ROTHAMSTED RESEARCH

Report for 1939-45

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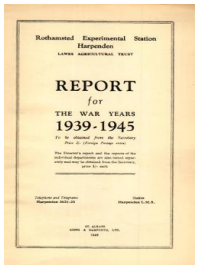

Rothamsted Report by the Director 1939-1945

W. G. Ogg

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REPORT BY THE DIRECTOR

Because of the war no annual report has been printed since 1938, and the present report covers the years 1939 to 1945 inclusive. It differs in certain respects from the pre-war annual reports. As in the case of the account published at the time of the Centenary, the work of each department is described in some detail by its head. There is a good deal to be said for describing in this way the work of a specialist institution engaged largely on the more fundamental problems. It should be made abundantly clear, however, that the work at Rothamsted is not conducted in a series of water-tight compartments. There is consultation and collaboration between the departments from the preparation of the programme to the writing up of the results, and many of the investigations or parts of them are carried out jointly by members of different departments. Contact is maintained formally by meetings of a Staff Council and by scientific discussions held about every three weeks, but the informal contacts, when the staff meet daily for tea, are even more important.

The war-time report follows the pre-war abridged reports in omitting the tables giving the detailed results of experiments. The figures for any particular experiments may be obtained on application to the Secretary.

Acknowledgement is made to Mr. G. V. Jacks for editing this report.

In spite of the proximity to London, Rothamsted suffered no damage from enemy action during the war. Incendiary bombs were dropped on two occasions, one landing on the roof of the laboratories and several others about the premises and in the Director's garden, but they were dealt with by the very efficient fire-watching service organised by the staff from its members. On a few other occasions, strings of high-explosive bombs were dropped on the Common in front of the building and on the farm, but no one was injured and no damage was done either to buildings or crops. Dr. R. K. Schofield was in charge of the A.R.P. work assisted by Mr. D. J. Finney, Dr. J. T. Martin and Mr. R. G. Warren; Dr. Winifred E. Brenchley also took an active part, especially with regard to first-aid and catering.

Accommodation was provided for workers evacuated from the Department of Biometry and Eugenics of London University, the British Leather Manufacturers' Research Association, Diagram Films Ltd., and the Public Health Department of the Ministry of Health.

The Centenary Celebrations

The Centenary of Rothamsted was celebrated on 21st July, 1943. Owing to the war and the difficulties of travelling, the celebrations were on a much smaller scale than they would otherwise have been. Nevertheless there were nearly 300 guests and 25 countries, including the Dominions, were officially represented. Amongst those present were Mr. R. S. Hudson, the Minister of Agriculture, the Duke of Norfolk, Joint Parliamentary Secretary to the Ministry of Agriculture, the Marquess and Marchioness of Salisbury, the

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Viscount and Viscountess Bledisloe, and Sir Henry Dale, President of the Royal Society.

In the morning the guests were taken in small parties round the laboratories and had an opportunity of inspecting the new south block, the remodelled sections of the main block, and the new pot-culture houses.

After a luncheon in the Public Hall, addresses were given by the Earl of Radnor, Chairman of the Lawes Trust Committee, Mr. R. S. Hudson and Sir John Russell.

Many messages of congratulation were received from overseas and from well-wishers in this country.

In the afternoon the guests were taken round the farm and inspected some of the more important experiments including the 100th successive wheat crop on the Broadbalk field.

Parallel meetings to commemorate the Centenary of Rothamsted were held in Moscow by the agricultural scientists of the U.S.S.R., in Cincinnati by the Soil Science Society of America, and commendations of Rothamsted's work were made at meetings in Spain and Portugal.

Retirement of Sir John Russell

On 30th September, 1943, Sir John Russell retired from the directorship of Rothamsted. Dr. W. G. Ogg, formerly director of the Macaulay Institute for Soil Research, Aberdeen, was invited to succeed him.

Sir John joined the Rothamsted staff in 1907 and was appointed director when Sir Daniel Hall left in 1912. During his long tenure of office, Sir John completely reorganised and greatly expanded the Station, and, what was still more important, gathered round him a first-class staff. He built up what is now one of the finest agricultural libraries in the world, and raised large sums of money for the rebuilding of the laboratories, pot-culture houses and farm buildings and for the purchase of Rothamsted farm and Manor House. In this summary it is impossible to deal adequately with Sir John's great services to Rothamsted and to the agriculture of the Empire. He travelled widely and did much to make the work of the Station known in other countries. Besides serving on numerous committees set up by the Ministry of Agriculture, the Agricultural Research Council and the Colonial Office, he took an active part in the work of the Allied Post-War Requirements Bureau and UNRRA. During the war he also served part-time with the Soviet Relations Division of the Ministry of Information which entailed making extensive lecture tours in many parts of the country.

When he retired the staff and former workers presented him with his portrait painted by Francis E. Hodge.

Improvements to Laboratories and Farm Buildings

In 1938 a Centenary Fund was inaugurated for the purpose of reconstructing some of the old laboratories and erecting new ones : also for setting up pot-culture houses and extending and improving the farm buildings. There was a ready and generous response from many friends and supporters of Rothamsted and, had it not been

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for the war, it seems certain that the target of £125,000 would have been reached. With the coming of the war, however, the appeal was discontinued, and the Rothamsted Centenary Fund was closed in 1939 when nearly £67,000 had been received or promised. With this sum, which included £15,000 from the Ministry of Agriculture for the South Wing and for spectrographic equipment, excellent accommodation has been provided for the departments of Chemistry, Biochemistry, Physics and Microbiology, pot-culture houses have been built and farm buildings reconstructed. The latter are now ideal for their purpose, having modern electrical equipment and spacious barns in which the experimental crops can be stored and threshed during the winter months. Unfortunately the projects for improving the accommodation of other scientific departments, re-housing our unique agricultural library, and providing administrative offices and an Assembly Hall, have had to be postponed. Lack of accommodation is hindering the development of the Station's work and has led to the necessity of refusing to accept some of the voluntary workers from other countries. It is, in fact, proving difficult to find room for workers training for our own and the Colonial agricultural research services.

There is also an urgent need for providing more farm cottages, improving the lay-out at the back and front of the laboratories, and re-making the road to the farm.

The Work of the Station in War-time

As was to be expected the war had a marked effect on the work of Rothamsted. The field work of the classical and the more important of the other experiments, particularly the long-term ones, was continued. Much of the laboratory work had to be allowed to fall into arrears and many investigations had to be postponed in order that *ad hoc* problems, immediately connected with increased food production, might be undertaken.

Most members of the staff were engaged in various forms of war work and consequently were reserved, nevertheless 14 entered H.M. Forces and we regret to record that two—Jack Olver (Fleet Air Arm), assistant in the Chemistry Department, and John Williams (R.A.F.), assistant in the Insecticides Department—were reported missing. A few members were seconded for scientific work elsewhere, but most of the staff carried on their war duties at Rothamsted.

Between 1938 and 1945 the total number of workers, including voluntary workers, assistant staff, farm workers and the Woburn staff, increased from 143 to 219.

Among those who left us were Dr. J. Henderson Smith, who resigned in 1940 after 21 years at Rothamsted, the last eight as head of the Plant Pathology Department, and Miss Mary S. Aslin, who resigned in 1942 after 23 years' service as librarian.

It is with regret that we record the death during the early war years of two heads of departments—Mr. E. H. Richards, head of the Fermentation Department, who died in 1939, and Mr. D. Ward Cutler, head of the General Microbiology Department, who died in 1941. Both of these workers had been on the staff since 1919.

In 1940 an Agricultural Research Council Unit dealing with

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soil metabolism was set up at Rothamsted under Dr. J. H. Quastel, F.R.S. This Unit was transferred to the University College of South Wales, Cardiff, at the end of 1945.

The Bee Section has been made a separate department recently under Dr. Butler, and a new Pedology Department has been established, in 1945, under Dr. A. Muir. Arrangements have also been completed for the setting up of a separate Biochemical Department, and for the appointment of a Colonial Soils Adviser.

The following is a brief review of the main lines of work : more detailed accounts are given by the heads of the various departments.

Soils and crop nutrition

Much of the soil work consisted of short-term investigations which could be regarded as " operational research " in the food-production campaign. These investigations, however, have had more than a short-term value for they have supplied much information which will be of value in long-range soil-fertility investigations. Amongst the problems set us by the war were : how to maintain or increase production and at the same time practise a rigid economy in the use of fertilisers, and how to handle to the best advantage the large area of old pasture land which had to be broken up.

A statistical examination by E. M. Crowther and F. Yates of the results of all the recorded field experiments made during this century in Britain and various European countries revealed the average fertiliser needs of different farm crops. This threw light on problems of fertiliser imports and showed how the supplies could be most efficiently distributed. It was of great value in formulating the war-time fertiliser policy.

As in the past, much of the soil-fertility work was a combination of field experiments and laboratory investigations. In addition to those on the Rothamsted and Woburn farms, many experiments were carried out on commercial farms in different parts of the country.

A good many of the special war-time investigations were done on behalf of the Agricultural Research Council, the Ministry of Agriculture and the Ministry of Supply, and in collaboration with the staffs of other research institutes and with the advisory chemists.

The sugar-beet manuring trials begun in 1933 were continued, and it was clearly shown that the outstanding requirements of this crop are nitrogen and sodium. It was demonstrated that sodium acts as a direct plant food and the application of 5 cwt. of common salt produced, on an average, about 5 cwt. of extra sugar. As a result of these experiments the manuring of sugar beet has been put on a more satisfactory basis. As well as throwing light on the manuring of sugar beet these experiments have proved useful in developing and improving methods of soil analysis for advisory work.

A considerable amount of work done on the manuring of flax showed that this crop is relatively unresponsive to fertilisers and should be manured like barley.

Investigations on organic manures have also been a feature of the war-time programme, and an attempt has been made to assess the physical as well as the manurial effects. The materials studied included farmyard manure, sewage sludge, straw and various

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composts. Stacked young bracken gave excellent results. Sewage sludges proved much less effective than good farmyard manure or bracken compost and supplied little beyond nitrogen and phosphate. Promising results were obtained from composts of straw and sewage sludge. An investigation on waste leather showed that it can be converted into an active nitrogen fertiliser by de-tanning, but the process has not yet reached a commercial scale.

Another major project has been the study of phosphatic fertilisers and particular attention has been given to questions of availability and to the problem of phosphate fixation. It is perhaps not generally realised that of the phosphate applied as fertiliser not more than 20 per cent. as a rule is recovered in the crops. A new phosphate fertiliser—silico phosphate—was developed in collaboration with the Building Research Station, and was found to compare very favourably with superphosphate for swedes and for re-seeding in wetter areas.

Fertiliser placement provides an obvious economy, particularly in the use of phosphate, and the process is now well established for cereals and is being tested for other crops.

Work on trace elements has been carried out in the departments of botany, chemistry and biochemistry and considerable progress has been made in the study of manganese deficiency. Deficiencies of manganese, boron, magnesium and potassium can now be recognised and distinguished from each other and from chlorosis due to virus and fungus diseases. The trace elements contained in Chilean nitrate were studied for several years by Dr. Brenchley and Dr. Warington, boron being the most important. Iodine gave negative results, but there were indications that molybdenum improved the growth of lettuces, and this element is being studied more intensively with various crops. The toxic effects of larger amounts of molybdenum and other trace elements are also being investigated.

Soil-moisture and cultivation studies

An examination of the daily readings of the Rothamsted drain gauges for the period 1871 to 1940 and of the continuous records taken since 1925 has yielded important information about the rate of evaporation from bare soil, and laboratory experiments have helped to elucidate the physics of the process. The transpiration of short grass continuously supplied with water from a controlled water table has been measured during two summers and its dependence on the supply of energy from solar radiation established. It is proposed to make the same measurements for tall crops. This technique should provide more precise indications of the optimum quantities of water to be supplied in irrigation work.

The study of the manner in which water is retained in soil has been continued, and progress made in devising means for measuring *in situ* the suction (or pF) of the soil moisture. A method has also been devised for obtaining the volumes occupied by solids, water and air in soil clods. Measurements have been made of the fraction of soil particles of effective diameter less than 0.1μ, and a physico-chemical study of the buffer action of a number of pure polysaccharides has paved the way for an attack on the complex chemistry of the organic matter of the soil.

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The results of soil-cultivation experiments on different soils and in different seasons are consistent with the laboratory and drain-gauge work and with comparable experiments in the United States and elsewhere. They demonstrate the depression of crop yield due to weed competition, but show that inter-row cultivation does not reduce direct evaporation from the soil.

Nodule bacteria and other soil micro-organisms

Some strains of nodule bacteria, particularly on clover, produce nodules practically ineffective in fixing nitrogen. These appear to be characteristic of poor pastures in hilly districts in the west and north of Britain, and the possibility is being investigated of improving the clover content of such pastures by inoculation with effective strains of nodule bacteria. The problem is by no means simple, however, for effective strains are liable to mutate and become ineffective on certain soils : moreover, acute competition has been found to take place between the nodule bacteria introduced by inoculation and those already present in the soil. The cause of ineffectiveness appears to be the inability of certain strains to grow strongly on the host-plant tissues or to survive therein long enough to fix appreciable amounts of nitrogen. The behaviour of the nodule bacteria is controlled by genes in the host plant as well as by the nature of the bacterial strain.

A study of the chemical nature of the bacterial secretions which cause deformation of root hairs by nodule organisms eventually led to the discovery of the high toxicity to many dicotyledonous plants of 2 : 4 dichlorphenoxyacetic acid. This and a closely related compound are now in practical use in this country and in America as differential weed killers for use in cereal crops.

Studies on the general micropopulation of field soils have been facilitated by the development of a new direct method of counting bacterial cells and of estimating the quantity of mycelium in soil by direct microscopical observation. A greatly improved technique for estimating numbers of protozoa in soil has also been devised. By the use of these improved techniques several groups of micro-organisms, formerly thought to be very rare or even adventitious in soil, have been found to be true and widely distributed soil inhabitants. These include giant rhizopods, acrasieae and myxobacteria. Of special interest are the myxobacteria which secrete compounds that destroy and dissolve gram-negative as well as gram-positive bacteria. Most of the former group are not attacked by penicillin. Soil protozoa and acrasieae have been found to be very selective in their bacterial food so that they are capable of altering the quality as well as the total size of the soil bacterial flora.

Virus diseases of plants

Plant-pathological work has increased greatly since 1939 and particular attention has been given to the diseases of potatoes, sugar beet and cereals. As far as possible all the lines of work both with viruses and fungi that were being studied in 1939 have been continued, and a good deal of advisory work has also been undertaken.

The study of viruses has been facilitated by the acquisition of an ultra-centrifuge and an electron microscope. New viruses have been

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isolated and identified as crystalline nucleoproteins, and studies have been made of their physical, chemical and serological properties. The serological work has led to the development of a rapid method of diagnosis for some of the commoner virus diseases. Wide variations in the size and shape of tobacco-mosaic virus have been detected and the conditions responsible for the variations have been determined. The shape of the virus particles has been found to account for their serological behaviour. The factors responsible for flagellar and somatic-type serological behaviour have been elucidated. The manner in which viruses are held in infected tissues has been studied, and it has been found that infected plants contain much more virus than was previously suspected. The work has included studies of the origin and significance of intra-cellular inclusions, new types of which have been found in infected plants and new insects have been identified as vectors. The intricate relationships between viruses and their vectors have been studied, and in the field special attention is being given to the factors which affect the spread of virus diseases particularly in potato and sugar-beet crops. Annual surveys of the insects and virus diseases of these two crops have been made and much information has been obtained on the effects of weather on the insect vectors, the relative importance of different species of insect in causing spread, the distance over which spread occurs and the important sources of infection. A book on Plant Viruses and Virus Diseases was published by F. C. Bawden in 1939 (second edition, 1943).

Biochemical work on normal and virus-infected leaves has been in progress since 1940 and has included studies of the conditions governing the release of normal protein from the leaf fibre. Use has been made of methods involving fine grinding and enzymatic disintegration. Work has also been done on plant proteases and on pectase. Extraction and fractionation of tobacco-mosaic, tomato bushy-stunt and the tobacco-necrosis viruses were carried out in the Biochemical Section.

Fungus diseases

Increased attention has been given to field work on fungus diseases. Surveys of commercial crops in many districts have shown the importance of Eyespot of wheat (*Cercosporella herpotrichoides*), and many experiments have been made to ascertain the conditions favouring this disease and to devise control measures. A survey of the causes of wastage in stored potatoes showed that *Phytophthora infestans* was the main cause but also revealed a previously unsuspected cause *Fusarium avenaceum*. Studies have been made of the environmental conditions affecting the survival of soil-borne fungi, their ability to cause infection and their survival in the absence of susceptible crops. Among the fungi studied were *Ophiobolus graminis, Fusarium culmorum, Plasmodiophora brassicae, Rhizoctonia solani* and *Verticillium albo-atrum*. A book on Root Disease Fungi by S. D. Garrett was published in 1944.

Studies of earthworms, slugs and various insects

Work in the Entomology Department can roughly be grouped into three divisions, a study of the causes of insect outbreaks, secondly work on particular pests—not necessarily insects—such as

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slugs, wireworms and gall midges, to study their biology and control, and thirdly an investigation on earthworms and their relation to soil formation and fertility. The last mentioned was started about three years ago, and some 15 species of earthworms have been found on Rothamsted farm in varying relative abundance according to the type of soil and cultivation. A new species has been discovered. Each species has its own particular life cycle and habits, and each will no doubt have its own specific effect on soil conditions. It is already apparent that it is neither desirable nor justifiable to speak in general terms of the effect of " earthworms " any more than of the effect of "insects." Some go deeply into the soil, others live near the surface : some make worm casts above the ground, others do not. Every effort is being made to put the work on a sound basis both biologically and statistically.

Observations on the life cycle and abundance of slugs have now been going on for a considerable period on a statistical basis. The various species are being identified and their habits and ecological relationships studied. It has been found that very small changes in the environmental conditions of gardens make big differences in the total slug population and particularly in the relative numbers of the component species.

A study which has been going on for 20 years of wheat midges on Broadbalk has shown a relationship between the percentage of grain attacked and the annual yield. There is also a correlation between the date of emergence of the wheat midge and the harvesting date. The study of insect outbreaks is really a study of changes of insect numbers in a locality, as outbreaks are only a sudden increase in numbers beyond the danger point. This increase can be brought about by weather conditions favourable to the pest or unfavourable to its enemies, or, alternatively, by a deliberate or accidental movement into the area from outside—in other words by migration or by drift. Some progress has been made in all these branches, and C. B. Williams has obtained a formula for forecasting the general level of insect abundance at Rothamsted for any one month from the weather conditions of the previous three months. It has been shown that under the climatic conditions at Rothamsted, temperature is the most important factor in the winter months and rainfall in the summer months in determining insect abundance.

The control of insect pests

During the period under review there was naturally a concentration of effort on problems connected with the war, and later on the application of recently discovered insecticides to agriculture and horticulture. It was possible, however, to carry on some of the pre-war programme, and the search for new insect test subjects for evaluating insecticides was continued and also studies on the effect of environment on insect resistance. Extensive researches have been carried out on insecticides derived from plants used by the natives of tropical countries as fish poisons. Species of Derris, Lonchocarpus, Tephrosia and many others have been examined. The work on derris root included its evaluation by chemical means and the investigation of the effect of its several constituents on each other's insecticidal value. Six active principles, of which

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rotenone was the most potent, were isolated, and S. H. Harper elucidated the structure of elliptone and malaccol and discovered a compound with an *iso*-flavone structure which he suggested might well be a precursor of the several compounds found in Derris and Lonchocarpus.

Much work has also been done on the powerful insecticide pyrethrum. In the years 1939-42 pyrethrum flowers and their extracts were of importance for food preservation and the control of insect pests such as the mosquito and the body louse. An important drawback was the dermatitis caused by pyrethrum preparations in susceptible people. J. T. Martin, himself a susceptible subject, studied this problem and showed by personal experiments that the pyrethrins themselves were not responsible, and further work has since been done on sorption methods for preparing concentrates relatively free from this trouble. Biological methods were worked out for the evaluation of the pyrethrum heavy-oil insecticides extensively used for the protection of stored food. Another piece of work dealt with the stability of certain pyrethrum preparations for prospective use as mosquito repellants. Methods of preparing standard pyrethrum-in-oil preparations were devised, and methods of chemical analysis of similar commercial preparations worked out and it was found that the biological and chemical techniques gave results which agreed fairly closely.

Attention has been concentrated recently on the biological assessment of stomach-poison insecticides : the susceptibility of insects as affected by strain, species, age and environmental factors : and on the investigation of certain potent synthetic compounds such as D.D.T. developed largely for war needs in order to ascertain their usefulness in the agricultural and horticultural field. Field-scale trials in conjunction with the Plant Pathological Laboratory of the Ministry of Agriculture were carried out with D.D.T. at several centres. It was shown that cabbage caterpillars and such pests as mustard beetle were completely controlled. Other pests were controlled to varying extents, but red spider and, to a less degree, certain aphides were resistant. Laboratory tests were also carried out on a wide range of insects and such points as potency and degree of persistence under weathering were studied. Work is in progress to test the effect of particle size and shape upon the toxicity of D.D.T., and a dipping technique for determining the insecticidal value of various types of preparations is being worked out. Account was taken of the effect of D.D.T. on beneficial insects and, jointly with the Bee Department, the toxic action on bees, both by contact and as a stomach poison, was studied. The results obtained so far indicate that the danger is less serious than was anticipated. The possibility of harmful effects on the plants themselves was also examined, and it was shown that cucumbers and vegetable marrow suffered some damage.

A prolonged research in which the various analogues of D.D.T. were compared showed that, molecule for molecule, D.D.T. was more toxic than its analogues but that the slopes of the respective regression lines were very different. An explanation of this is now being sought.

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THE DISEASES OF BEES

The researches of the Bee Department fall into three categories—(1) work on the physiology, behaviour and morphology of the healthy bee; (2) investigations on the pollination of fruit and seed crops; (3) researches on the diseases of adult bees and their brood. An advisory service is also maintained and some 4,000 to 5,000 samples of bees and combs suspected of disease are examined every year free of charge.

The spread of the disease known as foul brood had been viewed with some concern during the years preceding 1939. On the outbreak of war it was feared that the spread might be accelerated by the call-up of beekeepers and the consequent neglect of their colonies. The Rothamsted Bee Research Advisory Committee therefore drew up a plan for the control of foul brood by means of legislation which eventually became law as the Foul Brood Disease of Bees Order, 1942. It provides for the inspection of any premises on which bees are kept, within three miles of a suspected outbreak of foul brood, and for the compulsory destruction of all infected colonies in the area. The application of the Order has shown that in many areas the incidence of foul brood was in fact much higher than had been suspected and that the introduction of legislation was necessary. The returns for 1945 justify the hope that the cumulative effects of widespread neglect of the foul-brood problem prior to 1942 are now being overcome and that continued vigilance will result in a steady decrease in the incidence of disease in future years.

The use of sulphonamides fed in sugar syrup to colonies infected with American foul brood, first reported to the Department by Mr. C. A. Ekins of Surrey, has given highly promising results, and further work is in progress with a view to obtaining a method of treatment as an alternative to destruction of colonies infected with either American or European foul brood.

Another activity of the department is a survey of adult-bee diseases. During the 1914-18 war Isle of Wight disease caused losses estimated at 90 per cent. of the bee population of Britain. The situation was restored by a re-stocking scheme, by the discovery of the causal agent of the disease and by the subsequent development of control measures, though the trouble, better known now as Acarine disease, continued to occur in many districts. Surveys carried out in 1941-42 and 1943-44 were designed to determine the incidence and distribution of Acarine and other adult-bee diseases and to reveal, in time to prevent the possibility of disaster on the 1914-18 scale, any tendency for a disease or diseases to assume epidemic proportions. Fortunately there was no evidence of any serious situation arising and, as regards Acarine disease, the position showed some signs of improvement in the interval between the surveys.

THE APPLICATION OF STATISTICAL METHODS

On account of the great demand for statistical assistance in connection with a wide variety of war-time activities including military operations, new researches in statistical theory and method had necessarily to be curtailed. Apart from the war, however, the trend was in the direction of the fuller development of already

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established principles, for each type of problem requires its own specialised approach. There had in the past been a tendency to over-generalised treatment, and insufficient account was taken of the complexities to which each problem is subject. Many improvements on method and refinements of technique have been introduced, however.

One of the most valuable contributions of the statistician is in the design of experiments and the planning of experimental programmes. It is now becoming more generally recognised that the modern type of factorial design can greatly increase the information obtainable. If all combinations of several different sets of treatments or " factors " are included in one factorial experiment a number of interrelated aspects of the same problem can be studied simultaneously with considerable economy of space and with the advantage that the dependence of one treatment on the intensity of another can be determined. The advantages that come from being able to study variable material quantitatively, from asking several questions at a time and from obtaining unbiased measures of the effects of treatment and of experimental error are obviously invaluable in biological work.

Various references have already been made to the application of statistical methods in the work of the Station. Not only are practically all the field experiments of Rothamsted and its associated centres dealt with, but also many of the laboratory and other experiments. Numerous enquiries are also received from other institutions both in this country and overseas.

One of the most valuable contributions of the Statistical Department has been the preparation of critical quantitative reviews of all the experimental data on certain problems. An example is the summary of fertiliser trials already mentioned. Another instance is the investigation of the effect of changes in level of feeding of dairy cows on milk production. This review showed that overstringent rationing resulting from shortage of foods might result in a serious reduction in milk supply without any equivalent saving in food.

An investigation has just been begun to compare the economic value to the livestock farmer of temporary leys as compared with old grass. This forms only a small part of a much more general problem which is, broadly, the study of the agronomic and economic value of ley farming compared with other farming systems. This complex problem is naturally the affair of many other research stations besides Rothamsted.

During the war the importance has been realised of having accurate and reliable information on farming conditions, on agricultural practices, and on the incidence of diseases and pests. Such information is also useful in peace-time—for instance in the planning of research, but it was particularly necessary in war-time in planning the utilisation of scarce resources. The Statistical Department has been closely concerned with three major pieces of survey work of this kind : the Survey of Fertiliser Practice, the National Farm Survey and the Wireworm Survey. These projects are described in the detailed report.

The Survey of Fertiliser Practice revealed, amongst other things, the fact that farmers ploughing up old grassland had failed to

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recognise the deficiencies of lime and phosphate so common in such land. The National Farm Survey deals with such aspects as tenure, condition of farm, incidence of insect pests, quality of farming and supplies of electricity and water. The object of the Wireworm Survey was to evolve methods suitable for assessing wireworm infestation of particular fields so that advice could be given to farmers on cropping and preventive measures.

The classical and other field experiments

Field experiments continue to occupy a prominent place in the Rothamsted programme, and in addition to the large number of experimental plots on the farms at Rothamsted and Woburn many field experiments have been carried out on private and institutional farms in various parts of the country.

For many years, there has been co-operation with Mr. A. W. Oldershaw at Saxmundham and Tunstall, and this has been continued. In spite of, or perhaps because of, the war the number of modern experiments as distinct from the classical experiments on the Rothamsted farm has increased greatly. There are long-term experiments, including rotation experiments, to study the effects of deep ploughing, various methods of returning straw to the land, the response of fertilisers in relation to season, and several other problems. There are also annual experiments in which the effects of treatments are measured in a single crop.

The classical experiments have been continued. The earlier work by the Botany Department on the reduction of the weed-seed population of arable land by fallowing led to the establishment of a five-year cycle on Broadbalk whereby one section is fallowed each year. Samples taken annually over a long period of years support the conclusion that the routine fallowing of one section per year has fully justified itself, as the weed-seed population has not only been kept in check but has also decreased during the 15 years that the system has been in force. This is particularly so in the case of poppy which has been decreasing steadily since periodic fallowing was instituted in 1925. Recently, however, trouble has arisen from the spread of species of wild oats, and special experiments are being carried out to find, if possible, some effective way of controlling this weed.

The botanical analyses of the herbage of Park Grass and High Field that were slowed up during the war years are now being dealt with, and the accumulation of analytical and observational data for many years is being examined and prepared for publication in order to bring the ecological history of the plots up to date.

Because of the urgent need for food production the non-experimental areas on the farm at Rothamsted were farmed as intensively as possible. Old grassland was broken up and the arable acreage increased from 137 in 1938-39 to 308 in 1944-45, whilst the value of the produce sold for these years rose from £2,922 to £7,401.

The timber in Knott Wood was not included when the farm was purchased in 1934, and, when it was felled, we were left with an area of about 74 acres of derelict land full of tree stumps. Part was replanted and part has still to be dealt with, but an area of about 24 acres was reclaimed in a variety of ways. In one section the land

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was sown out to pasture without removing the stumps and without cultivation, in another cultivation was carried out, and in a third the tree stumps were also removed and the land has since been cropped.

The Crop Physiology Section has acted as a link between farm and laboratory, preparing the detailed plans of the field experiments and exercising general supervision from the laboratory side. This Section also carried out certain urgent investigations arising from the war. One of these was concerned with damage to crops that might be caused by war gases, and another with the storage of potatoes in clamps. These duties curtailed the work on the factors affecting leaf growth and leaf size on which the Crop Physiology Section is engaged.

Woburn Experimental Station

The work at Woburn (run by Rothamsted since 1926) has been continued under Dr. H. H. Mann. The light, somewhat sandy, soil is derived from the Lower Greensand and is in marked contrast to the fairly heavy soil from the Clay-with-Flints at Rothamsted. Woburn, therefore, provides a useful centre at which experiments carried out at Rothamsted can be repeated on a very different soil type.

The continuous wheat and barley experiments, commenced at Woburn in 1876, have been greatly modified, following fallows in 1927-28 and 1933-34 to get rid of weeds, and since 1940 the influence of previous manuring on the effectiveness of nitrogenous manures has been studied. Amongst the more recent work is a rotation experiment, similar to one at Rothamsted, with artificial manures only, which has been going on since 1930, and so far there is no sign of any deterioration in the crops. In 1938 an interesting long-term alternate-husbandry experiment was started to compare the fertility of soil, after three years under a grazed grass-and-clover ley, or under lucerne cropped annually for hay, with land which carries a well manured arable crop each year. Other experiments deal with cultivation problems, green manuring, the making of a market-garden soil, the manuring of sugar beet, take-all diseases of wheat and barley, and various other problems. Several lines of work are also being carried out in the pot-culture station including the studies on clover sickness commenced about 10 years ago : the conclusion has been reached that the disease is due neither to an eelworm nor to a fungus.

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