ROTHAMSTED RESEARCH

Report for 1957

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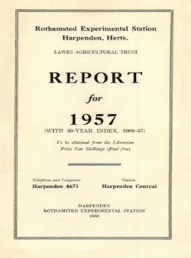

Introduction

Sir William G. Ogg

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INTRODUCTION

BY THE DIRECTOR

This is the fiftieth year for which the Rothamsted Annual Report has been published. A summary index covering this period has been included in this issue.

By the death of Sir John Simonsen on 20 February 1957 the Lawes Agricultural Trust Committee lost a valued member. He was appointed to the Committee in 1950 and had been Treasurer since 1952. He has been succeeded on the Trust Committee by Dr. L. E. Sutton and as Treasurer by Professor A. Robertson.

It is with deep regret that we record the death in June 1957 of Lord Clinton, who over a long period of years rendered great service to Rothamsted. He was Chairman of the Lawes Agricultural Trust Committee from 1925 to 1937 and a Trustee from 1929 until his death. He has been succeeded as a Trustee by the Marquess of Salisbury.

We also record with regret the death of Mr. C. T. Gimingham, a former director of the Ministry of Agriculture Plant Pathology Laboratory; he was on the Rothamsted staff from 1905 to 1907 and from 1923 to 1928.

Three members of the staff who have given long and devoted service to Rothamsted retired at the end of September: Dr. H. G. Thornton, who had been head of the Soil Microbiology Department since 1920; Dr. Katherine Warington, who joined the Botany Department in 1921 and did pioneer work on trace elements; and Miss M. M. Browne, a member of the staff of the Plant Pathology Department since 1927, who was awarded the M.B.E. in the New Year's Honours list. Dr. P. S. Nutman was appointed head of the Soil Microbiology Department, of which he has been a member since 1939.

Sir William Ogg was elected a Corresponding Member of the All-Union Academy of Agricultural Sciences of the U.S.S.R., and at the invitation of the Academy visited Moscow to attend the Anniversary Session and receive his scroll of membership. Other visitors to the U.S.S.R. were Dr. P. W. Arnold and Dr. J. L. Monteith, who spent a month there under an exchange arrangement, and Dr. R. Greene-Kelly, who is working in the Faculty of Geology and Soil Science of the University of Moscow for nine months under an exchange scheme between the Academy of Sciences of the U.S.S.R. and the Royal Society.

Dr. J. M. Bremner was awarded a Rockefeller Foundation Fellowship and is dividing a year between Iowa State College and the University of Illinois. Dr. E. W. Buxton visited the University of California and research institutes in the U.S.A. with a Kellogg Foundation Fellowship. The National Research Council of Canada awarded a post-doctorate Research Fellowship to Dr. Gillian N. Thorne, enabling her to work in the Science Service Laboratories in Ottawa for a year; and Mr. H. D. Patterson accepted a Visiting

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Professorship at the Institute of Statistics, University of North Carolina. Mr. R. H. Kenten and Mr. A. J. Arnold have been seconded to the West African Cocoa Research Institute, Ghana, and Mr. G. V. Dyke to Hunting Technical Services to work on a land improvement scheme in Iraq.

Mr. F. C. Bawden attended meetings of the Advisory Committee for Agricultural Research in the Sudan, and Dr. F. Yates visited the Indian Statistical Institute and the Indian Council of Agricultural Research. Mr. F. G. W. Jones took part in a nematology " Seminar-Workshop " held at the Agricultural Experiment Station, Knoxville, Tennessee, and visited research centres in Alabama and Florida. He also attended meetings in Munster as Advisory Editor of *Nematologica* and as a member of the Governing Board of the Society of European Nematologists. Dr. H. Greene, Adviser on Tropical Soils, visited Malta, Pakistan and several East African territories. Mr. D. H. Boalch attended meetings of the Executive Committee of the International Association of Agricultural Librarians and Documentalists in Paris, and Dr. K. Mellanby went to Amsterdam for the first editorial meeting of *Entomologica experimentalis et applicata.* Dr. G. W. Cooke visited laboratories in Holland and France for discussions on phosphate fertilizers; Dr. A. Muir and Dr. D. A. Osmond took part in the F.A.O. Working Party on Soils at Bonn. Dr. P. W. Murphy, a member of the Zoology Committee of the International Society of Soil Science, visited Geneva for discussions on the organization of the International Colloquium on Research Methods in Soil Zoology to be held at Rothamsted in July 1958.

Sir William Ogg attended the International Potash Congress in Vienna. At the invitation of the Royal Society Dr. H. L. Penman was a delegate to the Pacific Science Congress in Thailand. Mr. F. C. Bawden took part in the International Congress on Poliomyelitis in Geneva and in Symposia on Viruses and Virus Diseases in New York and Madison. Mr. N. W. Pirie attended conferences on " Cellular biology, nucleic acids and viruses " organized by the New York Academy of Sciences and the Poliomyelitis Foundation. He also took part in a conference on " The origin of life on the earth " arranged by the Academy of Sciences, Moscow, and the International Union of Biochemistry. Mr. M. V. Tracey accepted the invitation of the U.S. Navy to a symposium on " Marine Biology " in Seattle. Dr. J. B. Free attended the Congress of the International Union for the Study of Social Insects and Dr. O. Talibudeen the UNESCO International Conference on Radioisotopes in Scientific Research, both held in Paris. Rothamsted sent delegates to the 16th International Congress of Pure and Applied Chemistry in Paris, the 4th International Nematology Symposium in Hamburg, the 4th International Congress of Crop Protection in Hamburg, the 30th Session of the International Statistical Institute in Stockholm, the 3rd International Conference on Potato Virus Diseases at Wageningen and meetings of the International Institute of Sugar Beet Research.

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Visitors

Visitors to the Station included Lord Hailsham, Lord President of the Council; Mr. W. M. Seivwright, Minister of Agriculture, Jamaica; Mr. S. P. Le Roux, Minister of Agriculture, Union of South Africa; Mr. L. R. Abavona, Minister of Agriculture, Ghana; Mr. L. Korbut, Embassy of the U.S.S.R.; Dr. Corcinschi, Roumanian Minister in London. Among scientific visitors were Professor N. J. Thomas, of Ontario Agricultural College; Dr. L. D. Baver, Director of the Experiment Station of Hawaiian Sugar Planters' Association; Professor Belina of Warsaw University; Professor Litynski of Cracow University; Professor Imshenetsky, Director of the Institute of Microbiology of the Academy of Sciences of the U.S.S.R.; Professor Lazarenko of Lvov University with a party of clay mineralogists; delegations of Russian drainage experts and agricultural engineers. Three Russian scientists, Professor F. E. Kolyasev of the Agro-physical Institute of Leningrad; Mr. D. A. Korenkov of the All-Union Research Institute of Fertilizers and Soil Science, Moscow, and Mr. G. S. Muromtsev of the All-Union Research Institute of Microbiology, Moscow, stayed at Rothamsted for a month on an exchange basis.

The Work of the Station

In the **Physics** Department much attention is being given to clays. Studies of water uptake suggest that the slaking action of water on dry clays or clay soils is caused by rapid swelling of the clay, entrapped air being a rare and very minor contributory factor. Slow uptake of water, from a humid atmosphere, for instance, permits gradual swelling with time for readjustment of the clay structure, and such material remains coherent when flooded; whereas dry clay wetted quickly will disrupt. In field conditions, as one would expect, water vapour diffuses downwards ahead of the liquid wetting front, so confining the slaking action to a thin surface layer. Further studies of the electrical charges on kaolin have led to the suggestion that the charge distribution may be such that large electrical stresses are set up at the edges of the kaolin crystals, causing crumbling to a debris that greatly affects the physico-chemical behaviour of the clay.

Crop environment (microclimate) work has been concentrated on spring wheat; a new technical development is a balance that gives a continuous measure of transpiration or condensation. The records obtained show that short-period fluctuations in the rate of water uptake by the wheat follow very closely the changes in sunshine intensity. The irrigation experiment at Woburn showed good crop responses to watering in the dry spring and early summer of 1957, the yield of beans—a new test crop in this experiment—being doubled by 4 inches of irrigation between April and July. The first few cuts of grass showed a benefit, but from mid-July onwards there was adequate rain for all crops.

The results of a ploughing experiment started at outside centres in 1944 have been published. On average, over a range of loam soils, deep ploughing (to about 14 inches) increased potato yields

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by about ½ ton/acre as compared with shallow ploughing (to about 8 inches). On organic soils, deep ploughing decreased yields.

Several series of field experiments testing fertilizers carried out by the **Chemistry** Department were concluded in 1957 and are being summarized. Experiments during the past three years emphasize the large seasonal variations in the returns from nitrogen fertilizers; for wheat and potatoes in 1956 and 1957 only half as much nitrogen was necessary for maximum profit as in 1955. Over the same period there has been no advantage from the common practice of splitting the nitrogen dressing for winter wheat. Applying the whole dressing in spring has been as satisfactory as applying part when sowing and the remainder as a top-dressing in spring. Experiments with calcium nitrate have shown that heavy dressings damaged germination and early growth of all crops under conditions where an equivalent amount of ammonium sulphate was harmless. Similar damage was reported last year from the use of urea containing an appreciable amount of biuret. Neither material is used to any extent in this country at present, but their use may increase, and these drawbacks require thorough investigation. Experiments on vegetables have not shown greater yields from concentrated organic nitrogen fertilizers as compared with ammonium sulphate, which is much cheaper.

Experiments on phosphate fertilizers have shown that none of the materials tested is superior to superphosphate. Dicalcium phosphate dihydrate gives as good yields for many crops and on many kinds of soil, but as produced at present its physical condition —a dusty powder—is unsatisfactory.

Processes involving the use of nitric acid to attack rock phosphate or the ammoniation of superphosphate are possibilities in the future, but generally the products contain dicalcium phosphate, which, in granulated form, tends to be slow-acting. A nitrophosphate made on pilot plant scale proved to be much inferior to fertilizers based on superphosphate. An ammoniated compound fertilizer which had half of its phosphate in water-soluble form was more promising, the phosphorus it contained proving nearly as satisfactory as that in superphosphate. Experiments with Gafsa rock phosphate showed it to be of little value for grass on acid soils but much more useful for kale and swedes. There was no advantage from grinding it more finely than is specified in our Fertilizer Regulations.

Progress has been made in using a radio-isotope of phosphorus to investigate the way in which soils supply phosphate to crops. Appreciable amounts of soil nitrogen may be fixed by clay minerals, and in some subsoils half of all the nitrogen present was found to be combined in this way. Further progress has been made in elucidating the nature of the soil nitrogen combined with organic matter. Field investigations at both Rothamsted and Woburn show that ammonium salts are converted to nitrate much more slowly than was supposed. Average summer rainfall did not wash nitrate out of the surface layers, but it was leached out during prolonged wet weather. Rapidly growing grass quickly removed all nitrate or ammonium supplied by quite heavy fertilizer dressings. Laboratory work on the mats which often form on permanent pasture, particularly on marginal and hill land, show that these are

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associated with acid conditions and deficiency in bases. Besides mechanical treatment, adequate liming is essential to bring about their decomposition.

In the **Pedology** Department the determination of clay minerals in soils and rocks forms an important contribution to the work of the Soil Survey by assisting with soil correlation and classification. Among soils from abroad that have been examined, some from Somaliland contain an uncommon clay mineral (palygorskite) similar to that widely found in soils from the Middle East and derived from rocks of similar age. An unusual mineral (jarosite) has been found associated with peaty soils in Romney Marsh and with soils derived in part from Oxford clay. It is a basic sulphate of iron and potassium, and probably comes from the sulphides formed in the peat or existing in the clay. In connection with the study of the mechanism of aggregate formation in soils, an investigation of the micro-structures of clay powders has shown that with montmorillonite, a swelling clay, the surface area is very sensitive to small additions of water, although the aggregates have considerable rigidity at low water contents. Further work has been done on the mineral beidellite; in this the new electron microscope, with the aid of which it is possible to measure platelets down to 10 μ thick, is proving invaluable.

In the study of trace elements of the Lower Lias clays, associated with the disease known as " teart " in stock, a correlation has been found between the heavy metals (e.g., molybdenum, copper, etc.) and organic matter and also to some extent with carbonate content. In South Wales most of the Lias clays have a low molybdenum content, which fits in with the apparent absence of " teart " in that area. The trace element content of soil on Broadbalk field at Rothamsted is remarkably uniform, considering the varied and long-continued manurial treatments. As might be expected, the unmanured plot in general shows the lowest contents of the various metals.

In the study of aqueous leaf extracts, further work has been done on the nature of compounds which are active in mobilizing iron and other elements in soils.

The current programme of the **Soil Microbiology** Department deals with two main topics, the ecology of soil micro-organisms and various aspects of the nitrogen cycle. Because it bears upon the practical question of assessing the contribution of the free-living nitrogen fixers to the nitrogen resources of the soil, a study has been made of the distribution of Azotobacter in certain soils. This has revealed differences due to seasonal influence as well as to cropping and manurial treatment. Investigations on symbiotic nitrogen fixation have been continued. These include selection and breeding work on strains of red clover which are defective in the power of fixing nitrogen. Studies on the initial infection of clover roots by nodule bacteria include an examination of the relation of the primary pattern of root-hair infection to actual nodule formation. All soils in which legumes have been grown for more than one season develop a bacteriophage active against the nodule organism, and a study is being made of the relationship between bacteria and phage in an attempt to ascertain what may be happening in soil to change the properties of nodule bacteria.

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The inhibition of germination of fungal spores by certain aerobic spore-forming bacteria has been demonstrated in all soils examined except those with very acid reaction. This has an important bearing on the control of soil-borne diseases. Germination of some fungi is completely inhibited; in other cases chlamydospores form immediately after germination. The inhibiting action disappears in the close proximity of growing roots; this action of root exudates is being investigated. Further work on the bacterial decomposition of herbicides in soil is in progress.

Earlier work in the **Botany** Department has shown that variations in yield of crops are brought about mainly by changes in leaf area and that changes in the photosynthetic efficiency of the leaves (net assimilation rate) are relatively much less important. More attention is therefore being given to investigating factors that affect leaf growth, an aspect of plant physiology that has been neglected. A study is being made of the changes brought about by nitrogen, phosphorus and potassium in the leaf area per plant by affecting the rate of production, expansion and length of life of leaves. Gibberellic acid sprayed on potato leaves increased their size without much affecting their photosynthetic activity, and so in a short period increased yield; but it caused deformations of the tubers. Reduction in yield in a sugar-beet plot which had insufficient soil moisture was accounted for almost wholly by reduced leaf growth. There were indications in the same experiment that irrigation water applied in small amounts gave slightly greater increases in yield than the same amount given at one watering. An experiment on barley confirmed previous work on kale and sugar beet in showing that there is not much, if any, scope for increase of yield by increasing leaf area at the time it is high; increased dry-matter yield depends, therefore, on extending the period of high leaf area, but the grain yield of cereals depends on photosynthesis in the ears as well as in the leaves. Striking confirmation has been obtained of the fact that it is the upper leaves of a crop that do most of the photosynthesis.

From the weed-control studies there is further evidence that, under temporary ley, the population of wild oats decreases only slowly after a rapid fall in the first year or two. Stubble burning stimulated germination of wild oat seeds at or near the surface, but most of the seeds in the soil were not affected. Further work has been done on the physiological effect of virus infection.

In the **Biochemistry** Department the location and state of enzymes in the leaf are being investigated in subcellular fractions damaged as little as possible by the extraction process. In previous work the ribonuclease and phosphatase associated with microsomes have been studied, but attention is now being given to the larger or mitochondrial fraction of the cell, since it is known that the oxidation mechanisms of many other tissues are associated with this fraction. Many difficulties have been encountered in making mitochondrial preparations from leaves in anything like a pure state, but their oxidizing properties have been demonstrated. The processes that convert latent into active enzymes are also being studied. The phenol oxidase of broad-bean leaves is activated by exposure to acids, alkalis and detergents. An understanding of the conditions

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necessary for activation of this enzyme may shed light on other enzyme activations and on the manner in which variations in the protein content of a leaf is reflected in its enzymic composition. Further work has been done on the thiaminase of bracken, and amine oxidase is being tested with more complex substrates in order to make alkaloids with more complex structures than those made hitherto. Previous experience with the catalytically active metals and oxidative enzymes is now being applied to a study of the factors controlling blackening in potatoes. Work on the enzymic and possibly non-enzymic processes leading to loss of infectivity by fragmented portions of tobacco mosaic virus continues, and also the work on chitinase and other enzymes in connection with the study of soil organic matter. Progress has been made in isolating the hatching factor of the potato-root eelworm. The technique for extracting leaf protein has been improved and the product, which is now nearly tasteless, can be given a wide range of flavours to make it acceptable as human food. Pig and chicken feeding experiments in other institutes show that it has the nutritive value expected from its amino acid composition.

Further progress was made in the **Plant Pathology** Department in finding treatments to free vegetatively propagated plants from viruses; a preliminary trial with a clone of King Edward potatoes, rendered virus-free by treatment, indicated that this may yield better than commercial clones. The mild winter and spring led to unusually early and heavy aphid infestations, and in consequence virus diseases were extremely prevalent. In previous years, spraying potatoes with DDT has proved adequate to control leaf roll, but this year aphids were on the plants as soon as they emerged, and it is unlikely that spraying will have been so beneficial. Because of the early infestation of beet crops, warnings were issued to farmers and over 100,000 acres were sprayed against aphids. Where spraying with " Metasystox " (applied at high or low volume) was timely, virus yellows was checked and increases in yield of roots up to $4\frac{1}{2}$ tons/acre were obtained; but where spraying was delayed until aphid infestation was established, it gave no benefit. Breeding against yellows shows promise. Inbred lines of beet previously selected for their resistance to yellows out-yielded commercial lines by more than 25 per cent in places where yellows was severe. Of the four cereal viruses being studied, barley yellows dwarf was exceedingly prevalent. It infects many grasses, is transmitted by several aphid species and occurs in strains of different virulence, as does ryegrass mosaic virus, which is transmitted by eriophyid mites and also infects many grasses. Weather studies and other work on apple scab caused by the fungus *Venturia inaequalis* was continued in an attempt to improve the forecasting and prevention of outbreaks. This disease is now better controlled in the Wisbech area than previously, though fewer sprays are applied. Further studies on eyespot and take-all confirmed the importance of preceding crops on the incidence of these cereal diseases. Wheat, barley and oats, but particularly wheat, yielded better on land which had carried potatoes or beans the previous year. Take-all was unusually severe on Broadbalk, especially where lime had been applied to plots that were previously acid. Attempts to prevent pea wilt by treating

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infested fields with fungicides only delayed the onset of the disease, and resistant varieties seem to offer the only method of control. Even these may be only temporarily effective, because the fungus readily produces new forms able to infect previously resistant plants.

In the **Nematology** Department work continues on eelworm species of economic importance. Investigations have recently been started on migratory nematodes that move about in the soil, feeding on roots with or without actually penetrating into them. Some species are widespread in permanent grassland and in various cultivated crops, and their occurrence may have to be taken into account in considering crop sequences and rotations. A beginning has also been made in the study of the pea-root eelworm with experiments to determine the effect of different levels of infestation on the growth of peas, field beans and broad beans. Further work has been done on cereal-root eelworm and cabbage-root eelworm. Irradiation of infested mushroom compost has shown that heavy dosage rates of gamma rays are required to kill the nematodes, many of which are harmful in mushroom production. A number of small soil-inhabiting insects and allied animals have been found which feed on nematodes, especially on the white immature females of the cyst-forming kinds. An attempt is being made to find out what part these predators play in limiting field populations of nematodes injurious to crops. Much attention continues to be given to the potato-root eelworm. Experiments on the effect of nematicides on the cysts have shown that hatching tests designed to assess the kill obtained must be continued until hatching ceases if reliable results are to be obtained; it is not sufficient to judge the effect of nematicidal treatment by tests run for short, fixed times. During the year the potato-root eelworm has been successfully cultured on tomato roots in sterile root culture, and it is hoped that this will help in the elucidation of the reproductive cycle of the eelworm and enable advances to be made on problems connected with its physiology. This may also throw light on the races of the eelworm which can break the resistance of crosses between cultivated potato varieties and wild potatoes from the Andes. A high proportion of field populations contain resistance-breaking forms, and these increase each time that resistant potato hybrids are grown. The wild potato, *Solanum vernei*, proved more or less resistant to all populations of eelworm against which it was tried.

In the **Insecticides** Department further research has been done into the effect of organophosphorus compounds on the esterases present in insects and into the various factors, such as temperature, which affect the toxicity of insecticides. The study of the pyrethrins has also been continued and a chemical method evolved for the preparation of Pyrethrin I and Pyrethrin II in pure form from pyrethrum extract in sufficient quantities for large-scale experimental work. The fact that the relative toxicity of the four active constituents of pyrethrum appears to differ with the species of test insect makes the assessment of their relative value as insecticides difficult.

On fungicides, the effect of temperature on the toxicity of mercury salts to fungus spores is being investigated.

Further field experiments have confirmed that one correctly

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timed spraying with a systemic insecticide can control bean aphid and give large increases in yield of spring beans in years when aphid attack is severe. In work on the effect of chemical control on the natural enemies of the bean aphis it was shown that in early June when insecticides were applied predators were uncommon, and that the spraying did not upset the natural control by predators in July and August. Low and high volume applications were equally satisfactory in the case of systemic insecticides; with contact insecticides high volume appeared to be more effective. In collaboration with the Plant Pathology Department, further work was done on the chemical control of the vectors of potato viruses. The search for improved chemical methods of controlling wheat-bulb fly has continued. No consistently effective spraying method has been found, and for seed treatment nothing that has been tested is more satisfactory than dieldrin and heptachlor. Dieldrin, either drilled with the seed or applied at a high rate as a seed dressing, has so far proved the most effective control measure, but the cost is considerable. Laboratory experiments showed that chlorinated hydrocarbon insecticides, such as dieldrin, applied as seed dressings, are taken up by the seedling wheat plant and have an important systemic action; in work on the relative importance of contact and systemic action of seed dressings it was shown that the former may be relatively unimportant unless the seed is sown close to the soil surface.

Although most insect and farm pests can be controlled by insecticides and fungicides, there is no cure for slug attack on a farm scale, and the **Entomology** Department has re-started work on the subject. The life cycle of the various species, and methods of estimating populations more accurately on a field-scale, are being studied. New work has also been begun on the ecology and biology of the frit fly, which in recent years has done considerable damage on Rothamsted farm.

Some progress has been made with the investigation of the effects of climate on the metabolism and behaviour of insects. Many larvae, even those found in the soil, may suffer from dehydration, and the upset in water balance renders them less able to survive exposure to unfavourable temperatures. Some species of insect are much more cold-hardy than others, and there is considerable variation within the same species, depending apparently on the conditions under which they have been reared; it appears that there is no direct relationship between the properties of their tissue fats and ability to withstand high or low temperatures. So far, we cannot foretell accurately how winter temperatures will affect survival of insect pests, but acclimatization plays an important part. Further detailed studies have been made on the wheat-bulb fly, both in the field and the laboratory, and on insect populations. The latter have dealt particularly with the establishment and growth of aphid populations under various conditions, and with the importance of parasites, predators and attendant ants. Work on gall midges continues. The importance of these pests and the value of the service given by the department in this connection is demonstrated by the fact that in the first three months of 1957 over a hundred inquiries, from twenty-two countries, were received on this subject. Some progress has been made with the study of

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forest soils, particularly in determining the rate of disappearance of leaf litter from the forest floor and on the biology of mites found in these types of soil. Although much work has been done on earthworms, there is still much to be learned about the part they play in maintaining or improving soil fertility, and further studies are being carried out on worm populations in marginal land and in orchards where insecticides and fungicides may drastically reduce the soil fauna.

Direct experimental evidence has been obtained by the **Bee** Department that " queen substance ", which the worker bees lick from the body of their queen, plays a very important role in controlling colony behaviour. An ethanol extract of this substance, prepared from queens and fed in distilled water to a group of queenless worker bees, caused them to behave as though they possessed a queen. Drifting or wandering of bees from one colony to another can result in the transmission of disease, and if extensive, can nullify records of honey production and breeding programmes based on them. Attempts to prevent this undesirable phenomenon have shown that much more attention should be paid to the directions in which the hives are facing than to their colours. Drifting is reduced to a minimum by arranging the hives in irregular formation, painting them different colours and, above all, facing them in different directions.

The importance of weather conditions and nectar flow in determining the incidence of both Nosema and Acarine diseases has been demonstrated, good nectar flows being correlated with marked reductions of Acarine infection. It has been shown that the death of a colony from this disease in winter is unlikely to occur unless 70–80 per cent of its members are infected in the previous autumn. Further attempts are being made to find a practical means of controlling European Foul Brood. Work on swarming behaviour has shown that brood rearing, swarming and honey storage do not, as has been widely believed by beekeepers, form a sequence in the summer cycle of behaviour of honeybee colonies; all show a similar distribution throughout the season. Other subjects investigated include the size of the apertures in wire gauze through which bees can feed one another—important in introducing queens in cages—and the efficacy of some of the simple methods for extracting wax from old combs.

In the **Statistics** Department the electronic computer has continued to give reliable service and has enabled much more work to be handled, the results dealt with being double and the actual analyses treble the numbers dealt with in 1956. A Pye magnetic-tape transport store unit presented by the National Research Development Corporation is being linked up with the machine. Several long-term experiments have been statistically analysed, including the six-course rotation experiments at Rothamsted and Woburn, the Woburn ley–arable experiment and experiments comparing the fertilizer responses of crops grown with and without farmyard manure. Close collaboration has been continued with the National Agricultural Advisory Service on the design and analysis of crop and animal experiments, and assistance given to them and to other bodies, including the Agricultural Research

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Council Statistics Group at Cambridge, in the summarization of experimental data.

The Survey of Fertilizer Practice, carried out in conjunction with the National Agricultural Advisory Service, was considerably extended in 1957 with the co-operation of the Fertiliser Manufacturers' Association, forty-five counties or part counties being surveyed. The analysis of the data was carried out, for the first time, on the electronic computer, which has considerably speeded up the preparation of the reports. Assistance is being given in a national survey of the diseases of dairy cows which has been undertaken by the Ministry of Agriculture, Fisheries and Food, and in various other surveys of animal diseases and fertility. There has also been co-operation with the National Institute of Agricultural Engineering, the National Vegetable Research Station, the Pest Infestation Laboratory, the Milk Marketing Board and other organizations.

The number of experimental plots dealt with by the **Field Experiments** Section and **Farm** staffs has more than doubled in the last 10 years, and now stands at about 3,400 full-scale plots and a large number of microplots. With this expanding programme the provision of suitable sites for experiments will shortly become a problem. On the Rothamsted estate, after deducting woodlands, allotments, roads and unsuitable portions of fields, the area available for experiments amounts to just over 300 acres. About 65 acres are taken up by the classical and other long-term experiments, leaving about 250 acres, of which only 85 are suitable for critical experiments on phosphorus and potassium.

The season was remarkable for the absence of winter frosts, resulting in the worst seedbeds for many years; a drought followed, and the spring-sown crops had a bad start. They made a good recovery, however, and yields were only slightly below average. Broadbalk was harvested by combine harvester for the first time; the straw was baled and weighed. The plots of the Agdell rotation experiment were again manured with nitrogen only and cropped with potatoes to study residual effects from the long-period mineral treatments. Similar work on residuals from an old classical experiment was carried out on the Exhaustion Land, where six different crops were grown instead of the usual barley crop. The deep ploughing experiment has been stopped after two complete six-course rotations, and the results have been summarized. Ploughing to a depth of 12 inches (compared with 6 inches) has not been very successful in Rothamsted soil. Its most consistent effect has been on sugar beet, where the increase has averaged 2·9 cwt. sugar/acre or 6 per cent of the mean yield. The average effect on potatoes and wheat over the 12-year period has been negligible. The after effects of deep ploughing on barley, oats and hay (which had normal depth of ploughing) were also negligible. The interactions of deep ploughing with various manurial treatments have also been examined. For sugar beet there was no advantage from ploughing-in dung to 12 inches depth; the dung gave a rather bigger return when ploughed-in to the shallower depth. Phosphate and potash did better when ploughed-in than when harrowed into the seedbed. For potatoes, fertilizers gave better results applied in the ridges than ploughed-in.

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At Woburn the permanent wheat and barley areas are again being cropped following a period of fallow, during which the land has been limed to correct acidity. The occurrence of potato-root eelworm has necessitated the substitution of sugar beet for potatoes as the first test crop in the ley–arable experiment. In the same experimental area, lucerne-stem eelworm has been found, and certain plots have had to be ploughed up as a control measure. Some of the infested land is being used by the Nematology Department for experimental purposes.

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