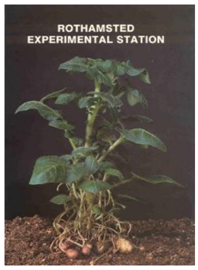
ROTHAMSTED RESEARCH

Rothamsted Experimental Station Report for 1983



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General Report

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GENERAL REPORT

This year's Report is produced in a somewhat altered style. Parts I and II, previously bound separately, are incorporated within one cover, which is illustrated for the first time. The length of the overall Report has been curtailed and hopefully the shorter form will permit the reader to get an overall impression of our programmes and to identify significant research findings or practical developments more easily. The research reports reflect the activities of the five Divisions into which the Station's scientific programme is now grouped (see below for details). Separate sections report progress during 1983 in our major multidisciplinary field experiments, and in the programme of the Soil Survey of England and Wales.

Lawes Agricultural Trust Committee. Early in the year, the Earl of Selborne was appointed Chairman of the Agricultural Research Council (ARC), redesignated the Agricultural and Food Research Council (AFRC) after Royal assent was given in October. The elevation of Lord Selborne led to his resignation from membership of the Trust Committee after five years' service. His colleagues on the Committee, and the staff of Rothamsted, greatly respected his wise counsel during this time, and convey their good wishes for success in the important and challenging office he has assumed. The Earl Ferrers was appointed in December to the vacancy on the Committee as a representative of the Royal Agricultural Society of England (RASE).

Staff. A number of senior staff changes occurring in the later part of 1982 and the first half of 1983 created the flexibility needed for the adoption of the new divisional structure. M. Elliott and E. Lester vacated Deputy Directorships which they had held since 1979. The former also relinquished the Headship of the Insecticides and Fungicides Department and returned to full-time scientific duties as leader of the synthetic pyrethroid programme; the latter retired. E. Lester joined the Station in 1976 as Head of the Plant Pathology Department; he brought to this responsible post a wealth of experience and a deep understanding of applied research and agricultural practice, and among many tasks gained immense respect by his Chairmanship of the Station's Working Party for Field Experiments. His qualities were appreciated widely; he was a member of a number of important external bodies, and is currently Chairman of the British Crop Protection Council. T. Lewis and P. B. Tinker were appointed Deputy Directors.

Other long-service staff who retired during 1983 were: A. W. Wheeler (Biochemistry, 26) J. Iwanicki (Broom's Barn, 34), D. H. Rees (Computing Unit, 32), Brenda M. Simpson (Farm [Rothamsted], 30), A. W. Neill (Farm [Woburn], 37), A. J. Arnold (Insecticides and Fungicides, 35), P. E. Burt (Insecticides and Fungicides, 33), A. H. McIntosh (Insecticides and Fungicides, 39), Audrey M. Shepherd (Nematology, 25), D. B. Slope (Plant Pathology, 30), O. J. Stedman (Plant Pathology, 35), Brenda Messer (Soils and Plant Nutrition, 35); parentheses give individual's final department and years of service. The Station was saddened by the death of G. J. W. Dean (Entomology).

Appointments were made to Divisional Headships (DCSO graded posts), with effect from August, as follows: Agronomy and Crop Physiology, R. K. Scott; Biomathematics, J. A. Nelder; Crop Protection, T. Lewis; Molecular Sciences, B. J. Miflin; and Soils, P. B. Tinker. W. Day, J. A. Pickett and R. T. Plumb were appointed, respectively, to the Headships of the Physiology and Environmental Physics, the Insecticides and Fungicides and the Plant Pathology Departments.

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L. Fowden became the member appointed by Her Majesty The Queen to the first Board of Trustees for the Royal Botanic Gardens, Kew.

Organization and financing of agricultural research and development

National considerations. Last year's Report suggested that agricultural research would face difficulties in the period 1984–87 as funding from government sources contracted. During the past year, the magnitude of the financial problem became starkly clear as its impact on the component institutes of the Agricultural and Food Research Service (AFRS) unfolded gradually. The constrained situation perhaps was a major factor evoking a rash of high-level reports each examining how agricultural research and development (R & D) is organized in the UK. The first commentary on this subject was produced by the Joint Consultative Organisation's Consultative Board; its main thrust was towards a simplified organizational structure for all R & D in which a single central body would assume the policy and funding responsibilities now exercised by several public sponsors (i.e. the Ministry of Agriculture, Fisheries and Food (MAFF), the Department of Agriculture and Fisheries for Scotland (DAFS), the Department of Agriculture for Northern Ireland (DANI) and AFRC). The idea of a single central body was developed further by the House of Commons Agriculture Committee (HOCAC) in their report entitled 'Organisation and Financing of Agricultural Research and Development'; the Committee foresaw this body as being outside government departments but in receipt of a grant-in-aid jointly from MAFF and the Department of Education and Science (DES), in line with current practice for the funding of AFRC. This HOCAC report strongly emphasized the need for a national strategic plan for agricultural R & D, for close and effective collaboration between the different major groups involved in R & D (the public research institutes, the Agricultural Development and Advisory Service (ADAS) of MAFF, university departments with agricultural interests, and the industrial sector), and for the purposeful and efficient dissemination of research findings to farmers and other users.

A Working Party of the Advisory Board for the Research Councils (ABRC) chaired by Mr J. R. S. Morris surveyed the relative extents to which the Councils use their funds to support in-house and university research, and the appropriateness of undertaking different types of work in Research Council institutes and in universities, The Morris report did not recommend any major shift of funding in favour of the universities, but stressed the advantages likely to result from closer intellectual links between institute and university researchers and the desirability of locating any new Council institute on, or near to, a university campus. Other recommendations encouraged Councils to examine carefully the present range of institutes they maintain, particularly the size and location of individual institutes in regard to their scientific effectiveness; to require institutes to compete with universities for a proportion of their research funds; and to consider how greater flexibility in the scientific manpower of institutes can be achieved to foster the development of new research initiatives. Finally, at the invitation of the Chairman of ABRC, Sir Ronald Mason examined the manner in which commissioning of research by government departments affected the ability of institutes and universities to undertake basic and strategic research. In respect of agricultural research, he concluded that the present dual funding arrangements leave some concern about the adequacy of resources for strategic research. The report recognized the need for more effective, informed procedures for resource allocations, and recommended the strengthening of R & D policy and programme formulation within government departments coupled with an enhancement of the authority and responsibilities of ABRC.

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The Government's response to the HOCAC report is awaited with great interest by all concerned with agricultural R & D because it is likely to determine the future responsibilities of the parties forming the research establishment. The report did not criticize the principle of a customer-contractor relationship, but suggested that the present commissioning procedures were too restrictive. In defining the need for a national strategic plan for R & D the Committee stresssed that a system for monitoring commissioned work at the level of broad objectives should meet the customers' requirements. Meanwhile, the AFRC has produced a corporate plan, which will be updated annually to provide a rolling five-year forward assessment of its research policy and programmes.

The need for a broad restructuring of programmes within the AFRS and for consequent changes in institute briefs is envisaged in this first plan. The effort in food research will increase, as will support for major new initiatives within the institutes and for agriculturally-relevant science in the universities, whilst traditional programmes in crops and animals research will contract. These changes, when fully implemented, will require the termination of about one quarter of the AFRS work now funded by the grant-in-aid from DES over a three year period. Decisions taken by Council in December will lead to the implementation of proposals within the plan, including those for major savings in arable crops research. These entail the closure of two smaller institutes. The programme of the AFRC Letcombe Laboratory will be amalgamated with that of Rothamsted, with ultimate withdrawal from the Letcombe site.

Developments at Rothamsted. The new divisional structure was established in response to the perceived need to strengthen the formulation of research policies and to improve the allocation of available resources across broad areas of the Station's scientific programme. The Divisions comprise related departments as follows: the Agronomy and Crop Physiology Division includes Broom's Barn Experimental Station, the new Physiology and Environmental Physics Department, the Field Experiments Section, and the Farms; Biomathematics Division consists of the Statistics Department and the Computing Unit; Crop Protection Division (the largest Division) encompasses the Entomology, Insecticides and Fungicides, Nematology and Plant Pathology Departments and the Chemical Liaison Unit; Molecular Sciences Division consists of the Biochemistry and Molecular Structures Departments; and the Soils Division has brought together the Soils and Plant Nutrition (including soil physics personnel) and Soil Microbiology Departments. The divisional management team assumed their new responsibilities at a critical time for the Station's finances, because the budget indicated for 1984/85 is 8–10% less, after allowance for government inflation indices, than the grant-in-aid received this year. This large reduction will require considerable retrenchment. Few posts vacated by normal retirements will be filled whilst staff opting for premature retirement will not be replaced. Inevitably, current expenditure also must be cut; but even these savings will not be sufficient and reluctantly a decision to terminate some research programmes, with consequent redundancy of posts, has had to be taken. The areas affected include work in molecular structures, invertebrate fine structure, and soil physics. Staff have been kept informed of the developing financial situation through the local Whitley Committee and the Station's weekly bulletin.

After a year of discussion and careful planning, a 'Friends of Rothamsted' organization was launched at mid-summer. The purpose of the 'Friends' is to foster further contact and understanding between Rothamsted and leading farmers, advisers and consultants, and the agricultural press, to encourage the dissemination of research findings to practical users, and to promote a two-way exchange of views on current

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problems of soil management and crop production. Whilst not a direct response to the HOCAC report, for the concept of a 'Friends' organization pre-dated its publication, the development is very much in the spirit of a major recommendation of the Committee calling for the creation of additional channels for information flow.

Channels for scientific interchange

For more than a century Rothamsted has influenced theory and practice in the sciences supporting agricultural production, and ideas developed in our laboratories have been applied to the solution of problems world-wide. In continuation of this endeavour it is crucial that we (i) disseminate scientific information through both learned journals and the agricultural press, and demonstrations and (ii) encourage contact and exchange between scientists and agriculturalists, nationally and internationally.

Visitors to Rothamsted number several thousands each year. They come as individuals, and members of small delegations or of large parties. They have widely different interests, and technical and national backgrounds. Notable among daily visitors this year were His Excellency the Ambassador of the People's Republic of China, accompanied by his wife Mme Ma Lanson, and the First Secretary and Scientific Counsellors of the Embassy, and A. A. Goltsov, a Deputy Minister of Agriculture of the USSR, leading a delegation of four scientists. Larger parties of agricultural students came from West Germany, the Netherlands, and UK universities, polytechnics and agricultural colleges. More than 70 overseas visiting scientists, representing 33 countries, participated in collaborative research or gained training in our laboratories during 1983. A proportion of these overseas visitors are registered for higher degrees in association with universities, and form part of a group of more than 30 students who are based at Rothamsted for the whole, or a part of, their postgraduate research. A further valuable link with universities and polytechnics is achieved by the presence, annually, in our laboratories of about 30 undergraduate 'sandwich' students. The first fellowship awarded under the new AFRC scheme enabling UK academics to spend a sabbatical period in AFRS institutes supported the attachment of A. Vivian to the Soil Microbiology Department.

Visits overseas by members of Rothamsted staff were made for purposes of research collaboration or for shorter study, discussion or lecture tours; others attended international scientific conferences, and in all nearly 200 staff were involved in such international contacts. Longer collaborative research visits were made to: Australia (J. C. Gower), Brazil (P. Etheridge and F. T. Phillips), China (A. J. Cockbain), India (D. W. Lawlor), and USA (T. M. Addiscott and S. Gutteridge). The Station was well represented at the 6th International Congress of Photosynthesis held in Brussels, and at the 4th International Congress of Plant Pathology in Sydney, Australia. External sponsors provided travel and subsistence costs for almost two-thirds of all visits undertaken, a situation indicating the high repute of Rothamsted's contributions to many fields of science.

Exhibits of research, particularly those prepared for poster sessions of scientific conferences, have placed an increasing pressure on the information and photographic services. During 1983, the Station provided exhibits or demonstrations at several major agricultural exhibitions. During Royal Show week at the National Agricultural Centre the potential agricultural significance of three research developments was outlined for visitors: these were the use of earthworms in the utilization of farm organic wastes, the effects of nematodes on the establishment of leys, and the nitrogen requirements and

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factors governing yield and quality of spring barleys for malting. Great interest was shown in a field demonstration of our multifactorial experiments on winter wheat, introduced as part of an impressive RASE 'Wheat '83' event at Haslingfield, Cambridge: other Rothamsted exhibits displayed on this occasion related to the use of ^{15}N-labelled fertilizer to trace the uptake and losses of N supplied to winter wheat, a programme contributing to our attempts to model the relationships of the crop and to develop a computer-based system for the prediction of N requirements, and to the quantifiable benefits derived from the infection of wheat root systems by vesicular-arbuscular mycorrhiza. The potential for more efficient control of weeds, diseases and pests associated with electrically charged spraying systems was explained to visitors at the East of England Agricultural Show at Peterborough.

An aspect of the Station's research in genetic engineering that illustrated new opportunities stemming from the regeneration of whole potato and wheat plants from protoplasts or tissue cultures attracted considerable attention during the Royal Society's Soirees held in May and June.

A wide cross-section of the Station's research, both field and laboratory based, was on display at an Open Weekend in June. About 7000 people attended, mostly local citizens.

Weather and crops

Winter 1982–83 was relatively mild; only February was colder than the long-term mean, so that autumn-sown cereals generally overwintered well. Good conditions with less than average rainfall prevailed for much of March, favouring early spring cultivations and sowings, but April and May were cool and very wet, rainfall for each month being about double the long-term mean. Many crops of barley sown under these conditions established and grew poorly, root development often being slow and shallow in the very wet soil. The drilling and early growth of the sugar beet crop also was affected adversely, and many fields appeared poor and uneven at the end of May. Potato planting was interrupted frequently, and general crop spraying was difficult on many days in these months. In contrast the period spanning June, July and August at Rothamsted was considerably drier, warmer and brighter than average. The approximately 20% greater than normal radiation receipt in this period was particularly important for potato and sugar beet crops. Harvesting of all crops proceeded without difficulty, and continued favourable weather throughout the autumn facilitated the timely drilling of overwintering crops.

The seasonal conditions overall were relatively favourable to winter wheats and good yields were obtained from many experiments, but spring barleys generally proved disappointing, and some yields on lighter land at Woburn were poor. Despite the adverse conditions prevailing during the sowing and early growth periods of the potato and sugar beet crops, the combined effects of the high irradiance of the mid-summer months and the clement autumn weather gave many good yields, and sugar production from the national beet crop was one of the highest on record.

The scientific programme: developments and achievements

Much of our scientific programme has continued to be interdisciplinary in character. The divisional structure will enable effort to be focused more intensively on major problems requiring a cooperative approach, and will seek to exploit opportunities within divisions and in research themes linking two or more divisions. Each year sees an increase in the proportion of field work involving multidisciplinary teamwork, whilst laboratory-based investigations requiring the combined skills of chemists, physicists, biologists and biomathematicians continue to develop.

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Multifactorial field experiments

The programme of field experiments in which scientists from several different disciplines participate has continued with winter wheat, winter barley, field beans and potatoes, and a new group has begun work on leafy peas. The wheat and barley experiments are the most complex allowing up to eight factors or treatments to be assessed singly or in combination with others. The term multifactorial is often used in later references to these experiments. In any year, the largest yields of particular crops on our farms commonly result from suitable combinations of treatments within these experiments, and this was again the case in 1983 when some yields in excess of 10 t ha^{-1} were recorded in the wheat experiment. However, the designs of the experiments also allow us to establish how the use of less N fertilizer or the omission of pesticide, fungicide or growth regulator treatments affect yields, and so provide information enabling individual judgements to be made concerning the wisdom of using fewer inputs than those needed to obtain maximum yields.

Soils research

Soil maps and data base. The 1:250000 soil map of England and Wales was published in six sheets in April, and later in the year was commended by the presentation, to the Head of the Soil Survey, of the British Cartographic Society's John Bartholomew Award 'for excellence in small scale thematic cartography'. Soil information arising in this and previous mapping programmes is being incorporated into the data base management system Datatrieve, and by September 1984 it will be possible to retrieve all field and laboratory data from detailed profile descriptions, all National Soil Inventory field data and about 60% of purposive boring records (made for about 100000 sites). The 1:25000 Coventry South maps have been used in a trial seeking to transfer map units in raster form to the Prime 550 computer, when the printed soil map in essence is transformed into a digital graphic database which can be linked to non-graphic information. The arrangement will enable a variety of computer drawn maps to be produced to illustrate selected themes.

Soil type and wheat yields. In conjunction with the ICI Ten Ton Club's investigations of winter wheat growth in 1979 and 1980, the soils on which more than 600 crops were grown in each year have been identified to series in an attempt to explain how soil type influences yield. ICI's own multifactor regression model indicated that soil type, as classified by topsoil texture only, accounted for only 3–4% of the total yield variance. However, when the soils were reclassified according to series mapped by the Soil Survey, soil characters accounted for 18% of the variance of yield in both years. Although all crops were subject to good husbandry, including adequate nutrition and plant protection regimes, mean yields for the 19 most frequently represented soil series varied from 6·0 to 8·9 t ha^{-1}, but the variances for crops grown on a single series did not differ significantly. The allocation of a soil to a particular series is thus a useful step in assessing how well winter wheat will perform on a site.

Root growth and soil nutrient uptake. The growth of roots of winter wheat crops has been measured carefully at several sites at Rothamsted and Woburn; the pattern of growth shows similarities between sites, and root length is closely correlated with elapsed 'thermal time'. The wheat plant seems to be programmed to produce a given amount of root (in relation to thermal time) irrespective of reasonable differences in soil type or overall grain yield. If this can be confirmed on more sites, modelling of root systems and nutrient and water uptake will be made easier. Nevertheless, there is a need

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for a much fuller understanding of the physiological and biochemical mechanisms associated with the uptake of nutrients by crop roots from field soils, and of the internal regulatory controls affecting the passage of nutrients across cell membranes and their transport within the plant. Ultimately, such knowledge might allow the application of genetic engineering procedures to the breeding of wheat cultivars having root systems with specified desirable attributes. For the present, two specific investigations concerning nutrient supply and uptake have immediate interest. The first involved ^{15}N-labelled fertilizer, applied as a spring dressing (mid-April) to winter wheat at three sites over four years, and revealed that 10–30% of the N could not be accounted for in the crop and soil at harvest, and that this loss was related directly to rainfall in the four-week period following application. On average 8% of the applied fertilizer N was lost for each 25 mm rainfall—a useful relationship in determining the size of late supplementary N dressings in wet springs. The other has established the wisdom of expressing nutrient concentrations in arable crops on the basis of tissue water, rather than as a percentage of dry matter, if the plant's physiological status is of concern. For example, with K in barley a concentration in tissue water of about 100 mM is maintained during most phases of growth, provided adequate K-nutrition is available, and so this level may become the basis of a diagnostic tissue test for possible K deficiency.

Aspects of crop protection research

Much of our research in this area seeks knowledge that will allow the more accurate prediction of potentially damaging infections or infestations of crops so that appropriate control measures can be applied in a timely and environmentally acceptable manner to eliminate or markedly reduce yield loss caused by pathogens and pests. The research is concerned equally with factors influencing the aerial dispersal of fungal spores, the migration of insects behaving as virus vectors, and the incidence of pathogenic fungi and bacteria or parasitic nematodes in field soils. Part II of this Report includes an account of the damage caused by stem nematodes in field crops.

Aerobiology of pathogen dispersal. This investigation includes both experimental and theoretical components on the dispersal of spores and other small particles and has offered the opportunity for valuable collaboration between physicists and pathologists. Both theory and measurement give values for spore deposition gradients away from disease foci and a simulation model has been developed that determines the consequential spread of disease. Simulations of disease spread in mixtures of crop varieties have suggested circumstances in which mixtures may be particularly effective in reducing disease levels. Field measurements of disease gradients in plots of single varieties or mixtures this year have given the data necessary to test this model.

Aphid movement and virus spread. Aphids form the single most damaging group of insects affecting crops in the UK and for this reason the Rothamsted Insect Survey has concentrated on the task of measuring aerial populations and predicting the movement of the principal aphid species. Very comprehensive data based on suction trapping has been accumulated over nearly 20 years, but now we envisage the exciting possibility of augmenting this information by new measurements made with the aid of 'vertical-looking' radar. The technique hitherto has been used to study the migration of relatively large insects (locusts and moths), but newer developments enable radar signals to detect even small aphids at heights up to 500 m. We have commissioned the first equipment able to monitor aphids in two height bands (20–100 and 100–500 m), and to provide information that can reveal the weight, shape, speed and direction of flight, and wing beat frequency of individual insects and so serve to aid identification. The

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information will be analysed immediately by a dedicated computer and, when several radar installations are operating in south and east England, the monitoring of pest movements over a large area will be improved significantly and it will be possible to relate particular infestations to their source and to weather conditions likely to encourage their spread.

Infectivity indices and virus incidence. Earlier reports have described an infectivity index that predicts the likelihood of infection of cereal crops by barley yellow dwarf virus (BYDV). The index is derived from a knowledge of migrant populations of the principal aphid vector *(Rhopalosiphum padi)*, the proportion of the aphids carrying virus, and the date of autumn-sowing of the crop (the earliest sown crops are most prone to aphid infestation and virus transmission). The forecasts were adopted quickly by ADAS and have been quite valuable; however, the importance of using indices derived on a regional basis is now recognized, because similar development of BYDV in different localities can be associated with quite different values for the index. For this reason, the number of sites for which an index was derived in 1983 was increased from four to nine, and after gaining two or three years' results it should be possible to set a series of local threshold values above which preventive spraying is recommended. Meanwhile, infective aphids were found only at a few sites in 1983, suggesting that few crops would benefit economically from an autumn aphicide spray.

Reduction of aphid feeding. Virus is transmitted to crop foliage as aphids probe the tissues to feed. The extent of virus infection is then likely to be reduced if aphids can be dissuaded from settling on foliage, if their movement between plants is lessened, or if, in the case of persistent viruses, the time spent by aphids feeding on individual plants is shortened. Collaborative research between members of the Plant Pathology and Insecticides and Fungicides Departments has indicated some approaches potentially useful in limiting aphid-transmitted spread of viruses, based on the activity of the aphid alarm pheromone, *(E)*-β-farnesene and derivatives. Related research has provided an explanation of why many plants are colonized by aphids, although they contain significant amounts of *(E)*-β-farnesene which normally would be expected to deter the insects from settling. Another common plant product, the sesquiterpene (−)-β-caryophyllene, has been identified for the first time as an inhibitor of pheromone communication in aphids (*Myzus persicae* and *Lipaphis erysimi*), being capable of antagonizing about 30 times its own concentration of *(E)*-β-farnesene.

Efficiency of fungicide applications. In conjunction with several other institutes within the AFRS and with the agrochemical industry, we have continued to assess the biological efficacy of pesticide spraying techniques with particular emphasis on the APE 80 spraying equipment producing electrostatically-charged droplets. The spacing between individual spray heads along the boom was reduced to improve uniformity of droplet deposition across the swath and to increase the space charging effect. The equipment has been compared with conventional hydraulic sprayers in several fungicide trials, i.e. for the control of eyespot in winter wheat, and of mildew infection of barley and swede; in each instance the pathogens were controlled as, or more, effectively following electrostatic rather than hydraulic application of comparable amounts of fungicide, and equivalent control of mildew in swedes was obtained when half and full doses of fungicide were applied, respectively, by electrostatic and hydraulic sprayers.

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Molecular biology and genetic engineering of crop plants

The long-term possibility that the architecture and physiological functioning of root systems might be manipulated by gene transfer techniques to permit greater economy in supply of plant nutrients has been mentioned in an earlier paragraph. Another goal, and perhaps one likely to be attained more quickly by the application of genetic engineering techniques, is improved efficiency in legume host-rhizobia symbiont associations involved in biological nitrogen fixation. The fixation process is sustained by photosynthate transported to the root nodules from the legume's foliage, but the efficiency with which this transported material is utilized (expressed as N_2 fixed to C consumed) may show a 2·5-fold variation and is *Rhizobium* strain dependent. We hope that our ability to construct strains with defined genetic make-up may provide a new approach to creating more efficient symbioses. The amount of carbon consumed in N_2 fixation is controlled, at least in part, by the rate of oxygen diffusion into the nodule. Some legumes appear able to alter resistance to oxygen diffusion rapidly, and genotypic differences in this flexible control mechanism may partially govern the quantity of N_2 fixed by different legume crops.

As part of the research on plant cell biology underpinning the genetic manipulation programme, T-DNA from *Agrobacterium tumefaciens* and *A. rhizogenes* has been introduced into cells of commercial tetraploid potato varieties. Transformed plants have been regenerated from the cell cultures containing bacterial DNA, and these have formed tubers, one of which was sprouted to give a second generation transformed plant. To our knowledge these are the first transformed potato plants of their kind in the world, and the achievement is particularly significant because it is likely to lead to the co-introduction with T-DNA of modified or unmodified genes, and the opportunity to investigate what factors influence their stability and expression in the transformed plants: furthermore, if the genes are expressed, their effects on the plants can be examined.

Earthworm culture

Successful farming requires that materials and practices be employed in cost efficient ways, and much of Rothamsted's work on chemical inputs to agriculture, especially fertilizer-N and pesticides, seeks to improve their efficacy in use. Coincidentally, improved agrochemical practices also lead to reduced contamination of the environment. Another of our programmes, namely the development of techniques for the mass culture of earthworms, eventually may lower pollution caused by organic farm wastes. Systems of mass culture developed at Rothamsted since 1980 have been adopted for commercial exploitation by British Earthworm Technology, with support from the British Technology Group. Further trials in which worm-worked cattle wastes have been tested as horticultural composts, jointly with the Lea Valley and Efford EHSs have shown that the material admixed with peat and, in some cases, slow release fertilizer, supports the growth of a range of annuals and woody ornamentals at least as well as, and often better than standard peat and sand potting composts. Trials with vegetables are continuing. Meanwhile, much painstaking research has been accomplished to identify worm species most appropriate for mass culture and to specify the conditions favouring the growth of worms throughout an annual cycle.

Computing in the service of research

The Computing Unit was formed in October 1982 to promote the application of computing to a wide range of research programmes, often by the attachment of computing specialists to disciplinary teams. The Unit received a new Digital Equipment

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Corporation VAX 11/750 general purpose mini-computer system in July as part of the AFRC distributed computer network. By October, 240 scientists were using the equipment for new projects or for others transferred from the ICL System 4 machines of the AFRC Computing Centre; the System 4 mainframe computer will be phased out in 1984. The VAX system will be enhanced in January 1984 to provide sufficient capacity for the transfer of all System 4 work, and it is expected to be augmented further by a second VAX 11/750 in summer 1984. The VAX systems permit scientists to access not only software mounted directly on the Rothamsted machines, but that available at any AFRC institute or UK university connected to the network. In addition to their role in installing and commissioning this new equipment, members of the Unit have been active in the development of insect databases for entomologists, a meteorological database, computer-controlled glasshouse automation systems, laboratory data capture and analysis procedures for physicists, physiologists and soil chemists and surveyors, and graphical display software for many scientific user groups.

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