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Report for 1973 - Part1

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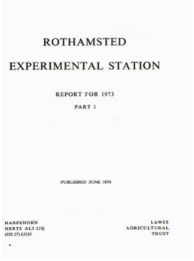
ROTHAMSTED
EXPERIMENTAL STATION
REPORT FOR 1973
PART 1

General Report

L. Fowden

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GENERAL REPORT

L. FOWDEN

The year 1973 brought many changes to agriculture and agricultural research. Arable farmers saw the value of their harvests almost doubled, but livestock farmers will remember the year for its swingeing increases in the cost of concentrated feeds. For agricultural scientists the year heralded a new system of governmental support for research and development. These changes have begun to affect planning at the Station, but the considerable internal changes occurring in staff and buildings have perhaps impinged more immediately upon the lives and work of many of our staff.

Staff. L. Fowden assumed the Directorship of the Station on 1 April. He had been a member of the academic staff of University College, London, since 1950, latterly as Professor of Plant Chemistry and Dean of the Faculty of Science. G. W. Cooke was Acting Director until 31 March and he and F. G. W. Jones, as Deputy Directors, have since given unstinted support to the Director. W. Barnes became Secretary of the Station on 1 January, having previously been Assistant Secretary to the Petroleum Industries Training Board, and Susan E. Bishop was appointed as Personal Secretary to the Director.

The Director's first day in office was marked by the creation of a new Department. The Station accepted responsibility for the ARC Unit of Structural Chemistry (former Honorary Director, the late Sir Ronald Nyholm), and welcomed Mary R. Truter and her small group of collaborators as our Molecular Structures Department. They continued to work in laboratories on the Strand, London, until the end of the year, but are now moving into temporary accommodation at Rothamsted.

N. W. (Bill) Pirie retired officially at the end of March. He had joined Rothamsted in 1940 at the invitation of Sir John Russell, and became Head of the Biochemistry Department when founded in 1947. He collaborated with the late Director, Sir Frederick Bawden, in studies of plant viruses for more than 30 years: in an early phase of this work they successfully obtained a liquid-crystalline preparation of infective nucleoprotein from tobacco mosaic virus. In more recent years Pirie devoted himself mainly to the task of developing large scale methods for bulk extraction of protein from leaves. In 1971 he received the Copley Medal, the Royal Society's most esteemed award. Pirie is continuing at Rothamsted as a temporary worker attached to the Chemistry Department. B. J. Miflin succeeded him as Head of the Biochemistry Department on 1 September, coming to the Station from the Plant Science Department of the University of Newcastle-upon-Tyne.

Mildred E. Ashford also retired in March after 30 years' service. She had been Personal Assistant to the Director and her wisdom and knowledge of the organisation of the Station were invaluable at all times but especially in the period following Sir Frederick Bawden's death. Everyone was delighted that she was honoured by being made a Member of the Order of the British Empire in the Queen's Birthday Honours, 1973. Other retirements occurring during the year included C. J. Banks (Insecticides and Fungicides Department) and H. G. C. King (Pedology Department). J. V. Lake (Physics Department) resigned his post on transfer to ARC Headquarters as a Scientific Adviser.

Barbara Mosse (Soil Microbiology Department) was promoted to Senior Principal Scientific Officer under the scheme for Special Merit Promotion.

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The deaths of R. G. Greene-Kelly, R. C. Gallavan and R. A. G. Rawson saddened their many friends. Greene-Kelly, who died suddenly in May, had been at Rothamsted since 1949, and had made important contributions to work on the mineralogy and structure of soils. Gallavan, his collaborator in the Pedology Department for many years, died on the preceding day. Rawson (Chemistry Department) died suddenly in December: recently he had responsibility for the development of a multi-channel atomic adsorption flame photometer for mineral nutrient analysis.

Buildings. An extensive laboratory building flanking the northern edge of our campus was completed in May. It provided new, well-designed accommodation for the Botany, Physics and Nematology Departments, and some specialised facilities for work on potato storage and electron microscopy by the Plant Pathology Department. This group of laboratories has been named the Bawden Building.

The Lawes Agricultural Trust Committee agreed that other major groups of buildings should be named after previous Directors, and the campus map now shows the Hall, Russell and Ogg Buildings. It was deemed inappropriate to couple the names of Lawes and Gilbert with individual buildings because they are so closely identified with the whole fabric and lore of the Station.

A new laboratory building was provided for the Chemical Liaison Unit, enabling them to work for the first time as an integrated group. At Broom's Barn a new farm building has been completed; this releases space for conversion to urgently needed office and laboratory accommodation. Work has begun on the construction of a mobile glasshouse–rain shelter on the Rothamsted Farm. The shelter will move automatically to cover an experimental area when rain starts, so permitting exact control of irrigation and imposition of drought conditions whatever the rainfall.

An immense amount of conversion work has been generated following completion of the Bawden Building. Rooms released by the Physics, Botany and Nematology Departments will help to alleviate severe overcrowding in the Soil Microbiology Department and the Library, to provide some space for the transferred Molecular Structures Department, and to develop additional controlled environment facilities. Contractors have been reluctant to tender for these conversion jobs, so most of the work has fallen on our own hard-pressed Maintenance Department.

In common with many older institutions, Rothamsted has developed its present campus in a somewhat uncoordinated manner: opportunities to build were grasped as presented, but buildings and facilities were not necessarily located on sites fitting the future development needs of the Station. The reconstituted Building and Grounds Committee has begun discussion of a long-term site plan for our campus, with the advice of a consultant, Mr. Meyrick, until recently Directing Architect to the University Grants Committee. The Trust Committee and ARC have given their full support to this approach and agreement has been obtained in principle from the Department of Education and Science (DES) for building starts during the financial year 1974–75 to provide new laboratory accommodation for the Molecular Structures Department and additional accommodation for the Entomology and the Insecticides and Fungicides Departments. The need for an adequate staff amenities building integrated with a meeting–lecture room complex is also recognised as urgent. A development of this type would not only provide a social environment worthy of our famous institution, but also it could not fail to enhance the scientific awareness of our staff to both internal and external developments.

Support of research. In addition to gaining a new Director and a new Department on April Fool's Day, the Station began also to prepare itself for the demands of com-

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missioned research under the terms of the Government White Paper (*Framework for Government Research and Development*, Command 5046), which officially came into effect on 1 April—the day Value Added Tax was instituted. The simultaneous introduction of these two government measures led to an intriguing financial musical chairs between the Treasury, the DES, the Ministry of Agriculture, Fisheries and Food (MAFF) and the ARC (see *Nature*, **243**, 255, 1973).

In practice, the commissioning of agricultural research during the financial year 1973–74 has been notional, merely involving paper transfer of money between government departments and the ARC, and leaving the research programmes of institutes unaffected. Discussions during 1972 between the ARC, MAFF and the Department of Agriculture and Fisheries for Scotland (DAFS) led to an agreement to set up a Joint Consultative Organisation (JCO) consisting of five Boards covering the principal divisions of agricultural research and development. Almost all of Rothamsted's programmes fall within the field of review of the Arable Crops and Forages Board, and its three specialist committees dealing with cereals, potatoes, and grassland and forage. The composition of this Board and its committees have been decided, and we are pleased that G. W. Cooke is a member of both the Board and the Cereals Committee, whilst J. M. Hirst is a member of the Potatoes Committee. Now the Boards and Committees are collecting and evaluating information that will enable MAFF and DAFS jointly to agree with ARC projects appropriate for commissioning at institutes receiving financial support from the Council. It is not expected that commissioned projects will become part of our programme before April 1975, and the main impact of commissioning may not be felt until 1976.

Dr. W. M. Henderson, Secretary of the ARC, has established a further committee (the Secretary's Policy Advisory Committee) composed of senior staff at ARC Headquarters and eight elected Directors of institutes, representative of the principal fields of agricultural research. He believed it essential that he should be able to call upon the assistance of Directors in formulating policy either at the level at which his is the responsibility for decision or when matters must be referred to Council. L. Fowden will serve as a member of this Committee.

During the past year we have been pleased to welcome Dr. Henderson to the Station on two occasions, and to notice his concern that the new system of financial support should not lead to any devaluation of the role of the research scientist within the agricultural research service. It is also reassuring to have his statement (Third G. E. Blackman Lecture, delivered at Oxford on 15 November 1973), 'It is only by demonstrating clearly that the Council still regards scientific excellence as a prerequisite for successful research that we shall continue to recruit the best people. The recipe for scientific progress is to provide the best conditions for very able people to follow their own special interests.' Similarly reassuring is the statement by Dr. H. C. Pereira, FRS, Chief Scientist of MAFF, 'We must make sure that commissions are broad enough to leave scope for initiative by those doing research' (*Biologist* **20**, 117–121, 1973). Staff also welcomed the visits of Mr. J. S. Martin, Chairman of the Arable Crops and Forages Board, and of Major E. S. Dobb and his three senior officers within the Agricultural Development and Advisory Service (ADAS). Each visit provided an opportunity to discuss means of establishing more effective collaboration between our scientists and those within the ADAS arm of MAFF with the aim of fostering the flow of information to the farmer.

Other visitors and visits. Many senior agriculturalists made individual visits to the Station during the year. Among those welcomed were Herr Dr. Brünner, Minister of Agriculture of the German Federal State of Baden-Württemberg, Dr. D. D. Breshnev, Director of the All Union Plant Breeding Research Institute (USSR), Dr. U. J. Grant, Director-General of Centro Internacional de Agricultura Tropical (Colombia), Dr. H.

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Albrecht, Director of the International Institute for Tropical Agriculture (Nigeria) and Dr. H. Huque, Director-General of the Agricultural Research Council of Pakistan. We were also hosts to a large party of agricultural administrators and advisers visiting Britain under the auspices of the Overseas Development Administration (ODA), and to the members of the Technical and Machinery Committee of the National Farmers Union.

Many members of staff travelled overseas to engage in research, to give advice or to attend international conferences. Details of these visits are given at the end of each Departmental Report. A particularly important meeting was the Second International Congress of Plant Pathology held in Minneapolis, and we were strongly represented at the conference. L. Fowden visited Poland as a member of a Royal Society Delegation to the Polish Academy of Sciences to discuss an enlarged agreement for exchange of scientists between the two countries. He visited Ithaca, New York, to participate in a symposium marking the retirement of Professor F. C. Steward, FRS, from the Faculty of the New York State College of Agriculture at Cornell University, and to hold discussions at the United States Department of Agriculture's Plant, Soil and Nutrition Laboratory. Later in the year he contributed to the Annual Symposium of the Phytochemical Society of North America held at Asilomar, California, and visited the University of California at Davis to participate in research sponsored by the North Atlantic Treaty Organisation. He also attended the Phytochemical Society's Symposium on Plant Proteins held in September at Gent, Belgium.

Crops and yields. The year was warmer, sunnier and drier than normal; higher mean air temperatures, more hours of sunshine and less rainfall than average were recorded in eight individual months. The winter was mild and particularly dry, and spring crops were planted early: almost all the country's sugar beet had been drilled by early April. Growth of both winter and spring crops was checked by cool weather in April and early May, when relatively dry conditions persisted, but the weather in late May and June encouraged rapid crop growth. Excellent hay was made early on both the Rothamsted and Woburn farms. Rainfall, although less than average in July and August, tended to be heavy during thundery spells; many cereal crops lodged badly especially those receiving high levels of N, but root crops developed rapidly. Very few days were lost during the cereal harvest, but cutting in many fields was slow because of lodging and the presence of secondary tillers with green grains meant that most grain samples had to be dried. Potato lifting started in early September but the work was hampered by a shortage of pickers, a situation common to many farms in eastern England. Sugar beet made excellent growth during the summer, but grew less well in the autumn, when many early sown plants bolted.

Yields of wheat were generally good; the mean yield of the variety experiment at Rothamsted was 7·1 t/ha compared with 6·7 t/ha in 1972. In this experiment the best yield was from Maris Huntsman (8·4 t/ha), closely followed by Maris Templar (8·3 t/ha) and Maris Nimrod (7·8 t/ha). Two 'quality' wheats gave poor yields, Bouquet (6·2 t/ha) and Maris Widgeon (5·8 t/ha); the premium paid for quality was quite insufficient to compensate for these lower yields. At Woburn, Maris Huntsman (7·4 t/ha) again performed best in the variety trials; in an experiment in which this variety followed beans a yield of 8·3 t/ha was obtained, probably the best ever for wheat at Woburn. The new Maris varieties have completely outyielded Cappelle by 1 to 2 t/ha during the past three years, both in our variety trials and in NIAB trials throughout the country; this remarkable increase is comparable to that gained when Cappelle was introduced in the 1950s. The new varieties seem to yield more in a wide range of conditions including variations of soil fertility and of the incidence of soil-borne diseases in different seasons.

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Barley yielded about average at Rothamsted, Maris Mink (7·4 t/ha) performing best in the variety trials. Julia, sprayed against mildew with tridemorph, gave 6·3 t/ha at Rothamsted and 5·4 t/ha at Woburn; yields from untreated plots were 5·3 and 4·5 t/ha respectively. ADAS scientists estimated that mildew cost barley growers in England and Wales about £40m in lost yields in 1973.

Beans grew well at Rothamsted during the summer and yields were rather better than in 1972, averaging just less than 4 t/ha. Crops treated with phorate granules to control aphids gave larger yields than those sprayed twice with demeton-S-methyl.

Potatoes grew well and yields were generally equal or better than those of recent seasons. Most areas were sprayed three times against blight, an aphicide being incorporated in the first spray. The tubers were generally of good size with little blight or common scab, but many harvested from Barnfield were infected with pink rot.

Agrochemicals: costs and effective use. Cheap food and abundant energy were once taken for granted. Now we have a steeply rising spiral of agricultural prices, attributed to recent relatively poor grain harvests in North America and the USSR, the astute wheat deals negotiated by Russian trade officials, and many other more ephemeral factors. Further rises are inevitable as agriculture absorbs the effects of the huge increases in the cost of crude oil and rock phosphate. The manufacture of fertilisers and many other agrochemicals has a high energy requirement; this is especially so for ammonia-N production which requires high temperatures and hydrogen commonly derived from refinery or natural gases. Oil is also the basis of chemicals used as feedstock in synthetic processes yielding important herbicides, fungicides and pesticides. Agrochemicals are then certain to become much dearer: they also may become much scarcer if constraints on crude oil production continue. For these reasons it is imperative that available materials should be used with maximum efficiency, and work in several of our departments seeks ways of achieving this aim.

UK farmers now spend about £100m annually on N fertilisers, so research improving the utilisation of N by even a few percent would be fully justified. At present, there are anomalies in the ways N fertilisers are applied to different crops. The average dressing of N fertiliser to cereals is probably near the optimum but many farmers tend to give sugar beet amounts of N considerably in excess of the recommended levels. In contrast, grasslands in Britain are still receiving too little N fertiliser. Such considerations should be relevant to farmers reassessing their practices if supplies of fertilisers are restricted. However, farmers should not immediately over-react to fertiliser price changes. A statistical evaluation of ADAS experiments relating N applications and yields of barley, growing on chalk or limestone soils in southern England, has shown that if the cost of fertiliser was to increase 50% with constant grain prices, the maximum profit/ha would be achieved by a modest 5% reduction in N dressings. Even if a five-fold change occurred in the ratio of fertiliser to crop prices, the recommended dressing would remain within the range of 75–125 kg/ha.

Several investigations described in the report of the Chemistry Department seek ways of reducing losses of fertiliser N resulting from leaching or denitrification. Between 50 and 70% of the N applied to arable crops, and up to one-half that given to grass may not get into the crop; a considerable proportion of this wasted N may leach as nitrate and enter streams and deep aquifers. These large losses can be reduced if at least a part of the N is provided after the season of spring rains. Aqueous ammonia, injected in widely-spaced rows as a single dressing to grass in winter, has given good growth throughout the following summer: it was more effective on grass than sulphur-coated urea, and the yield was as good as that obtained following repeated application of solid fertilisers during the growing season. The amount and incidence of rainfall relative to fertiliser application

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markedly influences leaching and therefore the efficiency of nitrogen use by a growing crop. In the relatively dry winters of the past few years, N has accumulated in many soils and thereby been used more efficiently by recent crops. But the resulting, vigorously-growing crops of many older cereal varieties lodged seriously during the heavy storms of 1973: high N residues in soils also contributed to a progressive decline since 1969 in the sugar percentage of beet harvested at Broom's Barn. Other work on beet has emphasised the importance of providing adequate amounts of K, and supplementary Na, if the recommended N applications are to be fully effective in increasing the total sugar yields, yet more than one-half of the national crop still receives no Na.

Experiments still continuing seek to define the best time and method for placement of phosphate fertilisers, but it is already clear that no single set of recommendations will fit all crops. Our more basic work on mycorrhizal-stimulated P uptake may lead eventually to agronomic practices less dependent upon added phosphates; this possibility has interested workers at CIAT, Colombia, where low-P tropical soils are common.

If pesticides are to be used more efficiently and selectively, better methods for their formulation and application are essential. Seed dressing is likely to increase in popularity as a method for applying both insecticides and fungicides, yet there is much evidence that the actual commercial loadings of insecticides on seed samples fall well below the target dose. Members of the Insecticides and Fungicides Department have devised adhesives which make it possible to apply insecticides and fungicides efficiently and evenly to seeds such that each receives almost the target dose, even at rates much greater than those traditionally applied. Further improvements have been made in our micro-encapsulation techniques for insecticides which should improve selectivity by controlling release and persistence: glasshouse tests are in progress comparing the new materials with more traditional formulations. The Nematology Department after some years spent assessing the potential of soil fumigants in nematode control is now concentrating effort increasingly on granular nematicides applied in spring, and is exploring the effectiveness of various methods of incorporating them in the seed bed. Several gave very effective control of potato cyst-nematode (*Heterodera rostochiensis* and *H. pallida*), beet cyst-nematode (*H. schachtii*), pea cyst-nematode (*H. goettingiana*) and cereal cyst-nematode (*H. avenae*) with associated large increases in crop yields: aldicarb generally gave more effective control than 'Du Pont 1410' or 'Dowco 275'.

Pathogen and pest research. In 1973 virus yellows were more prevalent on sugar beet than in any year since 1961. Recent mild winters had favoured the insect vectors, and many farmers failed to heed the spray warnings probably because the crop had been free from serious virus during the last decade. Nationally, 13·9% of the sugar-beet crop showed virus symptoms. Given another mild winter, virus yellows could be severe in 1974, unless good control is effected by adequate and timely spraying.

Success in the control of virus diseases by limiting the sources and spread of infection does not reduce the need to counteract viruses more directly; the report of the Pathology Department suggests novel possibilities for direct control of virus multiplication. Injection of polyacrylic acid into tobacco leaves conferred resistance to infection by tobacco mosaic virus; the polymer injected had a minimum mol. wt. of 3500, but very recent experiments suggest that smaller polymer molecules are effective and have the advantage of being taken up from soil or from leaf surfaces. For the first time the development of a chemical spray effective against a virus seems a possibility.

New viruses have been recognised in honeybees, and it now seems that viruses may be more harmful than any of the better known bee pathogens. Possibly bees would be more efficient pollinators and honey producers if virus free stocks could be obtained and maintained.

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The re-awakened interest in methods of reduced cultivation has resulted in collaborative experiments with other institutes. Rothamsted's contribution at present involves monitoring the pathological and entomological consequences of minimum cultivation practices, including stubble burning. The present cereal experiments were begun only in 1971, so reliable trends in the levels of viral and fungal diseases have not been established. However, it is important to recognise quickly any marked rise in diseases, especially those that are trash-borne and therefore likely to reflect first changes consequent upon reduced tillage. Stubble burning has had few serious effects upon the soil fauna, numbers of both beneficial and harmful animals being little changed three weeks after burning wheat stubble.

Joint work with the Grassland Research Institute has tested the damage to pastures by pests and diseases. At first effort was concentrated on old mixed pastures where insecticides gave small yield increases but fungicides were less effective. Extra growth by one species to compensate for damage to another made measurement in mixed swards difficult. More recently newly-sown ryegrass has been used in the hope of improving measurement. Pesticide treatments have given an increased yield at every cut: increases in dry matter production have ranged from 17–29% over a four-year period, indicating that insects and other invertebrates cause a steady drain on grass crops.

Work relating molecular structure and biological activity. In several aspects of our work, we seek a clearer understanding of how the structure of molecules influences their biological activity. The synthesis of pyrethroid insecticides of increased potency developed logically from a basic understanding of the molecular features necessary for high activity coupled with acceptable persistence. This work culminated in the synthesis of a new insecticide, temporarily coded NRDC 143, which is up to 30 times as active as dieldrin and up to 100 times as active as DDT. Preliminary tests show that the new insecticide retains the advantages of low mammalian toxicity and absence of toxic residues, yet it does not suffer from extreme instability in air and light as do natural pyrethrins and earlier synthetic pyrethroids. The increased stability should prove invaluable in horticultural and agricultural applications. NRDC 143 is easier to synthesise than earlier compounds in this series, and so the material should be cheaper to manufacture. Patent applications have been filed and negotiations are proceeding for commercial production in the UK and abroad. This work is supported in part by the National Research Development Corporation. A description of NRDC 143 and its potential in horticulture and agriculture formed the basis of a Press Conference in November.

Other work reported this year seeks a better understanding in chemical terms of the differential permeability shown by membranes towards different alkali metal ions. X-ray crystal structure analysis of model complexes containing chelated metal ions may provide clues concerning the mechanism of selective membrane transport. Similar techniques can tell us more about the molecular architecture of the transition metal complexes being developed as agents for chemical fixation of nitrogen by the ARC Unit of Nitrogen Fixation.

Soil research. A new soil classification was introduced by the Soil Survey of England and Wales to identify units shown on their soil maps. Kinds of soil profile are differentiated at four successive categorical levels, termed major group, group, subgroup and soil series. Classes in the three higher categories are defined partly by the composition and mode of origin of the soil material, and partly by the presence or absence of particular horizons within specified depths, using properties that can be observed or measured in the field, or inferred from field examination by comparison with analysed samples. Soil series are distinguished by other characteristics, chiefly lithologic. Most soil groups

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are very like those in other European systems, in the United States Department of Agriculture System, or in both.

Concern that current methods may underestimate the availability of toxic metals in sewage sludge is raised by experiments in the Pedology Department. The levels of sludge that may be applied to agricultural land are assessed on the basis of amounts of metals extracted from the sludge by standardised procedures. But extractabilities may change, increasing strikingly for some metals during aerobic or anaerobic incubation of sludge and soil mixtures. Therefore a safe guide to the maximum amount of sludge spread on agricultural land should be based on the *total* content of toxic metals.

Mathematical services. The Genstat Mark 3 Statistical program was released during the year; by providing substantial extensions of previous facilities, it has generated considerable interest both at home and overseas. Versions are available for the ICL System-4 range of computers and for the IBM 360/370 series. Distribution of the program to prospective users is being negotiated on the basis of annual licence fees.

The growth in demand for computing services during 1973 was considerable. Although the average daily hours of operation increased by only 15% the work submitted and completed increased by 130%. The growth in demand was most marked during the multiaccess session, and this load seems to be approaching a Multijob limit: an extension of the multiaccess session will only marginally ease the present position because most users conform to the normal working hours of their Institute.

Assistance to tropical agriculture. The Station provides help to tropical agriculture by seconding specialist staff to work on pressing local problems for periods ranging from a few weeks to several years. The majority of this work is supported by the ODA.

During 1973, the following people were overseas on long secondments to countries and projects given in parentheses: A. R. Bromfield (Nigeria, chemist working with S-deficient soils), G. J. W. Dean (Laos, development of a crop protection laboratory), R. H. Kenten and M. Bigger (Ghana, swollen shoot disease of cocoa), S. J. Eden-Green (Jamaica, coconut lethal yellowing disease), and P. Walker (Nigeria, biometrics service). Other work of relevance to tropical agriculture is conducted in part at Rothamsted and includes projects on insect control, research on soils of the humid tropics, virus diseases of taro (*Colocasia esculenta*), nitrogen fixation in tropical legumes, and further biometrics assistance for overseas workers dealing with annual crops. Eight staff at present supported by ODA are engaged on these programmes. Several brief 'trouble-shooting' visits were made to tropical countries by other staff during the year.

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