ROTHAMSTED RESEARCH

Report for 1953

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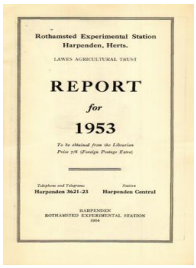

Introduction

Sir William G. Ogg

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INTRODUCTION

By The Director

It is with very deep regret that we record the deaths of Dr. Winifred E. Brenchley, Dr. Tom Goodey and Mr. Arthur Oggelsby, all of whom were held in affection and esteem by the staff. Dr. Brenchley, who retired from the headship of the Botany Department in 1948, came to Rothamsted in 1906, and was the first woman member of the staff. She not only achieved eminence in her subject but did a very great deal for the social life and welfare of the Station. Dr. Goodey, after two short periods of service on the staff (1912–13 and 1920–21), returned as Head of the newly-formed Nematology Department in 1948, but during the intervening years he was closely associated with Rothamsted, both socially and professionally. He was one of the leading nematologists in the world, and his friends will also remember his high spirits and his accomplishments as a singer and actor. Mr. Arthur Oggelsby, who gave many years of valuable service to the Chemistry Department and later was Head Storekeeper, retired in 1951 after fifty years at Rothamsted. He was one of the last links with our founders, for Sir Henry Gilbert was still Director when he joined the staff.

Sir Edward Salisbury, a representative of the Royal Society on the Lawes Trust Committee since 1940, retired from it during the year, and his place was taken by Sir Lawrence Bragg. Miss L. M. Crump, a member of the Microbiology staff since 1918, retired in October. In addition to her valuable scientific services, she took much interest in the library, particularly in the collection of early books. Dr. F. M. Roberts, of the Plant Pathology Department, who returned from secondment to the Clove Research Scheme, Zanzibar, resigned to take up a post in Jamaica under the Colonial Agricultural Research Service, and Dr. T. W. Tinsley's secondment to the West African Cacao Research Institute has been extended for a further tour of eighteen months. At the invitation of the Colonial Office and the Government of Nyasaland, Dr. A. Muir took charge of a soil survey of the Shire Valley area in connection with an extensive land development project; Dr. D. A. Osmond is in Cyprus for six months initiating a soil survey. Dr. J. Meiklejohn has returned after spending a year at the East African Agriculture and Forestry Research Organization, Nairobi, where she was working on problems of soil microbiology. Dr. P. S. Nutman, of the Microbiology Department, was awarded a three-year Senior Research Fellowship by the Commonwealth Scientific and Industrial Research Organization (Australia) to work in Canberra, and Dr. W. R. Smithies, of the Biochemistry Department, was awarded a one-year Fellowship of the National Research Council of Canada to work in the Council's Department of Applied Biology in Ottawa. Both are on leave of absence. Mr. B. W. Avery returned after spending a year with the Soil Survey of New Zealand in exchange with Mr. E. Cutler.

Several members of the staff made shorter visits abroad in connection with various projects. Dr. E. M. Crowther made a tour

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in the Sudan and East Africa at the request of the Sudan Government, the Empire Cotton Growing Corporation and the Colonial Advisory Committee on Agricultural Research; he also attended a Specialist Conference on Fertilizers at the East African Agriculture and Forestry Research Organization and the Annual Research Meeting of the Sudan Ministry of Agriculture. Dr. F. Yates visited India at the invitation of the Food and Agriculture Organization of the United Nations to advise the Indian Council of Agricultural Research on the development of their Statistical Branch, and Dr. D. A. Boyd spent six weeks in Rome, Greece and Cyprus as consultant on experimental design to the F.A.O. Working Party on Mediterranean Pasture and Fodder Development. Mr. G. E. Hodnett was one of the instructors at an eight-week course held at the African Training Centre for Agricultural Statistics at Ibadan, Nigeria. Dr. B. G. Peters spent three months at the Connecticut Agricultural Experiment Station to advise on nematological problems, and Dr. C. B. Williams and Mr. R. A. French visited the Mediterranean coast to study the autumn southward movement of insects in that area.

Representatives from Rothamsted attended the Ninth International Genetics Congress and the Third International Biometric Conference, both held at Bellagio, and the Twenty-eighth Session of the International Statistical Institute in Rome; the Sixth International Congress of Microbiology and the Symposium on the Interaction of Viruses and Cells, which took place simultaneously in Rome; the Fourteenth International Congress of Zoology in Copenhagen; the Thirteenth International Congress of Pure and Applied Chemistry in Stockholm, and the meeting of the International Institute of Sugar Beet Research in Bergen op Zoom. Mr. F. C. Bawden accepted an invitation to participate in an International Symposium on the Dynamics of Virus Infection held at the Henry Ford Hospital, Detroit; and, at the invitation of the Research Council for Ontario, Dr. H. L. Penman attended a Meteorological Conference in Toronto. At the request of Professor E. C. Wassink, Director of the Laboratory of Plant Physiological Research, University of Wageningen, Dr. D. J. Watson gave lectures in a course on photosynthesis in Wageningen.

Dr. F. Yates was awarded the Weldon Memorial Prize given by the University of Oxford for outstanding work in biometrical science. Mr. M. H. Westmacott was granted leave of absence for six months to take part in the Everest Expedition. Sir William Ogg was elected President of the Society of Chemical Industry.

Visitors

There were several thousand visitors to the Station during the year, including many farmers. Amongst the overseas visitors were the Ministers of Agriculture from Norway and from Western Nigeria, the Yugoslav Ambassador, the Paramount Chief of Swaziland, the Senior Chief of Bechuanaland, the heir to the Paramount Chieftainship of Basutoland, the Secretary-General of the Israeli Ministry of Agriculture, the Under-Secretary of State for Agriculture and the Director General of the Agricultural Department of Siam, a party of six United States Congressmen and a group of

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French Scientific Editors. Many organizations visited the Station, including the Institute of Biology, the Geological Association, the British Mycological Society, the Organization for European Economic Co-operation, the Empire Cotton Growing Corporation, the B.B.C. European Farm Organization and the Nuffield Foundation Survey Team of Architects. Overseas scientists who spent some time at Rothamsted included Dr. M. M. Burns, Principal of the Canterbury Agricultural College, New Zealand, Professor L. Davis of the University of California, Dr. Jonathan Garst of California, and Dr. C. S. Piper and Professor J. G. Wood of the University of Adelaide.

Buildings

Since the war there has been a rapid expansion in the scope of Rothamsted's activities. In addition to considerable growth in size of existing departments, two new departments, Pedology and Nematology, have been set up; two sections, Biochemistry and Bees, have been expanded into departments; the headquarters of the Soil Survey of England and Wales has been transferred to Rothamsted, and a Statistical Research Service has been set up in conjunction with the Statistics Department. As a result, the staff of the Station has more than doubled in numbers during the past ten years, and accommodation problems had become very acute. In order to meet the most pressing needs, several new buildings are being provided. One of these is the first instalment of a block which will ultimately house all the departments of the Plant Pathology group. Other buildings of a less permanent character are being erected to ease the congestion in the Statistics Department and to provide for fertilizer experiments and the work on the production of leaf protein. An extension of the Plant Pathology potting sheds and a new insectary have been completed. A historical account of the Manor of Rothamsted, now used as a Hall of Residence, has been written by Mr. D. H. Boalch, the Station's Librarian.

The Work of the Station

The **Pedology** Department is studying the weathering of rocks and the formation and classification of soils, and it works in very close association with the Soil Survey of England and Wales. Much attention is being given to soil and clay minerals, and the work is not confined to this country. Mineralogical studies of soils of the Athi Plain in Kenya and of the lower Shire River area in Nyasaland are throwing light on the nature of their parent materials. Good progress has been made in the survey of clay minerals, improvements have been made in techniques, and one or two new minerals discovered. These studies, which appeared somewhat academic, are beginning to have possible practical applications, for it has been found possible to characterize the clay mineral responsible for potash fixation in certain soils. Should this prove to be generally the case, we shall have a useful diagnostic criterion for this important soil property. A detailed comparison is being made of the soils in Broadbalk field and the adjoining strip (Broadbalk Wilderness), which has been uncultivated and under natural vegetation since 1882. There appears to be very little change either in the soil

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profile or the composition of the clay, but the structure of the surface soil in the Wilderness has improved through an increase in organic matter. Investigations are being continued into the minor-element content of soils in various parts of the country, and a number of copper- and zinc-deficient samples from Wales are being studied. The work on soils with impeded drainage has been widened in scope, and interesting information obtained on the movement of iron and aluminium in the soil profile. Satisfactory progress has been made on the Soil Survey of England and Wales—nearly 300 square miles having been mapped in various parts of the country and advice and assistance given on several projects.

In the **Chemistry** Department much attention has been given to assessing by laboratory tests and field experiments the agricultural value of phosphate fertilizers insoluble in water. This is important at the present time, when attempts are being made by manufacturers to effect economies in sulphuric acid by using new processes which give high proportions of the phosphate in forms insoluble in water. Two series of co-operative field experiments planned and co-ordinated at Rothamsted have been carried out in collaboration with soil chemists of the National Agricultural Advisory Service, the Macaulay Institute and the Northern Ireland Ministry of Agriculture. The general results emphasize the outstanding merits of water-soluble phosphate on most classes of land, especially when used as a " starter dose " and placed close to the seed. Some of the insoluble forms, however, gave almost as good results as superphosphate for certain soils and crops. Three kinds of nitrophosphate, prepared by different processes, were tested on potatoes and grass. They differed amongst themselves, and all were somewhat inferior to superphosphate, especially on potatoes on neutral soils. It is too soon to come to definite conclusions, but the results obtained, so far, suggest that the phosphate in these materials has about the same effect as that in high-soluble basic slags. The nitrophosphates were granular, and the question arises whether water-insoluble phospates in granular form can act quickly enough in the early stages of crop growth. The experiments also indicate that greater use might be made of ground mineral phosphates on acid soils, particularly for swedes and established grass in the wetter parts of the country. For other crops a starter dose of soluble phosphate would be necessary. At current prices, including subsidies, this material costs only about a third the price of granular superphosphate per unit of phosphate. The results from many recent experiments show the need for a National Compound Fertilizer with high ratios of nitrogen and potassium to phosphorus.

Earlier work on fertilizer placement was extended. On the average of seven experiments on potatoes, light dressings of ammonium sulphate gave better results when placed and heavy dressings when broadcast. There was no advantage in holding back half the nitrogen until summer, even where the potato crop was regarded as maturing too early. Placed fertilizers gave better results than broadcast on lettuce, cabbage, beetroot, broad beans and runner beans. Further work on the manuring problems of forest nurseries has given additional evidence that conifer seedlings grow better when supplied with ammonium than with nitrate. Pot and field experiments using radio-phosphorus are in progress to assess the

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availability of soil and fertilizer phosphorus to crops, and it has been shown that superphosphate combine-drilled with barley is utilized several times as efficiently as that broadcast. The investigations on soil organic matter and manganese have been continued.

Assistance has been given by the Adviser on **Tropical and Subtropical Soils,** both in the training of workers and in connection with the soil projects in various Colonies. Many Colonial soil workers spent part of their leave at Rothamsted discussing their problems in detail with the Adviser and other members of the staff, particularly those who have recently visited their territories. On the recommendation of the Soils Sub-Committee of the Committee for Colonial Agricultural, Animal Health and Forestry Research, approval has been given for the formation of a pool of three soil surveyors who will be available for periods of work in British Colonial Territories. At other times these surveyors will take part in the Soil Survey of Britain.

In the **Physics** Department a study is being made of the effect of organic matter on the crumb structure so desirable in soils, and a new laboratory test for estimating the strength of soil crumbs has been devised. Field experiments are in progress to study the effect of various crops on soil structure and, after two years under a grass ley, there is a distinct increase in the stability of the crumbs in the top 4 inches of soil. Further work has also been done on the structure of the land flooded by sea-water in February. It is well known that when rain has washed out the salt, heavy arable land may lose its crumb structure unless gypsum is applied before all the salt has gone. Calculations showed that, under the low rainfall of the East Coast, 2 tons per acre should in general have sufficed to prevent this during the past winter. More gypsum may still be required in certain cases, and a soil test has been devised which the National Agricultural Advisory Service can use to determine this. In the Woburn irrigation experiment the summer rainfall in 1953 was sufficient to maintain unrestricted transpiration, and calculated irrigation requirements were small and were not expected to lead to marked increases in yield. The early potato crop yielded 12 tons per acre without irrigation, but, with 2 inches of sprinkler irrigation, this was raised to 14·7 tons, and in seven cuts the gain from irrigating grass was 13 cwt. dry matter per acre. With sugar beet and barley there were no significant responses to irrigation in 1953.

Various soil micro-organisms produce substances (antibiotics) which might help to combat diseases in the roots of plants, and in the **Microbiology** Department further work has been done on this subject. It has been found that the production of antibiotics is influenced both by the strain of micro-organisms and by the type of soil—the effective action of many antibiotics being limited by the fact that they are rendered inactive by soil colloids. Nevertheless, in pot experiments with wheat, significant reduction of root diseases has been brought about in sterilized soil through the action of antibiotics produced by some strains of actinomycetes. Much of the work of the department deals with the nodule organisms of legumes. It has been shown that the number of nodules that develop on a root is determined more by the susceptibility of the root to infection than by the population of nodule bacteria surrounding it. It would also appear from studies on clover that hereditary factors

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in the clover plant influence the time at which root nodules first appear, the number of nodules subsequently produced and their effectiveness in fixing nitrogen. Attention will no doubt be given to this by plant breeders, for it is desirable to have strains of clovers which freely produce nitrogen-fixing nodules. There can be competition between different nodule bacteria in the root surroundings, but it would appear that this is most acute amongst closely related strains. Experiments have shown no evidence of such competition between lucerne and clover bacteria, so it is unlikely that a legume crop will be harmfully affected in this way by a different legume previously grown on the same land. In view of the increasing use of insecticides and herbicides, the bacterial decomposition of these substances in the soil is also being studied in the department.

In the **Botany** Department work has been continued on plant nutrition, weeds and the physiology of virus infection. It has been shown experimentally that some of the ill effects caused by excess of manganese, molybdenum, and vanadium can be prevented by increasing the supply of iron. Further interesting information has been obtained on the effects of applying fertilizer solutions to leaves. Earlier experiments had shown that the protein content of sugar-beet tops could be greatly increased by repeated spraying of the leaves with solutions of urea in late September, and it has now been established that a single low-volume spraying with a concentrated solution is as effective as several sprayings with a dilute solution, although it may cause some scorching of the leaves. The potash content of lucerne was increased markedly by spraying with a solution of potassium sulphate, although the yield was unaffected; the same amount applied to the soil gave only a third of the increase in potash content. Beneficial results on plant growth, apart from the control of insect damage, from applications of insecticides containing phosphorus have been reported, but these have not been confirmed in experiments at Rothamsted. The work on wild oats suggests that it is safer to sow winter corn than spring corn where the land is infested with *Avena fatua*; the winter sowing appears to lead to lower germination and reduce production of new seeds.

Much of the work of the **Plant Pathology** Department is basic research on the nature of viruses, and during the year studies have been made of variations in infectivity of virus preparations, the rate of virus multiplication in plants and the effects of ultra-violet radiation on viruses and other proteins. The electron microscope is used a great deal in virus research, and improvements have been made in the techniques for preparing sections of leaf cells. On the more applied side, further work has been done on the exposure of plants infected with tomato bushy stunt, cucumber mosaic, tomato aspermy and two carnation viruses for two weeks to temperatures of 35° C. Some were completely freed from infection; in certain other cases virus-free progeny were established by taking cuttings from the heated plants. Heat therapy was not successful with plants infected with tobacco mosaic, potato X or spotted wilt viruses. It would appear that only viruses of spherical shape are inactivated by heat treatment; the practice fails with rod-shaped viruses, for they go on multiplying although adversely affected by the heat. Four viruses were isolated from commercial stocks of carnations. Two of these were the spherical type, and no insect vector has been

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found for them. The other two are rod-shaped and transmitted by aphids; one of these was first recognized by serological tests and electron microscopy, and of the many plants to which it has been transmitted, only sugar beet has so far shown any symptoms. Studies of the viruses affecting cauliflower and broccoli have been continued, and it has again been shown that benefits are derived by surrounding seed-beds with barriers of barley. Turnip yellow mosaic virus was isolated from several species of cruciferous plants, and did much damage to some crops of broccoli in Northumberland. Further experiments with persistent insecticides applied to various crops, including potatoes, suggest that they have some value in decreasing the spread of viruses from infected to healthy plants, but they are largely ineffective in preventing infection by infective aphids arriving in a crop. In the sugar-beet crop attempts are being made to select breeding lines that either resist or tolerate infection with the yellows virus. So far, no resistance to infection has been found, but different lines varied greatly in their reaction to infection. This and other work suggests that there may be more than one cause for the disease now called yellows. The various methods which have been developed for controlling yellows in steckling beds are proving reasonably satisfactory.

In the Mycology section continued attention has been given to potato blight, and a piece of apparatus has been designed for use in studying the conditions favouring blight. It continuously records the amount of water that is deposited as dew or rain on potato shoots. Under the conditions at Rothamsted in 1953, spraying with copper fungicides and destroying the haulm with acid increased potato yields by only ½ ton per acre, despite the earliest attack of blight for over thirteen years. Further work has been done on the incidence of powdery mildew on cereals, particularly on time of sowing in relation to the date of application of nitrogenous fertilizers. Experiments are also in progress on the effect of various crop rotations in freeing land from weeds and from fungi that cause root rots of cereals. It has also been confirmed that on land contaminated with take-all and eyespot, yields of grain were almost doubled by giving 4 cwt. of sulphate of ammonia per acre and decreasing the seed rate from 3 to 1½ bushels per acre. It has been shown that there are physiological races of the fungus causing clubroot in turnip and cabbage. For instance, the variety of swede called Wilhelmsburger, bred for resistance to clubroot in Denmark, is very susceptible to the Norwegian form of club-root. The beneficial effects of dressing sugar-beet seed with a fungicide were again demonstrated, particularly for early sowing in cold ground. Work was started on the conditions that favour the rotting of sugar beet by the grey mould fungus (*Botrytis cinerea*), which threatens to become increasingly troublesome as mechanized harvesters become more widely used.

The **Biochemistry** Department is concerned mainly with enzyme actions, and those studied fall into three main groups. The first is ribonuclease, which digests nucleic acid. This substance is intimately connected with many cell processes, and particularly with virus infection; every plant virus that has been purified has turned out to be a ribonucleoprotein. The factors controlling the rate of destruction of normal nucleoproteins and of those connected with

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virus infections are therefore of interest, and a knowledge of them must precede a rational approach to the cure of virus diseases. The second group of enzymes bring about oxidations. Part of this work is a prelude to the study of the formation of complex molecules such as the alkaloids. It is already clear that oxidation products of amino acids and their derivatives can undergo further oxidation in the cell and build up cyclic molecules. By suitable choice of starting material, it is probable that fairly elaborate molecules can be made. The plant hormones and growth regulators are also subject to enzymic oxidation, and this may be part of the normal mechanism by which their concentration is controlled, and if so, these enzymes play a part in regulating the growth of the plant. The third line of work is an investigation of the breakdown of cellulose and chitin by enzymes. Cellulose is a characteristic component of the residues of plants, and chitin is present in fungal residues and those of most soil fauna; both may be of importance in the formation of soil organic matter. Enzymes, from soil organisms and from other sources, are being used to throw light on the natural course of breakdown of both substances in the soil and on the nature and composition of the cell walls and other structures in which they are found. Knowledge of the chemical behaviour of the various intermediates is expected to elucidate some aspects of the binding of trace elements, phosphorus and other nutrients in the soil. During the past year little practical work has been done on the pilot-plant production of leaf protein, but some machinery has been installed, and other equipment, both for production and for the control of the operations, is being designed and made.

It is important to be able to assess the number of potential eelworms (living eggs or larvae) in samples of soil. This is a tedious and time-consuming business, and in the **Nematology** Department a good deal of attention has been given to improving and speeding up the methods. One of the most promising approaches to control of eelworms is to find varieties of crops which are resistant and, in co-operation with the National Institute of Agricultural Botany, work is in progress along these lines. Numerous new oat varieties have been tested for resistance to stem eelworm, and one spring and and two or three winter varieties show promise. A race of the same species of eelworm (*Ditylenchus dipsaci*) attacks lucerne, and in preliminary trials two varieties of lucerne and most other legumes were found to be resistant. Twenty-four commercial varieties of potatoes were tested for resistance to the related potato tuber eelworm, but not one was resistant. There is a plant of the potato family from South America (*Solanum andigenum*) which shows resistance to potato root eelworm, and plant breeders are using this for crossing, in an attempt to get the resistance factor into cultivated potatoes. In the Nematology Department the nature of this resistance is being studied. It appears that the eelworm larvae can penetrate the roots of *S. andigenum*, but most of them fail to become adult. Resistance to cereal root eelworm is being studied in twenty-one varieties of barley and seventeen varieties of spring oats, in conjunction with the National Institute of Agricultural Botany and the National Agricultural Advisory Service. Eelworm attack can also be controlled by suitable crop rotations, and

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changes in the populations of potato root eelworm and cereal root eelworm under various rotations are being investigated at several centres. Work is also in progress on the root diffusates which stimulate hatching of cysts and on the control of eelworms by applying various chemicals to the soil.

In the **Entomology** Department further work has been done on insect migration and on the influence of weather conditions on insect populations. Many insects, harmful and beneficial, move southward in autumn over long distances and in vast numbers. In order to study this a small expedition was made to the Pyrenees, and extensive movement over a period of at least five weeks was observed of about a dozen species of Lepidoptera (including Small Cabbage White Butterflies and Silver Y Moths, both pests in Britain and Central Europe) and various species of Diptera (including Hoverflies of two groups, those that eat aphids and those that live on decaying vegetation and manure). In another investigation it has been shown that certain caterpillars grow and develop more rapidly when crowded together—an abundant population thus tending to become more abundant. The work on gall midges of economic importance has been extended, especially on grass seed midges, the lucerne leaf midge, and those attacking chrysanthemums. The biology of a species of midge which attacks the lower parts of the stems of grasses and cereals is being studied, and the range of host plants, of this and various other midges, investigated. Experiments have shown that the very injurious sorghum midges that are now causing great trouble in West Africa can survive for over nine months on sorghum heads in this country, and it may be possible to give some assistance on this problem. Work on aphids has been continued, and it has been shown that they can take off from their host plants during much higher wind speeds than was previously thought. It would also appear that aphids normally do not reproduce until they have made a flight, however short. The destruction of aphids by ladybirds and hoverflies is largely dependent on the number of these predators at the beginning of the season, and hence on the survival of adults from the previous year. In co-operation with the Insecticides Department and the National Agricultural Advisory Service, work has been commenced on the wheat bulb fly, and methods devised for rearing the flies in captivity, thus facilitating a study of their biology. In the wireworm investigation it has been found that, under a dense vegetation cover, there is very little movement of adult beetles, and with the Insecticides Department further work has been done on the chemical control of wireworms. The forest soil studies have been continued with particular reference to the activities of mites in natural and afforested heathland.

The main lines of work in the **Bee Department** concern the behaviour and diseases of bees and the pollination of red clover. In work on queen introduction, it has been shown that queen honeybees produce a substance (" queen substance ") which the worker members of their colonies urgently seek. This substance is the factor controlling the production of supersedure and emergency queen cells and probably plays an important part in swarming. So long as each worker obtains sufficient " queen substance " she is inhibited from building these cells and from tolerating the presence of eggs or larvae in swarm queen cells. The " queen substance " of virgin queens

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appears to differ from that of mated queens, but probably all virgin queens produce one kind and all mated queens another. It is suggested that the craving for "queen substance" is the most important factor in the maintenance of colony cohesion in honeybees, ants, and termites. The results of these and earlier observations have led to experiments on a simple and most economical method of queen introduction with which very satisfactory results have so far been obtained. Of 230 mated queens, including nearly 100 that had been in transit or caged in the laboratory for as long as five days, all except one have been introduced successfully. During the last few years it has been claimed that an anaesthetic prepared by adding crystals of ammonium nitrate to burning fuel in a beekeeper's smoker has very valuable practical applications. The active agent was said to be nitrous oxide, and the treatment was also claimed to cause loss of memory, so that when a colony were moved to a new position the bees did not drift back to the old site, even if it were close at hand. Work at Rothamsted has shown that the main anaesthetizing action must be due to other substances, as nitrous oxide has little effect on honeybees, that the fumes contain harmful cyanides and that little, if any, inhibition of drifting is obtained. Nevertheless, if used with great care, this method of anaesthetizing colonies of bees *in situ* is probably the most effective known.

Observations on worker bees visiting dishes of sugar syrup indicate that, even when a bee has become aware of a richer store of food, she may continue to forage from another source to which she is more accustomed. Investigations into the causes of swarming suggest that, whilst overcrowding of the bees in the hive predisposes a colony to swarm, an excess of bees to brood has little, if any, such effect. Work on the pollination of red clover has been continued, and it has been shown that although fertilizer treatment of the crop does affect nectar secretion, much greater differences are found between clones receiving the same treatment. This indicates the possibility of selecting strains of red clover more attractive to pollinating insects. Further studies have also been made on the pollination activities of bumble bees on this crop. In the bee disease work it has been shown that Nosema disease is carried over from one year to the next on old combs and that infected bees do not transmit it to any extent at times of the year when they can fly freely. The transference of all the adult bees of an infected colony to clean comb in spring is sufficient to eliminate this disease from the colony. This procedure seems likely to be more satisfactory than the use of drugs. A successful method has been found of treating old combs from infected colonies with vapour of either formaldehyde or acetic acid.

The **Insecticides** Department is concentrating on the study of the various factors—biological, chemical and physical—which determine the action of insect poisons. This type of work should enable existing products to be used more safely and effectively and also put the search for new and better materials on a more rational basis. Work is being carried out on the following groups of insecticides: (1) chlorinated hydrocarbons, chiefly D.D.T. and related substances; (2) organo-phosphorus compounds, including those which are taken up by the plant and render it poisonous; (3)

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natural pyrethrins and allied substances. Laboratory experiments are in progress on materials of the D.D.T. group to throw light on the effect of particle size of suspensions, for this influences both the amount of poison retained on the body of the insect and its effectiveness. The persistence and toxicity of deposits of these substances on leaf surfaces is also being studied. Strains of insects resistant to insecticides are becoming a serious problem, and attempts are being made to find out what favours the occurrence of a resistant strain. In the organo-phosphorus group further work has been done on the insect enzyme systems that are acted on by these compounds. A good deal of attention continues to be paid to the pyrethrin group of insecticides since they are so safe to use. The relationship between the structure of the molecules in this group of substances and their insecticidal action is being investigated. The four known active constituents which occur in Pyrethrum flowers have been isolated for the first time, and their properties are being studied. Although they differ in toxicity, all are highly effective. Some assistance has been given to the Kenya Pyrethrum Board in their endeavour to improve the strain of plant that is grown. On the field side, experiments on the control of bean aphis, wireworms and the aphids which transmit potato viruses have been continued. The wireworm results for 1953 again indicated that insecticides drilled with the seed gave protection for subsequent crops which a seed dressing failed to do. In collaboration with the Seale–Hayne Agricultural College further work has been done on the effect of plant protective chemicals on honeybees.

There have been no major changes in the work of the **Statistical** Department during the year. One of the problems being studied is the amount of experimentation economically justified when questions of immediate practical importance have to be settled. The future of a number of the long-term Rothamsted and Woburn experiments is being reviewed and a plan drawn up for the re-design of the Classical rotation experiment on Agdell field. As in the past, much assistance has been given to other departments at Rothamsted, the Colonial Office and the National Agricultural Advisory Service. Reports have been prepared on sugar-cane experiments and help given in connection with experiments on the manuring of rubber. A survey of hill and livestock rearing farms has been begun with the object of finding out how far improvements under the Hill Farming and Livestock Rearing Acts have affected the production, economy and working conditions. The surveyors are also estimating the scope for further improvements. The survey of fertilizer practice has been extended to eight more districts which had not previously been examined or had not been surveyed for many years. A report has been published on the 1952 survey of rabbit damage to winter wheat; a close correlation was found between rabbit grazing observed in January and the final loss of yield. On the animal production side, surveys are in progress, in conjunction with the Veterinary Laboratory, Weybridge, on diseases of dairy cattle, and assistance has been given to the Ministry of Agriculture, Northern Ireland, in the planning of a survey of diseases and husbandry practices of cattle, sheep, pigs and poultry. The survey of bloat carried out in Wales in 1952 has been reported on and further work carried out, and, in co-operation with the Veterinary Investigations

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Officer at Leeds, a survey has been made of the incidence of loss in pregnant ewes in Yorkshire.

An extensive programme of **Field Experiments** at Rothamsted and Woburn was carried out successfully. The cool, moist summer favoured roots and grass, and there were also good yields of cereals in spite of some lodging. The section of Broadbalk field immediately following the fallow had its worst attack of wheat bulb fly so far observed, and the fly is being studied on this field and on neighbouring areas. In addition to the Classical and other long-term experiments, many shorter experiments were undertaken. Some of these have already been mentioned. On the nutritional side they included studies of nitrophosphates and fertilizer placement, on the pathological side, eyespot in wheat, late blight in potatoes, virus spread in sugar beet, potatoes, and broccoli, mildew in wheat and barley, wireworm in wheat and aphis in field beans. For several seasons the residual effect of dung applied to potatoes has been measured in the following wheat crop, and again in 1953 dung was shown to have an appreciable effect, although the wheat had received a good dressing of fertilizers. Measurements of the effect of top dressings of " Nitro-Chalk " applied to cereals in late June after the ears had emerged confirmed that the nitrogen was utilized better by barley than other cereals. There was an increase in crude protein of 1·3 cwt. in the barley grain plus straw as a result of applying 3 cwt. of " Nitro-Chalk " per acre, a recovery of about 45 per cent of the added nitrogen. Experiments were commenced to see whether top dressings of either sulphate of ammonia or muriate of potash, applied just before the final earthing-up, would prolong the life of potato plants and thereby increase yields. Neither fertilizer had any effect in 1953, but the experiment will be repeated.

At Woburn in 1952 part of the permanent barley plots, sown with winter barley, gave much better results than spring barley, and it was thought that this might have been due to the winter barley suppressing weeds. Further work in 1953, however, suggests that winter barley is not superior, and that the differences can be accounted for by variations in acidity within the plots. The study of the effect of irrigation on the proportion of grasses and clovers in repeatedly cut leys has been continued, and although with the well-distributed summer rainfall in 1953 there appeared to be no check on growth, even on the dry plots, irrigation as in previous years raised the proportion of clover, though to a much smaller extent. Work on maize grown for grain has been continued at Woburn for fifteen years. The past season was a difficult one, owing to the long, cold spell in spring and early summer; nevertheless, certain hybrid varieties, acclimatized in Europe, yielded up to 31 cwt. of dry corn per acre, and it is clear that there are now types which, under proper management, can give an economic yield, even in an unfavourable year. In tests with sweet lupins for green fodder, yields of 2·7 and 3·4 tons dry matter per acre were obtained, and further work with serradella indicates that it may be a useful fodder crop on light acid land.

There has been a gratifying amount of co-operation between departments and also with the Farm Manager and his staff.

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