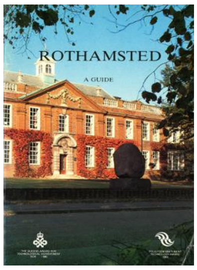
# Guide to the Work of the Departments 1984

Full Table of Content




## Crop Protection Division

### Rothamsted Research

Rothamsted Research (1985) *Crop Protection Division ;* Guide To The Work Of The Departments 1984, pp 16 - 28

Much of this work is done jointly with ADAS and some in collaboration with the Agricultural and Food Research Council Institutes and with other organizations such as the British Sugar Corporation and the Fertiliser Manufacturers Association.

### Methodology

The application of statistical methods constantly exposes areas where current theory is deficient, and this provides the stimulus for the Department's research work. We have an active interest in developing and using multivariate analysis, that is statistical methods of analysis that combine information on the many traits observable for any biological unit such as an experimental plot or an animal. Typical applications are in taxonomy, plant breeding, and the analysis of experiments involving many subjective judgments such as occur in assessing the qualitative aspects of foodstuffs.

We also collaborate with other departments in the development of mathematical models for the description of physical and biological systems. These aim to replace qualitative predictions about the behaviour of such systems with more precise quantitative ones.

### Statistical computing

The many statistical calculations, of great variety, are almost all done by computer. To allow us to write down quickly the instructions required for a particular analysis we have developed special computer programs, each with a problem-oriented language. Thus the Genstat system provides a language specially constructed to help in specifying the analysis of designed experiments, multiple regression and its extensions, and multivariate analysis. Other programs are MLP, especially useful in the fitting of non-linear models to data; GLIM, which extends regression analysis to generalized linear models; and Genkey, which deals with the construction of diagnostic keys, such as occur in taxonomy. We are major users of the Rothamsted General Survey Program, originated by F. Yates.

All the programs can be used interactively from a terminal to explore experimental data and associated models, and all have been written in a way that helps their conversion to run on machines other than our own. A licensing system covers their distribution to centres throughout the world.

### Overseas work

The Department contains a unit supported by the Overseas Development Administration, the function of which is to provide a service of statistical advice and computing to agricultural research workers in developing countries. We respond to continuing requests for help from all over the developing world and consultancy visits are paid to these countries from time to time.

## CROP PROTECTION DIVISION

In the UK 10–15% of the potential yield of arable crops is lost annually through pests and diseases, and on a world scale the losses are even greater. It is essential to protect growing crops from the many agents that contribute to these losses to ensure yields of a satisfactory size and quality. Important damaging organisms range from microscopic viruses, bacteria and fungi, to many forms of invertebrates including roundworms, slugs and insects. Their harmful effects can be prevented or minimized by a wide range of chemical, biological and cultural practices, often combined in a complex way to exploit vulnerable stages in the life-cycle of a particular pest or disease.

The Crop Protection Division, comprising four large departments – Entomology, Insecticides and Fungicides with their Chemical Liaison Unit, Nematology and Plant Pathology – contains many distinguished biologists and chemists who study, often in teams combining several specialists, the biological reasons for outbreaks of pests or diseases, ways of predicting if, when and where they are likely to occur, and how they can be controlled. The availability of such detailed and varied expertise on a single site provides unique opportunities for concerted approaches to solving many pest and disease problems.

## ENTOMOLOGY DEPARTMENT

The approach in this Department is essentially long-termed, based on an understanding of the responses of insects to their environment, including the weather, their habitat, food and other animals and pathogens. Ways in which insect numbers are modified by these factors are investigated. The work includes ecological studies aimed at establishing the underlying causes of population changes, examination of novel methods of pest control, and of the environmental effects arising from current pest control practices. Beneficial organisms including honeybees, earthworms, and viruses and fungi attacking pests are also studied.

### Monitoring airborne pests with traps

Aphids are very serious insect pests in Great Britain, causing direct damage and transmitting virus diseases to many crops. In an effort to give early warning of infestations so that pesticides can be applied at the correct time, a monitoring system has been established by the Rothamsted Insect Survey. Twenty-three suction traps, like the one sampling at a height of 12.2 m (40 ft) near the Meteorological Enclosure on Rothamsted Farm, are sited throughout Britain and daily samples of insects are identified. The resulting information on their distribution is published in a weekly Bulletin which is widely distributed to members of the Agricultural Development and Advisory Service of the Ministry of Agriculture, Fisheries and Food (ADAS), and to other interested people. For some species, this system is as effective in detecting the arrival of aphids as regular inspection of crops, and much less expensive. The suction traps used are very sensitive and capable of measuring airborne populations so sparse that, when deposited on the ground, they would be difficult to detect even with careful searching. A projected development to the system is to incorporate a series of radar sets alongside key traps to give even earlier warning of the presence of large populations of airborne aphids.

In addition to the suction traps, an extensive system of light traps is operated, with the help of numerous volunteers, to collect information on the density and dispersal of populations of night-flying insects. These include about 30 species of moths of agricultural interest, and beneficial predators including lacewings.

An entirely different method for monitoring insect populations is the use of simple traps containing a sex attractant. This approach, developed in coopera-

Suction trap (left) and radar set (right), with protective dome removed – two methods used for the detection of flying aphids.

tion with the Insecticides and Fungicides Department, has the advantage of being cheap, extremely sensitive and usually specific for a single pest, so that much of the labour needed to sort and identify catches is eliminated. These traps can be sited within growing crops so that an individual farmer can use them to make his own pest assessment, or they can be used by ADAS Agricultural Advisers or commercial organizations as a basis for regional spray warnings. So far, the method has been successful for pea moth; the possibilities for other moths, midges and beetles are being investigated.

**Integrated control**

The modern approach to pest and disease control is to encourage the establishment of natural enemies of pests wherever possible, resorting to insecticidal application only when necessary, rather than as a routine insurance treatment. This avoids environmental pollution and retards the development of resistance to pesticides in pest populations treated too often with insecticides. Work on integrated control is concentrated on measuring the impact of natural enemies of aphid populations in winter wheat and the possibility of using a fungus disease to control aphids directly in wheat and field beans. Predatory beetles are encouraged by organic manuring and the presence of a limited number of weeds in the crop. Such predators prevent outbreaks of aphids in most years; but is is important to ascertain when and why this natural control fails.

**Insect pests and crop yields**

Knowledge of the relationship between insect pest populations and crop growth and yield is essential to pest management and the prevention of yield losses. The effects of pest attacks can differ greatly between sites and seasons, being dependent not only on pest numbers, but on the growth stage of the crop when attacked, crop variety, soil conditions, weather and many other factors. This variability often makes it difficult to define pest populations that justify control, and intensive investigations are needed to measure yield losses and discover how they are caused. Pests that are being studied in this way include some on cereals, field beans and oilseed rape.

As part of an overall Rothamsted programme the Department is collaborating in multidisciplinary studies to assess the relative importance to field crop production of insect pests compared with other factors affecting the yield, such as soil fertility, weather, pathogens and nematodes.

## Honeybees and the pollination of field crops

Rothamsted has long held an authoritative position in this subject and work continues on determining the need for pollination of crops, especially oilseed rape, and of ways of increasing the efficiency of honeybee colonies used for pollination. Pheromones, chemical 'messengers' produced by queens and worker bees, have been isolated and synthesized by Insecticides and Fungicides Department, and used in the Entomology Department to encourage greater foraging activity and facilitate the handling and management of colonies. For example, one pheromone can be used to attract swarms to empty hives so preventing their loss, and another is being tested to see if it can be used to attract foragers to crops to optimize pollination and seed set.

Honeybee diseases are also studied intensively because only healthy colonies can produce abundant honey and act as effective pollinators. Many viruses attack honeybees and 10 of these have been identified as present in Britain. Of particular current concern is a parasitic mite, *Varroa jacobsoni*, which is spreading rapidly through most European countries, though fortunately it has not yet been found here. Recent work suggests that the mite may transmit virus diseases to bees, so every effort is being made to work out the relationship between the viruses, the carrier and the honeybee host.

## Exploiting animal waste with earthworms

Experience with soil animals over many years has led to a novel research programme aimed at the systematic use of earthworms to break down animal wastes and convert them into materials which could usefully be added to agricultural land to improve soil structure, and could be used in horticulture as plant growth media or peat substitutes. These worm-worked animal wastes have much more nitrogen, in a form available to plants, than raw or composted wastes; they also have more available phosphorus, potassium and magnesium, and a moisture-holding capacity similar to that of peat.

As they consume animal wastes, worms grow and multiply very rapidly. The conversion of such wastes into earthworm body tissue is very efficient; every tonne of suitable animal wastes can produce as much as 100 kg of worms; on a dry matter basis the conversion efficiency is of the order of 6–10%. Worms are the natural food of chickens, fish and pigs and their body composition makes them a valuable potential source of animal feed if they can be produced economically. Earthworm dry matter is 60–70% protein with more essential amino acids, such as lysine and methionine, than either meat or fish meal. The other constituents of worms are 7–10% fat, 8–20% carbohydrate, 2–3% minerals and a range of vitamins of which niacin and Vitamin $B_{12}$ are of particular value. Their composition makes worms suited to producing a protein additive suitable for fish, pig and poultry feeds.

The optimum environmental conditions and stocking rates for maximum production of protein and the fastest rates of breakdown of waste have been identified for several different species of earthworm. The work has progressed to a stage where on-farm schemes designed to exploit pig, cattle, duck, turkey or chicken wastes have been established. Overall, the study has pointed to ways of avoiding pollution from farm wastes, and of converting them into several useful, and valuable, products.

## INSECTICIDES AND FUNGICIDES DEPARTMENT

The work of this Department is aimed at making chemical control of pests and diseases more effective and safer. It involves developing and evaluating novel chemicals and approaches to crop protection by using a combination of chemical, biological, biochemical and physical techniques. However, because dependence on conventional insecticides and fungicides will continue for the foreseeable future, studies on these compounds, including attempts to understand and overcome resistance, form a major part of the research programme.

### Relationships between molecular structure and insecticidal activity

Most relationships between molecular structure and insecticidal activity are still poorly understood, and better knowledge is needed to provide a rational basis for finding new and better toxicants. Recently the Department has concentrated on compounds related to the natural insecticides, for instance those found in pyrethrum flowers; these are outstandingly safe for mammals and do not harm the environment. Synthesis of many different compounds and examination of their chemical and biological properties has revealed many of the chemical features required for insecticidal activity. One outcome of this work has been the discovery of several outstandingly active new synthetic insecticides, the pyrethroids, some of which are in commercial production. Earlier pyrethroids were used mostly to control indoor and glasshouse pests because they are expensive and decompose very rapidly outdoors. However, some of the most recently discovered compounds are cheaper and more stable while retaining the favourable properties of previous pyrethroids, so are finding extensive use, particularly for controlling pests in field crops.

### Mode of action of insecticides and fungicides and the causes of resistance

Resistance is one of the most important problems associated with the use of insecticides and fungicides throughout the world, and is becoming progressively more serious. Toxicological, genetical and biochemical studies on houseflies, aphids and barley diseases in the Department are helping to elucidate the nature and importance of the mechanisms responsible for resistance. Knowledge thus gained is being applied to develop crop protection regimes which will prevent or delay the development of resistance. These are evaluated in the field. Insecticides and fungicides from various classes are being studied, including the pyrethroids, so that infomation is made available to guide the synthesis of new compounds.

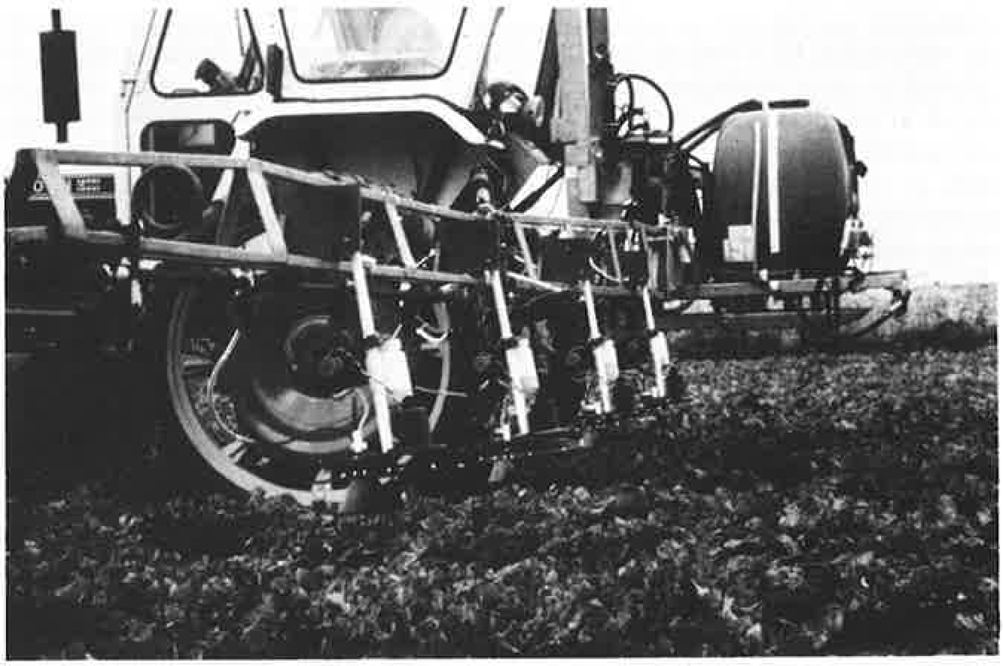
### Behaviour-controlling chemicals

The behaviour of many invertebrate pests of agriculture, and also of beneficial organisms, is mediated by small amounts of chemical signals such as pheromones. The minute amounts of compounds present naturally are identified by coupling high resolution chromatographic equipment with sophisticated spectroscopy and electrophysiological systems. In collaboration with other Divisional groups, methods are then developed for using synthetic compounds, and chemically modified products, to monitor or control pests and to manipulate beneficial effects of certain organisms. A major area of interest involves attempts to use the aphid alarm pheromone and its derivatives to prevent colonization and plant virus transmission by aphids. There are also studies on developing plant-derived antifeedants against aphids, on chemicals influencing the mating, oviposition or host location of moths, flies, beetles and nematodes and on pheromones and host attractants of beneficial Hymenoptera such as honeybees and aphid parasitoids. To restrict slug damage on winter wheat, seed treatments with synthetic and plant-derived antifeedants are being studied in collaboration with the Entomology Department and ADAS.

As well as the work with behaviour-controlling chemicals, selectivity of insecticides in favour of beneficial species and methods of assessing and minimizing the effects of pesticides on predators and parasites in crops are investigated, the latter also in collaboration with the Entomology Department.

### Novel spraying techniques

Crop spraying is one of the most inefficient processes on farms, as several hundred times more pesticide is applied than is theoretically needed to kill pest organisms present. The Department, with the Chemical Liaison Unit, is making a major effort to improve spraying techniques by developing novel systems. A



Tractor-mounted electrostatically-charged rotary atomizers are improving spraying efficiency and preventing drift method of applying an electrostatic charge to the output of rotary atomizers has been devised; like their uncharged counterparts these electrostatic sprayers have the advantage of using low volumes of liquid, but the charged droplets are attracted to plants so they impinge more readily and drift less. This results in greater chemical deposits on the plants and less environmental contamination. Field trials involving equipment designers, chemists and biologists are in progress on a wide range of crops to determine where the advantages of the system can be employed to best effect.

## CHEMICAL LIAISON UNIT

This Unit, associated with the Insecticides and Fungicides Department, comprises chemists seeking information about the application, redistribution and persistence of crop protection chemicals to ensure their effective use with minimal environmental contamination. The programme of the Unit is split between immediate practical problems in which the Unit works closely with other departments in the Crop Protection Division and outside agencies, such as the Potato Marketing Board, and studies of a more fundamental nature leading to an improved understanding of the behaviour of pesticides in the environment.

### Pesticide application

The current programme includes the incorporation of nematicides in soil for the control of potato cyst nematodes (with Nematology Department), the control of tuber-borne diseases of potatoes (with Plant Pathology Department and the Potato Marketing Board) and evaluation of the performance of electrostatic crop sprayers (with Insecticides and Fungicides Department).

### Factors affecting the behaviour of chemicals in the environment

As application of chemicals to soil is likely to remain an important method of controlling most soil-borne pests and diseases for the foreseeable future, research aimed at predicting the behaviour of chemicals in soil is continuing. However, the application of pesticides to soil is inefficient and environmentally undesirable, so work is also in progress to elucidate the influence of physicochemical properties on the redistribution of chemicals in plants and soil. This should lead to a definition of the structural requirements affecting the movement of pesticides to the site of attack by pests and diseases. Such knowledge will permit the design of precursors of pesticides which would be transported to the desired site.

### The movement of chemicals in the atmosphere

Tracer chemicals are being designed to assess the drift of chemicals following spray application and to provide a model system for obtaining information on the movement of spores above and within crop canopies (in conjunction with Physiology and Environmental Physics Department). Similar tracers are also being used to investigate the effect of formulation and chemical structure on the rates of release of volatile compounds from spray deposits to describe the most efficient methods of using crop protection chemicals, such as pheromones, which act in the vapour phase.

## NEMATOLOGY DEPARTMENT

This Department studies nematodes known or suspected to be plant parasites, of which over 2500 species have been described. A few live and feed on or in the aerial parts of plants, some are internal parasites of roots but most live in the soil and feed externally on roots or underground stems. There are also many other species of non-parasitic nematodes in soil. Some plant parasites are characterized by the formation of an egg-filled cyst which enables the nematodes to survive until a suitable host grows nearby. Others have resting stages which can survive drying and remain dormant in the seeds of host plants. It is such forms, particularly the 'cyst nematodes' and the 'stem nematodes' which can multiply rapidly on certain arable crops, cause important losses to UK farmers and which are difficult (or expensive) to control. Most of the Department's research concentrates on these forms, particularly cyst nematodes attacking potatoes, sugar beet and other arable crops, and stem nematodes on a wider range of arable and forage crops. Studies are designed to recognize existing problems and to predict new ones, to find improved or novel methods of control and to aid other endeavours intended to alleviate the effects of plant parasitic nematodes, especially those of the plant breeding institutes and ADAS. Because nematodes are small, about a millimetre long, work with them involves much microscopy and their extraction from soil or plants is a tedious process.

### Identification and biology

Identification, classification and the description of new species provide a foundation for other work – research is wasted unless the organism worked on is properly known. To aid this a reference collection of specimens has been built up over 35 years. Special attention is paid to economically important genera. Identification calls for knowledge of detailed structure, which requires refined microscopic techniques and the scanning electron microscope is used to study details of morphology beyond the resolving power of light microscopes, while chemical techniques are used to aid identification by recognizing nematodes through differences in their proteins and enzymes. The life cycles and host ranges, both on crops and weeds, are determined, for this knowledge is essential for controlling pests by suitable crop rotations.

### Stem nematodes

Races of *Ditylenchus dipsaci* attack a wide range of plants and their pathogenicity, biology and taxonomic status is studied to provide a background for work on their control. Resistance is important in controlling stem nematode attacks on some crops, so the efficacy of resistance and the occurrence of resistance-breaking stem nematode races is studied. Farm experiments investigate the effect of the races on plant growth and yield and also the survival of the nematode in the soil.

### Migratory nematodes

These are forms which move freely in soil between plants, feeding on or in roots. In sandy soils, crops may be damaged by stubby root (Trichodorid) nematodes, by needle (Longidorid) nematodes and by virus diseases which they sometimes transmit. Root lesion nematodes (*Pratylenchus*) can damage cereal and other crops, especially oilseed rape and field beans. Other migratory forms are also implicated in crop damage. The Department has a programme on the pathogenicity and control of these locally important pest species, currently including studies on rape and field beans and on the establishment of ryegrass pasture.

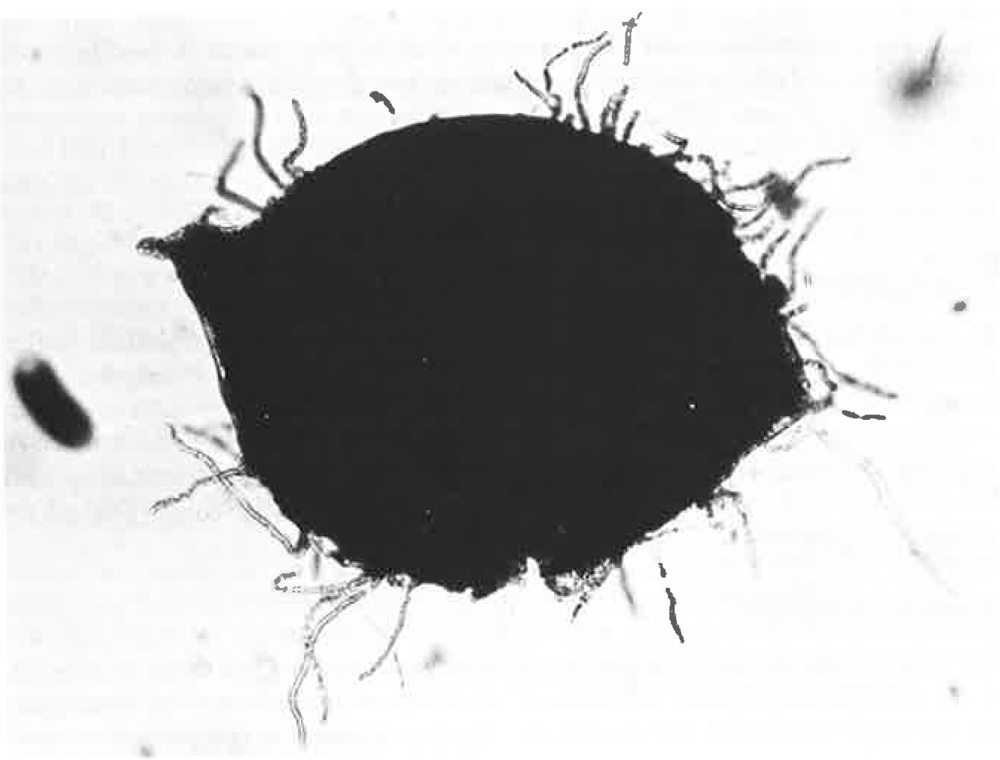
### Cyst nematodes

Two species, *Globodera pallida* and *G. rostochiensis*, attack potatoes in the UK and each exists as a series of races or pathotypes which can overcome the resistance of nematode-resistant potato cultivars. The Department collaborates with ADAS and with nematologists overseas in typing populations and standardizing nomenclature, and with plant breeders in studying the effectiveness of resistance and the ways nematodes can overcome it. Many British and foreign populations are maintained under licence and staff members have visited the USA, Mexico, Venezuela, Peru and Bolivia to study populations there. The genetics of inter-relationships of pathotypes and hosts are studied. This work is valuable for plant breeders and essential if rational use is to be made of the nematode-resistant varieties they produce.

Other work on cyst nematodes includes studies of physiology with a view to developing novel control measures.

### Biological control

Naturally-occurring soil populations of certain fungi are known to sometimes limit the size of cyst nematode populations. Such fungi have important potential as biological control agents, and field and laboratory studies investigate ways in which they may be manipulated to control nematode pests effectively.



Female cereal cyst nematode attached by the parasitic fungus *Nematophthora gynophila*.

### Control by nematicides

The Department does many experiments every year on the Rothamsted and Woburn farms and elsewhere to study control by chemicals of cyst nematodes, stem nematodes and others. Cyst nematodes, especially potato cyst nematodes, have been controlled by incorporating oximecarbamate nematicides in the seedbed. The best of these treatments not only prevents damage to the crop but also lessens or prevents nematode increase. The effectiveness of a nematicide is much affected by the way in which it is applied and a new method of application which causes minimum damage to soil structure has been patented and developed commercially. To ensure safe as well as effective use of nematicides, their persistence, movement and decomposition in soils and crops is investigated.

### Tropical nematodes

The Department houses work funded by the Overseas Development Administration Nematology Liaison Officer on root knot nematodes, of major importance in warmer climates.

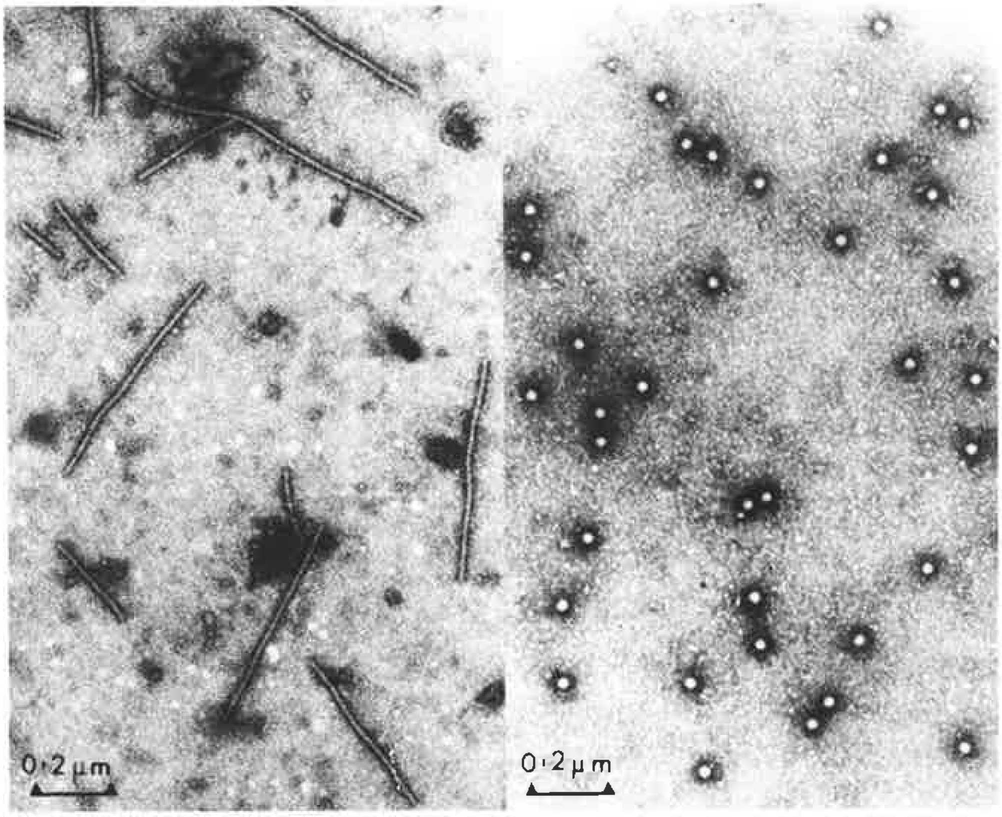
## PLANT PATHOLOGY DEPARTMENT

Plant diseases cause significant losses to growing and stored crops, losses which would be much greater if various control measures were not used. This Department identifies the causes of diseases, determines the effects on the host plant and elucidates the factors involved in the development of disease epidemics with the object of improving control methods. Studies cover diseases caused by fungi, bacteria, viruses and other pathogens, affecting mainly cereals and potatoes but work is also done on grasses, forage and grain legumes, oilseed rape and maize.

### Viruses

These are very small pathogens that multiply only in living cells. The particles have two main components; nucleic acid, the infective part and protein, which protects it. To study their shape, size and distribution in infected cells, preparations are examined under the very high magnification (40 000X) of the electron microscope. To make particles visible they must be immersed in stains that absorb electrons. Viruses are identified by their shape and size; by the symptoms they cause in natural hosts and when transmitted to indicator plants; by serological tests using specific antibodies prepared by injecting rabbits with the virus; and by their mode of spread. Most viruses can be transmitted by grafting, by vectors such as insects, mites, nematodes and soil fungi, and many are also transmitted through wounds. Some viruses are transmitted in seed, and in vegetatively propagated crops perpetuation in the planting material is important.

**Effects of viruses.** Potato yields are severely decreased by virus infection and virus-free seed tubers have to be obtained to maintain yields of ware crops grown in southern and eastern England. Field beans (*Vicia faba*), a valuable source of protein, would be grown more widely if yields were more reliable. Virus diseases and fungi have been shown to be important causes of this unreliability. Several bean viruses are transmitted by aphids but two, broad bean stain virus and broad bean true mosaic are seed-borne and transmitted by weevils. Severe and




Particles of barley yellow mosaic virus (left) and barley yellow dwarf virus (right) as seen in the electron microscope using a serological technique adopted for electron microscopy.

mild isolates of a virus often exist and their relative prevalence differs between regions and years. Plants are often affected differently according to the age or growth stage at which infection occurs. Early infection of cereals with barley yellow dwarf virus is very damaging, the less so the later the infection. Some crop plants, notably ryegrass, sugar beet, *Vicia* beans and clovers contain virus-like particles with which we have been unable to associate symptoms or harm.

**Control of virus disease.** Plant viruses are so intimately involved with cell metabolism that it is seldom possible to inhibit their multiplication without damaging the host plants. Control is based on planting healthy crops and then preventing the introduction and spread of viruses, often by spraying with pesticides. However, knowledge of how insects transmit, how long they must feed on an infected plant before they become infective and how long they remain infective is required to determine how insecticides can be used most effectively. Other methods to control virus diseases are also being sought. Glandular hairs on the wild potato *Solanum berthaultii* trap insects and it may be possible to control the spread of potato virus Y by breeding these hairs into commercial cultivars.

Aphids are the most important vector of virus diseases in this country although methods of predicting and preventing their activity have improved virus control in potato, cereal and sugar beet crops. Viruses transmitted by other vectors including ryegrass mosaic virus transmitted by mites and barley yellow mosaic virus transmitted by a root-infecting fungus are also studied.

Some natural resistance mechanisms restrict virus infection to a small area of leaf and can be enhanced by chemical treatment. The mode of action of these chemicals and the biochemical and physiological changes occurring in resistant plants are being investigated and may lead to new methods for controlling viruses.

### Mycoplasma and rickettsia diseases

Some diseases previously thought to be caused by viruses are now known to be associated with mycoplasmas, which are wall-less bacteria-like organisms, and rickettsia, which are a type of bacterium. The Department receives support from the Overseas Development Administration to investigate and diagnose virus, mycoplasma and rickettsia diseases of tropical crops.

### Fungus and other diseases

Pathogens attack foliage and roots although root disease often causes foliage symptoms. Both types of disease are affected by the crop environment and by interactions with other microbes. Their effects therefore have to be studied in a range of conditions and crop husbandry systems. The Department's contribution to the multidisciplinary programmes on beans, wheat, barley, potatoes and oilseed rape is an important part of these studies.

**Cereal leaf diseases.** Experiments under controlled conditions in a wind tunnel/ rain tower complex provide information about dispersal and deposition processes of air-borne and splash-borne spores. This helps understanding of disease development in field crops and will provide the basis of improved control. In field experiments with barley mildew and barley leaf blotch, transfer of pathogen spores, and even fungicide vapour, between neighbouring plots has affected disease incidence, yield and response to timed sprays and so complicated the interpretation of experiments intended to develop a sound basis for advice on control. With the Statistics Department experimental designs have been developed to minimize this problem or to measure its effects. These designs may be valuable in studies of other air-dispersed pests and virus vectors.

**Root diseases of cereals.** Growing cereals consecutively decreases cultivation and labour costs but yields are usually less than when cereals are grown in rotations. Take-all, a foot and root disease caused by the fungus *Gaeumannomyces graminis*, is often a factor in these lowered yields, but no effective fungicides or resistant cultivars are available to the farmer. Breaks in short cereal sequences may have only temporary benefit, because damaging disease is likely to recur, but in long sequences of wheat or barley, take-all often declines to a severity which allows continued profitable cropping and short breaks without severe disease. The mechanisms of take-all decline continue to be sought. Take-all may increase slowly on wheat after grass leys and this has been associated with *Phialophora graminicola*, a fungus from grass roots which restricts take-all. Experiments to exploit this method of biological control are continuing alongside means of testing critically and fairly claims of take-all control. Brown foot rot, caused by *Fusarium*, and the foot rot caused by the eyespot fungus are monitored as part of the programme.

### Potato diseases

With the expansion of mechanical handling and longer term storage of the potato crop, fungal and bacterial diseases attacking the tubers, especially through wounds, have become more important. Some can be soil-borne but air-borne inoculum may be an important source of re-infection of healthier, nuclear stocks in the earliest stages of multiplication. However, later and in the production of ware crops, the most important source of inoculum is the seed tuber. These diseases have several effects; they may prevent or delay emergence, decrease yield, alter tuber-size distribution, rot tubers in store, or cause unsightly blemishes, which are especially important in potatoes sold ready-washed in transparent packs. Nuclear stocks are produced by rooting stem cuttings, a technique devised at Rothamsted, or now by micropropagation. Such stocks rapidly become as heavily contaminated and infected as any others unless they are protected during multiplication by fungicides; with no effective bactericide, bacterial disease has increased in importance. Control by fungicides, pioneered in this Department, is now widely practised to protect the ware crop in store. The aim is to improve the effectiveness of fungicides by finding better ways of applying them, not only for the ware crop but also through disease control in seed crops.

### Moulding of stored grain and hay

Spore-trapping methods developed at Rothamsted are used worldwide to trap airborne pollen and fungus spores, to identify causes of hay fever and asthma and to provide advice for sufferers. Farmer's lung was shown to be an allergic reaction in the alveoli to inhaled spores of thermophilic actinomycetes from heated straw, hay and grain. Other diseases of man and farm animals have been shown to have similar causes. Requirements for preventing moulding of hay using chemical preservatives have been defined and the effects of fungicides on the microflora, yield and quality of grain and on grain deterioration in storage are being investigated. The ecology of fungi which may produce mycotoxins during storage of hay, grain and rape seed is being studied.

## MOLECULAR SCIENCES DIVISION

The Molecular Sciences Division was formed with the expectation that it would lead to the application of a spectrum of physical, chemical, biomolecular and cellular techniques to problems in plant science of agricultural importance; it was implicit in this hope that the total effect would be synergistic. Unfortunately serious budgetary reductions mean that the Station will not be able to continue research in Molecular Structures. Nevertheless we still believe in the validity of the approach which will be prosecuted with the resources remaining.

### BIOCHEMISTRY DEPARTMENT

Following the retirement of C. P. Whittingham, the plant metabolism group within the Botany Department merged with the Biochemistry Department on 1st October 1982. This has enlarged the Department and as a result we have reorganized our activities by defining a number of research areas. The nature of