ROTHAMSTED RESEARCH

Rothamsted Report for 1951

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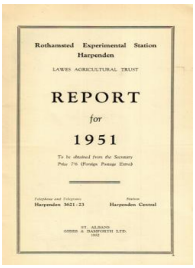

Introduction

Sir William G. Ogg

Sir William G. Ogg (1952) *Introduction ;* Rothamsted Report For 1951, pp 19 - 27 **- DOI: https://doi.org/10.23637/ERADOC-1-73**

INTRODUCTION

By The Director

Staff

Dr. R. K. Schofield was granted leave of absence at the end of October to take up a six months' appointment as Visiting Professor of Soil Physics in the Department of Agronomy, Cornell University, and Dr. H. L. Penman was awarded a Nuffield Foundation Fellowship to enable him to spend six months at the Waite Institute, Adelaide, Australia, to study irrigation research and water loss from vegetation. Dr. E. M. Crowther made an eleven week tour of the eastern half of the United States on an E.C.A. grant to study soil fertility and fertilizer investigations. Dr. F. Yates visited Jamaica to lead a seminar on sampling methods organized by the Institute of Social and Economic Research of the University College of the West Indies and spent a brief period at the Imperial College of Tropical Agriculture, Trinidad. He also gave a series of lectures in Sweden on modern statistical technique, and during a visit to Brazil lectured at the University of Sao Paulo and in Rio de Janeiro. In December he attended the fifth meeting of the United Nations Sub-Commission on Statistical Sampling held in Calcutta and visited various Institutes and Research Stations. At the invitation of the Consejo Superior de Investigaciones Cientificas, the Director spent three weeks in Spain lecturing at various centres and visiting research institutes. Mr. J. R. Moffatt spent about three months on the Continent studying farming and field experimental methods, and Dr. T. Goodey visited several European centres engaged on nematological work. Dr. P. H. Gregory visited Kenya to advise on the "bud disease" of pyrethrum, and Dr. R. Hull spent two months in the United States studying sugar beet diseases work there. Dr. C. Bloomfield took part in an E.C.A. Mission to West Africa to study the formation and development of laterite.

Rothamsted was represented at the 2nd International Congress of Crystallography, Stockholm, the 9th International Congress of Entomology, Amsterdam, the Conference on Potato Virus diseases, Wageningen, and the 14th International Beekeeping Congress. At the invitation of the Organizing Committee, Mr. F. C. Bawden attended the International Poliomyelitis Conference at Copenhagen. Dr. E. M. Crowther gave the Presidential Address to Section M (Agriculture) of the British Association in Edinburgh in August. Dr. C. B. Williams has been elected an honorary member of the Netherlands Entomological Society, and the degree of LL.D. was conferred on the Director by the University of Aberdeen.

Mr. Neely Turner of the Connecticut Agricultural Experiment Station spent six months in the Insecticides Department in exchange for Dr. A. H. McIntosh and his visit proved of great benefit to the department.

Visitors

The number of research workers and farmers visiting the Station has shown an increase, and, owing to the Festival of Britain, the proportion of overseas visitors was higher than usual. They included Mr. Charles Brannan, the United States Secretary for

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Agriculture, the Ministers of Agriculture for Sweden and Queensland, the United Nations Committee on Coordination of Agriculture and Research, the principal chiefs and advisers of the Paramount Chieftainess of Basutoland, and a party of French journalists. Amongst the conferences and courses held at the Station during 1951 were a conference for research workers on the use of insecticides and fungicides, a course on insecticides for overseas workers sponsored by the British Council, an international nematology course and symposia sponsored by the Food and Agriculture Organization, an international conference of bee research workers, and a conference of the Clay Minerals Group of the Mineralogical Society.

Buildings

The conversion of the old sample house near the main laboratory buildings into a library annexe and institutional store for apparatus and equipment has been completed. Progress has also been made with the flats and hostel accommodation at the Manor House, but unfortunately sanction has not yet been obtained for the new buildings for Statistics and Plant Pathology, and lack of accommodation is a serious problem.

The Work of the Station

In the Pedology Department, much attention has been given to mineralogical studies of soils and soil clays. Amongst the soils examined were samples from the Kongwa area of the Tanganyika groundnut scheme, the Equatorial Provinces of the Sudan, and an area of the Gold Coast near Accra. The general mineralogical character of soils of comparable origin in Tanganyika and the Sudan was found to be very similar. It was also found that the "cracking clays" of the Sudan appear to be characterized by a mineral of the montmorillonite type which swells and shrinks strongly on wetting and drying. Further work has been done on clay minerals, including their quantitative determination and improvements have been made on the X-ray equipment for their study. The interaction of clay and soil organic matter is important and in this connection the adsorption complexes between one of the clay minerals and organic molecules, including large protein molecules, have been studied. Progress has been made with the investigations of ill-drained soils and it would appear that the grey material in such soils may be the end-product of the reduction process and that the rusty brown material is usually a form of hydrous ferric oxide.

Shortage of sulphur has led to increased interest in phosphatic fertilizers which can be made without the use of sulphuric acid and the Chemistry Department has devoted much attention to the subject. Field experiments have been carried out with dicalcium phosphates, silicophosphate and ground Morocco mineral phosphate in comparison with superphosphate. It is too soon to draw conclusions but in 1951 with potatoes, dicalcium phosphate gave somewhat better yields than superphosphate on the average of thirteen experiments, whilst silicophosphate was less effective, and mineral phosphate still less so. For swedes, all three gave yields approaching those with superphosphate. The experiments also

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showed that quite small dressings of superphosphate often suffice to give good crops and one of the obvious adjustments to present shortages and high prices of phosphate fertilizers is to use less on land with appreciable reserves from past treatment. Experiments are also in progress with nitrophosphates made by two different processes and it has been found that one is superior to the other. There are indications from this that the size and stability of the granules may be important factors in the rate of action of the less soluble phosphate fertilizers.

Experimental work on fertilizer placement has been continued and extended. The advantage in the case of peas and beans of placing the fertilizer beside the seed has been shown over four seasons and where special placement drills are not available, farmers are advised to incorporate the fertilizer for these crops in the soil by ploughing or cultivation. Experiments on leys indicate that broadcasting the fertilizer generally gives better yields than applying it in bands below the surface. Preliminary results on potatoes planted by machine show that fertilizer placed in contact with the seed, or in bands beside it, gave higher yields than fertilizer broadcast on the flat or placed in front of the seed-shoe of the planting machine. It should be noted, however, that direct contact with the seed may be dangerous in dry spells.

Further work has been done on materials that might be used to supplement the inadequate supplies of slow-acting nitrogenous fertilizers and promising results have been obtained from formalized casein and from a product prepared from urea and formaldehyde. The work on the manuring problems of forest nurseries has been continued and the effects of formalin treatment of the soil further investigated. It has been found that Sitka spruce seedlings on acid soils are particularly sensitive to nutrient deficiencies and symptoms of lack of potassium and magnesium have been identified in the foliage. Progress has been made in the investigations on soil organic matter especially on the proteins and amino acids which it contains. Further work on the Classical plots at Rothamsted confirms earlier indications that phosphorus fertilizers may have residual effects extending over very long periods though only a small amount may become available in any one year.

In the Physics Department a good deal of attention has been given to soil structure. The physical effects of grass roots have been studied and evidence obtained that after the stems have been cut off and the roots are dead, they continue to conduct water and thus improve drainage. It is possible, therefore, that one of the physical effects of grass may be the prevention of the deflocculation of the surface soil layers in very wet conditions. The influence on soil structure of the concentration of salts in the soil solution has also been studied and a simpler method devised for determining the critical salt concentration below which soils are deflocculated. In irrigation schemes there is sometimes difficulty in maintaining good structure in the soil, but if the chemical composition of the irrigation water is known, the stability of the soil structure can be predicted and corrective measures applied when necessary.

An irrigation experiment designed to give detailed information on the times and levels of watering in conjunction with nitrogenous

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manuring at two levels has been laid down at Woburn, the crops being grass, spring barley, sugar beet and potatoes. The equipment was not ready in time to allow the full watering programme to be carried out, but, during this trial run, substantial benefits were obtained from the application of a few inches of water. Work has been continued on soil cultivation, evaporation and various other subjects.

In soil microbiology one of the main problems facing the research worker is that of discovering what particular microorganisms are responsible for certain chemical changes which are known to occur in soil. A study from this point of view is being made of reduction processes in soil. The reduction of ferric iron and of sulphates has an important bearing on soil formation processes and on the availability of plant nutrients whilst the reduction of nitrates affects nitrogen losses from soil. Such reduction processes used to be regarded as evidence of the existence of anaerobic conditions, at least locally, in the soil. Investigations carried out during the year on sulphate reduction however, show that it can take place in the presence of oxygen, and an aerobic sulphate reducing bacillus has been isolated. This is in line with previous work in the department on denitrification. In the case of iron, bacteria which can reduce ferric oxide in the presence of sugar have been isolated and their further study should throw light on the movement of iron in the soil.

Another line of investigation deals with the extent to which the addition to soil of a novel chemical compound will encourage the development of a specific microflora that can attack it. This has a very important bearing on the persistence in soil of the insecticides and weed-killers that are now added at times either intentionally or by accident. For this reason, the decomposition in soil of organic compounds containing chlorine and bromine is being studied from a bacteriological point of view. The building up of a specific flora of this sort is a special case of an induced change in the micropopulation.

A study of the more general effects of partial sterilization on the soil population, referred to in the 1950 report, has been continued, as has also an investigation of the effects of antibiotic actinomycete secretions on root disease fungi. The work on nodule bacteria and leguminous plants has made progress and further interesting results have come from the study of root secretions in affecting both the numbers of nodule bacteria in the root surroundings and the number of nodules produced. The progress of other lines of study will be found described in the report of the department.

In the Botany Department, work has been continued on micro-nutrients or trace elements and on the physiology of the uptake of plant foods by roots. The latter investigation has now been extended from excised roots to intact root systems to see if ion absorption is accompanied by increase in rate of respiration. Further progress has also been made with the study of the uptake of nutrients from solutions sprayed on the leaves. Sugar beet plants sprayed several times in late August and September with a solution of ammonium nitrate showed a marked increase in the dry weight and protein of the leaves and 80 per cent of the nitrogen applied was recovered in the plants. From further studies of the influence of moisture

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on germination, it has been concluded that conditions in the soil are rarely so dry as to inhibit germination; failures in establishing crops during drought are due to lack of water in the post-germination stage and increased death rate of seedlings through fungus attack.

In studies on the biology of wild oats it has been found that farmyard manure hastens the germination but reduces the viability of their seeds and that the seeds of one species (*A. fatua*) germinate more readily if sown in the surface soil whilst those of another species (*A. ludoviciana*) germinate better at a depth of several inches. Only 7 seeds of *A. ludoviciana* out of 2,000 fed to a calf have so far germinated in the excreta. A survey carried out in co-operation with the National Agricultural Advisory Service showed that the species *A. fatua* occurs throughout the eastern, midland and southern parts of England but in Wales was found only in Monmouthshire. *A. ludoviciana* has a much more restricted range and was recorded only from an area roughly within a radius of 80 miles of Oxford.

In the Plant Pathology Department much of the work, as heretofore, has been on virus diseases. The effects of ultra violet radiation on viruses and on plants were studied. This treatment reduces the infective power of viruses and in some cases, the infectivity is less when the inoculated leaves are kept in darkness. The damaging effects of ultra violet rays on the leaves themselves is counteracted by keeping them in daylight after irradiation. Virus infection is inhibited by extracts from certain plants and it has been shown that this effect is greater when the extract is from a plant of a different species; two substances which cause the inhibition have been separated from a plant extract. The influence of temperature on susceptibility to virus infection has also been studied and it has been found that exposing plants to a temperature of 36°C. before inoculation greatly increases susceptibility to several viruses. On the other hand exposure to heat after inoculation reduces infection and in the case of some viruses wholly prevents it. Work on sugar beet yellows has been continued and it has been found that the strains of viruses causing this disease reach higher concentrations in the infected plants than was the case a few years ago. It has also been shown that yellowing diseases of beet can be caused by several viruses, some of which have no connection with sugar beet yellows, and one of them is seed transmitted. In 1951 the field experiments on the spread and control of virus diseases in potato, sugar beet and cruciferous crops was hampered by the unusually small population of aphids and the consequent small spread of viruses; sugar beet stecklings were healthier than for many years and lifted roots over-wintered well in clamps.

Good progress was also made with the study of fungus diseases. Laboratory and field work on the dispersal of spores showed that the spore trap customarily used gave inaccurate results and a more efficient trap has been designed which gives continuous records of spore concentrations. These have shown, for instance, that the spores of potato blight spread mainly in the morning. Another observation on potato blight was that tubers infected in the field in 1950 produced plants with blighted shoots in 1951. Work on cereal mildews showed that *Erysiphe graminis* infections develop

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soon after dressings of readily available nitrogen have been applied to a crop. The investigations on take-all and eyespot have been continued and it has been shown that after two years under non-susceptible crops the former disappeared and the latter was much reduced; spraying with H_2SO_4 was again effective in reducing eyespot. The mummy disease of mushrooms was also studied and it has been shown that it is not caused by a virus.

The Biochemistry Department is investigating the nucleoproteins from normal and virus infected leaves, the technological production of leaf protein, the oxidation of manganese by plant extracts and the part played by fungal mycelia in building up soil organic matter. These rather diverse lines of work although started independently are now becoming more integrated. Thus the study of the range of nucleoproteins formed in the leaf during virus infection connects well with the work on the normal nucleoproteins of the leaf and on the enzyme actions they undergo and bring about. Again, the work on enzyme mechanisms that play a part in the manganese metabolism of the plant suggest other possibilities of interaction. It is now clearly established that there are mechanisms in the plant that can make hydrogen peroxide and that the latter can oxidize manganese with the help of the enzyme peroxidase but it has not yet been shown that this is the normal process. The investigations on the rôle of the resistant parts of fungal mycelia in the formation of soil organic matter have benefitted greatly from the experience already gained on the decomposition of leaves by enzymes and the latter was in fact undertaken in connection with the liberation of viruses from leaves. Chitin and some other polysaccharides have been isolated from several species of fungi and a survey is being made of the enzymes of fungal, bacterial or invertebrate origin that can attack them. In the course of the work on the production of leaf protein, improvements have been made in the extraction process and material from various crops has been prepared for chicken feeding experiments.

In the Nematology Department work has been continued on a wide range of eelworms and new species discovered include one associated with a root disease of oil palm seedlings and one destroying flower heads in Caucasian scabious. Studies are being made of the various strains or races of stem eelworms which attack oats, onions, certain flower bulbs and many other crops and weeds. From the farmer's point of view it is important to know what crops and weeds are attacked by the various races but the problem is complicated by the fact that many plants may be attacked by more than one race. For example the broad bean is attacked by both the oat and a " giant " race but not by the red clover race. Attempts are being made to find immune varieties of crops and a few spring varieties of oats have shown resistance to the oat race.

Further work has been done on the potato root eelworm. The search for substances to control this pest has been continued and several show a certain amount of promise. A three year field trial has shown that the use of the substance known as D.D. mixture is economically possible on certain soil types but not on black fen soils, and a new experiment has been started to ascertain the best stage in a crop rotation at which to apply it. The changes in

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eelworm numbers during a rotation are also being studied. It has been known for some time that a substance diffuses out of potato roots which stimulates eelworm larvae to hatch and this substance can now be standardized by a biological method. It is produced most abundantly in the early stages of the plant's growth. The black nightshade and certain other plants also produce a diffusate and this suggests the possibility of controlling potato root eelworm by means of a trap crop.

The work of the Entomology Department has continued on the lines of previous years, namely, studies of insect population, causes of outbreaks of insect attacks and investigations of problems relating to particular pests. Studies of the numbers of aphids at different levels in the air have shown that by far the greater proportion of those flying during the day are at altitudes above 100 feet and thus subject to considerable dispersal by air currents. The number in the air at any particular time, however, depends more on such factors as population and environment than on weather conditions. Work is also in progress on the natural enemies of aphids which include ladybird beetles, hover-fly larvae, lacewings and mites.

Studies of gall midges have been continued and include investigations into the range of host plants of the swede midge. Further work has been carried out on wireworms and on the effects of insecticides in controlling them. Progress has also been made in the study of earthworms and of forest soil insects.

In the Bee Department, much attention has been given to bee behaviour and to the foraging behaviour of wasps and bumblebees. The influence of scent, both that produced by flowers and also by the bees themselves has been investigated. It has been confirmed that as floral perfumes are generally rather weak and a worker honeybee's sense of smell being similar to that of man, she has to approach a flower very closely before appreciating its scent. Once she has learnt to associate the scent of a particular species of flower with food, she hesitates to enter any flower of this kind unless she can smell its perfume. This probably explains the observed temporary repellent effect on bees of many insecticidal and herbicidal sprays. It has also been shown that on nearing a source of food bees are helped to find it by the scent produced by bees already there.

The organization of bees in their colonies has also been studied and it would appear that the age of a honeybee is not the factor which determines the work she undertakes. The egg-laying activities of the queen have been investigated and also the behaviour of bees before and after swarming. The work on the composition and secretion of nectars of the more important species of flowers visited by bees, has been continued and the physiology of pollen digestion is being investigated. The extent of food transmission between the bees of a colony has been studied by means of a radioactive tracer and work on bee breeding has been continued.

The effectiveness of an insecticide varies with the species of insect on which it is applied and the reasons for this variation are being investigated by the Insecticides Department as part of their research programme. One group of insecticides, the organophosphorus compounds, is believed to act by inhibiting the esterase

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enzymes of the insect. It has been shown that esterases from different species of insects are different and this may be one reason for the differences in the effects of the organo-phosphorus compounds on different species of insects. In view of the very considerable human hazards attached to the use of many of the modern synthetic insecticides a considerable amount of time has also been devoted to the study of pyrethrum and the synthetic compounds akin to the pyrethrins which are, for all practical purposes, non-poisonous. Some progress has been made in determining the structural features of the molecule which are essential for insecticidal activity and a physical method for the separation of Pyrethrin I from Pyrethrin II has been worked out.

Some of the modern insecticides such as D.D.T. when sprayed on to a surface can form a protective coating that will kill insects and may last for a considerable time. A persistent protective insecticidal film is, of course, a useful means of insect control. When D.D.T. is applied to a plant surface the degree of effectiveness of the protective film and the length of time which it lasts varies a good deal and some work has been done on the reasons for the variation. It has been shown, for instance, that D.D.T. vapour can be absorbed by the surface wax of the plant and that the insecticidal activity of a film of D.D.T. is affected by the nature of the leaf surface and varies with the species of leaf on which it is applied. It appears that a film of D.D.T. on a leaf surface has a greater insecticidal activity than a similar film on a glass surface. Field experiments on the control of wireworms have shown that Aldrin and Chlordane give promising results and experiments on the control of black aphis on field beans have indicated that effective control of the aphis and a greatly increased crop yield can be obtained by a single application to the beans at a very early stage of infestation of any one of several different insecticides.

The Statistics Department has continued to design and analyse field and laboratory experiments for Rothamsted and various other research stations, and close contact with the National Agricultural Advisory Service has been maintained. The computations arising from this side of the work have involved the analysis of nearly 60,000 plot yields during the year. Work has been continued on the Rothamsted experiments and on various surveys. The Survey of Fertilizer Practice covered 11 counties during the year, and the field work of a Survey of Restored Opencast Coal Sites was completed. Other surveys analysed during the year concerned brassica crops grown for stock feeding in Wales, rabbit damage to winter wheat and ragwort infestation in Anglesey and Pembroke. The department is assisting the National Institute of Agricultural Engineering in an operational survey of farm tractors and final figures for the Survey of Maincrop Potatoes have confirmed results obtained in previous years. Critical summaries of published data on various branches of agricultural practice have been prepared, and the department has also studied the relative merits of a variety of laboratory and field techniques used by the National Agricultural Advisory Service and other organizations.

Long period experiments on modern problems of manuring, cultivations, and rotations were continued in 1951 on both

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Rothamsted and Woburn farms. The ley-arable rotations are both now in full cycle and, as in the previous season, the second-and third-year lucerne plots in this experiment produced more dry matter per acre than any of the old or seeded grass mixtures with which they were compared. The three-course rotation begun in 1933 to test raw straw and straw compost was terminated and the original treatments have been recast to study certain points arising out of the action of straw in this experiment. The Woburn irrigation plant has already been mentioned and the rotation in the market garden experiment at Woburn was recast in 1951 to allow of a somewhat longer period of growth for the crops grown, the organic manuring being unchanged.

The annual experiments have been continued. Top dressings of " Nitro-chalk " applied to cereals late in the season when the crops were in ear once more raised the nitrogen content of grain and straw but not quite to the same extent as in the previous year. Machine-planted potatoes again out-yielded those planted by hand and further experiments to study this effect and the location of fertilizer in relation to the seed are being designed. In all 2,445 experimental plots were handled in 1951.

At Woburn the work on certain exotic crops has been continued and in spite of the unfavourable season some Continental strains of soya beans ripened but the yield was low. Early varieties of hybrid maize were tested and this crop may have some future in certain districts. Heavy yields of green fodder were again obtained from yellow lupins and serradella and birdsfoot trefoil also gave satisfactory results. Progress has been made with the studies of weeds and further work done on clover sickness.

The farm manager and his staff have as usual given most willing cooperation and much valuable assistance to the scientific departments in all their experiments both at Rothamsted and Woburn.

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