mill and press have been designed which deal satisfactorily with grass and other leafy material on a pilot plant scale. Heat coagulation and separation of the protein present no particular problem.

In the Nematology department work has continued on the host ranges of several species and biological races of plant eelworms, especially the oat and narcissus races of the stem and bulb eelworm (*Ditylenchus dipsaci*), the potato tuber eelworm (*D. destructor*), and the strawberry eelworm (*Aphelenchoides fragariae*). Results of cross-infestation tests with the chrysanthemum and blackcurrant eelworms support the probable identity of these two species, *Aphelenchoides ritzema-bosi* and *Aph. ribes*. Pot tests show that the population of potato root eelworms (*Heterodera rostochiensis*) can increase 35-fold in one season, invasion of potato roots being heaviest in the first few days after planting. Sub-lethal doses of soil fumigants can also lead to population increases. A study of the conditions under which eelworm larvae are stimulated to hatch, by substances diffusing from the roots of growing potatoes, has led to an abbreviated hatching test and also to a method for the bio-assay of such diffusates. In soil, the latter are very localized in action and are rapidly broken down. The beet eelworm on Barnfield has not appreciably increased in numbers; it is most numerous on the plots giving the highest yields.

The work of the Entomology department consists of fundamental studies into the causes of insect outbreaks, and investigations of special problems relating to particular pests. Continuation of the work previously reported on measurement of insect populations has shown that most of the fluctuations in numbers can be accounted for by the rainfall and temperature of the previous three months. In the study of insect migration new evidence of autumn movements to the south has been obtained; there was very little influx of pests into Britain in 1950. New suction traps which separate out the catch for each hour of the day and night are throwing new light on insect activity and the drift of insects in the upper air from one district to another. One result is the demonstration of two peaks in activity, morning and afternoon, in many species of aphids. The forest soil studies have shown unexpectedly great numbers of "mites" (*Acari*), which outnumber the insects in many places. The earthworm investigations include tests of a new electrical technique for bringing the worms to the surface, so that the species and numbers can be determined. In co-operation with the Insecticides and Fungicides department work on the effect of various insecticides on the wireworm populations has been continued and a study is also being made of the increase of wireworm numbers in leys. Work on the swede midge has shown that it has a much greater range of food plants than was known and can attack many different parts of the plant. A further volume of Dr. Barnes' *Gall midges of economic importance* has been published.

In the Bee department work has been continued on the behaviour of the honeybee in the field. A study has been made of the effective flight range and the influence of distance on honey yield. The results bring out the disadvantage of placing a large number of

colonies of bees in a single apiary. It would appear that foraging bees are unable to communicate to other bees the colour or shape of plants on which they are feeding. A survey has been made of the sugars in nectar of various plants, and it has been found that bees prefer nectars containing equal proportions of glucose, fructose and sucrose. The investigations on bee breeding have been extended and a new type of syringe tip for instrumental insemination has been devised which promises to simplify the operation and to reduce the risk of damage to queens. Work is in progress on the feeding of colonies in spring and autumn and it has been found that in autumn it is more economical to feed the sugar as a concentrated syrup. Work has also been done on the feeding of pollen supplement in spring, and it has been found that the addition of a small trace of yeast to soya bean flour makes this a more effective food than the well-known soya bean flour and pollen mixtures.

The Insecticides and Fungicides department has continued work on various aspects of insecticidal action and the factors affecting the resistance of insects to insecticides. Differences in particle size of D.D.T. and rotenone had previously been shown to give differences in toxicity and injection experiments have now provided evidence that this is linked with the capacity to penetrate the insect cuticle. A study has been made of the mechanism of the toxic action of the new group of organophosphorus insecticides. In addition to their anti-choline esterase activity already recognized other esterases may be important. One aim in this work is to obtain compounds more toxic to insects and less poisonous to human beings. The synthesis of compounds allied to pyrethrins has been further studied, and insecticidal tests have given some information on the structural characteristics of molecules of this type which are associated with toxicity. In connection with the biological testing of insecticides, methods have been improved both for injection into insects and for contact applications. Preliminary work on insecticidal deposits on plants has shown that temperatures of leaves exposed to the sun may be considerably above air temperature and that D.D.T. deposits can volatilize comparatively quickly under these conditions. Field experiments on the control of wireworms have been previously reported and increased crop yields have been observed three years after soil treatments with B.H.C., D.D.T., ethylene dibromide and D.D. In the experiments on the control of black aphid on field beans parathion, H.E.T.P. and nicotine gave good results. D.D.T. not only gave a low kill but the treated plots ultimately had a much larger infestation than the control, probably due to the destruction of beneficial insects. Preliminary tests indicated that allethrin, the pyrethrins and dieldrin were effective insecticides against this pest.

In the Statistics department, an increasing amount of work has been undertaken for the National Agricultural Advisory Service, in addition to the usual assistance given to workers at Rothamsted and other stations at home and abroad. A start has been made on the investigation of experiments on animals. The Survey of Marginal Land was completed early in the year, and the third and last year's field work on the Survey of Maincrop Potatoes has also been carried out. Analysis of the 1949 results of this latter survey again gave an overall yield estimate in excess of the official estimate. The Survey

of Fertilizer Practice covered nine districts during the year, with a view to investigating changes following the reduction of subsidies, and a survey of restored open-cast coal sites is in its preliminary stages. The Hollerith punched-card computing equipment has been modified to permit greater flexibility of operation, and has been in continuous use in a number of investigations.

Investigations on the growing of hybrid maize, soya beans and other exotic crops have been continued at Woburn and the work on clover sickness has followed the same lines as last year. The number of plots laid down in 1950 on the Rothamsted and Woburn farms was 2,056, the largest number ever attempted. Over two-thirds of these were accounted for by the Classical experiments and the long-period rotation experiments on present-day husbandry problems. The most recent is the experiment testing different ley and arable rotations which completed its second preliminary year in 1950. This preparatory period is being used to develop grazing and sampling techniques. The experiment will attain full cycle with some 450 plots in the spring of 1951. Two long-period experiments have been terminated and fully reported: a test of the continued use of salt on sugar beet, and a potato experiment whose main purpose was the study of the spread of virus disease but which also tested the influence of time of planting on fertilizer action. New annual experiments were started to examine the effects of very late applications of nitrogenous fertilizer on the yield and quality of cereals. Promising increases in the production of crude protein, amounting to about 1 cwt. per acre, were recorded in 1950, which was probably a very favourable year for late top dressings. Wet weather in the autumn made harvesting operations very difficult. At Woburn the farm has been provided with modern and much needed additions to the farm buildings. Shortage of houses for farm workers, however, is giving rise to serious difficulties.

As in the past, the staffs of the various departments are greatly indebted to the farm manager and his assistants for their very willing and efficient co-operation.