The Scottish Horticultural Research Institute

19th Annual Report for the year 1972

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W. L. Dick
Louise F. Findlay *Resigned* September 1972
Elaine K. Fox *Appointed* October 1972
D. Husband *Resigned* October 1972
J. L. Milne *Resigned* January 1973
Katherine R. Myles *Appointed* October 1972
Heather A. Ross
Jeanette McD. Shepherd
E. Sweeney *Appointed* January 1973
I. R. Urquhart *Resigned* February 1973

Plant Breeding

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M. M. Anderson, N.D.H., S.D.H., D.H.E.
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Margaret Sedgley, B.SC.
P. Smith, B.SC.
Barbara M. M. Tulloch, S.D.H.
A. B. Wills, B.SC., M.S., PH.D.

Assistants Joyce E. T. Fyffe
Mrs Marjorie Morrison†
G. Steele *Appointed* July 1972
J. M. Wardlaw
Mrs Eveline M. Wiseman

Attendants Catherine T. Hempkin† *Resigned* July 1972
J. C. Alexander† *Appointed* September 1972

Mycology

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E. Patricia Dashwood, B.SC., M.SC.
J. M. Duncan, B.SC., PH.D.
A. J. Hargreaves, B.SC.
J. G. Harrison, B.SC., PH.D., M.I.BIOL.
W. R. Jarvis, B.SC., PH.D., D.I.C., M.I.BIOL.
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R. Lowe
Isabel G. Montgomerie, B.SC., PH.D.
M. C. M. Pérombelon, B.SC., M.SC.
D. A. Perry, B.SC., PH.D.
H. M. Wilson

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Mrs Norma M. Colliar *Appointed* March 1973
K. Doyle *Appointed* October 1972
Alison M. Findlay *Appointed* June 1972
Mrs Caroline M. Gill *Appointed* August 1972
Mrs Georgina A. Laing, B.SC.
Mrs Maureen Nicol
Lorna M. Parsons *Appointed* June 1972, *Resigned* November 1972
I. Rutherford *Resigned* September 1972

Attendant Norah E. Cotogno

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J. Chambers, B.SC.
J. I. Cooper, B.SC., M.SC., PH.D. *Resigned* November 1972
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W. P. Mowat, B.SC., DIP.AGR.SCI.
A. F. Murant, B.SC., PH.D.
I. M. Roberts
D. J. Robinson, M.A., PH.D.

Assistants Margot E. Anderson *Appointed* June 1972
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Eleanor M. W. Innes *Appointed* May 1972
Agnes M. D. Lowson
Rhonda R. MacLagan
J. H. Raschké
Mrs Jean S. Seal *Resigned* May 1972

Visiting Worker S. El Nagar, B.SC., M.SC.

Zoology

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T. J. W. Alphey, B.SC., PH.D.
B. Boag, B.SC., PH.D.
S. C. Gordon
W. M. Robertson
J. A. T. Woodford, M.A., PH.D. *Appointed* December 1972

Zoology—*continued*

Assistants D. J. F. Brown
R. R. Crichton
Sheena M. Morton
Irene E. Niven

Visiting Worker Lyle B. Forer, B.SC., M.SC.

Maintenance

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J. F. McLean
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Foreman R. D. Taylor

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Graphics Maureen I. McMaster, D.A.
Librarian Mrs Kathleen J. Harrison, M.A., A.L.A.
Mrs Margaret Mitchell

*Honorary Lecturer in the University of Dundee.
†Honorary Senior Lecturer in the University of St. Andrews.
‡West of Scotland Unit. Officer in Charge H. J. Gooding.

General Report

C. E. TAYLOR

For some time Professor John H. Burnett has indicated that his residence south of the Border was incompatible with his continuation in office as Chairman of the Governing Body. The Institute has been fortunate indeed in retaining his services since his acceptance of the University of Oxford's Sibthorpian Chair of Rural Economy in 1969. His friendship, help and guidance during the period following Dr Cadman's death and during my first year of office as Director proved particularly valuable. In all Professor Burnett has served as a member of our Governing Body for 17 years, 14 of them as Chairman, and his contribution to the work of the Governing Body and the Institute in general is recorded here with gratitude.

The appointment of Professor Noel F. Robertson, Principal of the Edinburgh School of Agriculture, as our new Chairman is particularly pleasing as it emphasises our close association with the Colleges and provides a direct link with the Horticultural Board of the Joint Consultative Organisation on which Professor Robertson is a member.

Appointments

Dr D. L. Trudgill was appointed Head of the Zoology Section in October and comes to the Institute from the Nematology Department at Rothamsted Experimental Station. Dr J. A. T. Woodford also joins the Zoology Section following 5 years as an Assistant Lecturer in the Department of Applied Biology at the University of Cambridge.

Mr P. A. Gill has been appointed to the staff of the Crops Research Section and one of his first responsibilities will be the construction of apparatus for the measurement and recording of plant response to low temperature.

There have been increasing demands for data processing services and Mr J. B. Cowan has been appointed to assist with this work.

Mr J. I. Campbell took up his appointment as photographer in June. He had previously been working at Glasgow University on the Nuffield Inter-University Biology project; an investigation of audio-visual techniques in education.

We also welcome the following Assistant Scientific Officers:—

Miss K. A. Myles	Crops Research Section
Miss E. K. Fox	Crops Research Section
Mr D. G. Cathro	Crops Research Section

Mr E. Sweeney	Crops Research Section
Mr J. C. Alexander	Plant Breeding Section
Mr G. Steele	Plant Breeding Section
Miss L. M. Parsons	Mycology Section
Mrs N. M. Colliar	Mycology Section
Miss A. M. Findlay	Mycology Section
Mrs C. M. Gill	Mycology Section
Mr K. Doyle	Mycology Section
Miss E. M. W. Innes	Virology Section
Miss M. E. Anderson	Virology Section

Resignations

With the completion of the Potato Marketing Board grant for research on spraing disease of potato, Dr J. I. Cooper left to join the Unit of Invertebrate Virology, Oxford.

The following Assistant Scientific Officers resigned:—

Miss L. F. Findlay	Crops Research Section
Mr D. Husband	Crops Research Section
Mr J. L. Milne	Crops Research Section
Mr I. R. Urquhart	Crops Research Section
Miss C. T. Hempkin	Plant Breeding Section
Mr I. Rutherford	Mycology Section
Miss L. M. Parsons	Mycology Section
Mrs J. S. Seal	Virology Section

Visiting Workers

Mr L. B. Forer from the Pennsylvania Department of Agriculture joined the Zoology Section in October. His year's stay is financed by a Rotary International Post-graduate Fellowship.

Miss T. Cetinal from Turkey joined the Plant Breeding Section in January for 9 months to gain experience of embryo and meristem cultural techniques as well as undertaking studies of the problems of incompatibility in brassica.

Mr S. El Nagar from the United Arab Republic continued his studies in the Virology Section on the insect transmission of plant viruses.

Research Students

Mr A. T. Dickson was awarded a Department of Agriculture and Fisheries for Scotland Research Post-Graduate Agricultural Studentship and joined the Zoology Section in October to undertake a study of the ecology of aphids infesting raspberry plantations.

Sandwich Course Students

Mr C. Baker from the University of Bath spent 6 months working on the problem of plant population in calabrese in the Crops Research Section.

Mr P. Smyth, West of Scotland College, worked at our West of Scotland Unit, Auchincruive, and Mr G. Pryde, Trent Polytechnic College, worked in the Plant Breeding Section.

Management Courses

The following senior staff attended management courses:—

Mr R. A. Fox	Statistics in management
Dr D. A. Perry	Middle management
Dr P. D. Waister	Organisation and staff management

Conferences at which papers were given

17–18 January	C. E. Taylor	Virus vector nematodes (ADAS Conference, Worthing)
6–7 April	W. R. Jarvis	Latency in Botrytis (Symposium on Botrytis Diseases, University of Hull, Hull)
11 April	D. J. Robinson	Production and some properties of 2 temperature sensitive mutants of tobacco rattle virus. (Virus Group, Society for General Microbiology, London)
17–20 April	D. A. Perry	Interesting effects of seed vigour and environment on seedling establishment (University of Nottingham 19th Easter School, Sutton Bonington)
	T. W. Hegarty	Temperature relations of germination in the field (as above)
8 June	H. M. Lawson	Pesticides: legislation and literature (Course of Industrial Hygiene, University of Dundee)
8 June	C. E. Taylor	Pesticides: a review (Course of Industrial Hygiene, University of Dundee)
11–13 July	J. G. Harrison	Studies on imbibition and damage to pea and corn seeds in water (Society for Experimental Botany, Dundee)
3–9 September	P. D. Waister	Climatic limitations on horticultural production with particular reference to Scottish conditions (6th International Bio Meteorological Congress, Noordwijk)

4–9 September	M. C. M. Pérombelon	Factors leading to the initiation of bacterial soft rot in potato tubers (European Association for Potato Research, Norwich)
	M. C. M. Pérombelon	Re-contamination problems in blackleg free seed potato stocks in Scotland (as above)
	R. A. Fox	Some factors affecting infection by and survival of the potato gangrene fungus (as above)
	B. D. Harrison	Ecological studies on potato mop-top virus in Scotland (as above)
	J. I. Cooper	Factors affecting the survival and spread of tobacco rattle virus in Scotland (as above)
10 November	J. I. Cooper	Comparative studies of potato cultivars as hosts of tobacco rattle virus and its nematode vectors. (Federation of British Plant Pathologists, London)
	A. T. Jones	A virus from elm (as above)
	A. F. Murant	Hybridization of strains of ringspot virus (as above)

Visits abroad

Mr R. A. Fox made a consultancy visit in September to Nigeria and to visit Firestone's plantations in Liberia to advise on research problems in plantation pathology.

Dr H. J. Gooding toured Italy with a party of strawberry specialists to study production.

Dr B. D. Harrison visited the West Indies in July to advise on research on virus diseases of yam that is to be supported by the Overseas Development Administration.

Dr D. L. Jennings attended as invited consultant the Cassava Mosaic workshop at the International Institute of Tropical Agriculture in Nigeria.

Dr Isabel G. Montgomerie attended a European Discussion group meeting in May at Bari, Italy, on the Cytology and Gentics of *Phytophthora*.

Dr C. North attended an FAO Eucarpia meeting in Bari, Italy, on Mutation and Polyploidy, and a meeting of the Board of Eucarpia in Paris.

Dr C. E. Taylor lectured at the 8th post-graduate Nematology Course, organised by the Nematology Department of the Agricultural University and the International Agricultural Centre, Wageningen. As a scientific councillor Dr Taylor attended meetings of Council of the Laboratory of Agricultural Nematology at Bari, Italy.

Mr R. Thompson and Mr R. J. A. Exley visited several centres in the Netherlands to discuss work on vegetable and flower crops. The Institute Association generously provided the funds and arrangements were made by the International Agricultural Centre, Wageningen.

Exhibitions

With the assistance of the Department of Education and Science this Institute again provided an exhibit for inclusion in the Scientific Section of the Royal Chelsea Flower Show. The exhibit demonstrated the potential advantage of an experimental technique for the rapid multiplication of the raspberry from root cuttings.

The Institute also made a photographic contribution to an exhibit on education organised by the West of Scotland College and displayed at the Highland Show.

Mr A. J. Hargreaves provided an exhibit showing bud death and lateral wilt in raspberry for the Botanical Society of Edinburgh Research Symposium held at St. Andrews.

Dr J. G. Harrison provided an exhibit showing the symptoms, causes and effects of hollow heart in peas at the University of Nottingham 19th Easter School.

Dr C. E. Taylor provided an exhibit on the European distribution of *Longidorus* and *Xiphinema* nematodes at the ADAS Conference in Worthing.

Dr C. E. Taylor organised a pictorial display for the European Society of Nematologists meeting at Reading. The subject was Nematology research at SHRI.

Radio and Television

Mr R. Thompson broadcast on the production of vegetables to suit processing requirements in the 'Farm Journal' programme on 8th May.

Dr P. D. Waister appeared on the 4th August edition of the BBC programme 'Nationwide' when a TV team visited raspberry harvester trials at Brechin.

Editorial duties

Dr C. E. Taylor	Member of the Board of Editors of *Annals of Applied Biology* Member of the Board of Editors of *Journal of Horticultural Science*
Dr B. D. Harrison	Member of the Board of Editors of *Annals of Applied Biology* Editor of *Commonwealth Mycological Institute/Annals of Applied Biology Descriptions of Plant Viruses* Member of the Board of Editors of *Intervirology*

Dr A. F. Murant	Member of Editorial Committee of *Journal of General Virology* Editor of *Commonwealth Mycological Institute/Annals of Applied Biology Descriptions of Plant Viruses*
Dr P. D. Waister	Member of the Board of Editors of *Journal of Horticultural Science*

Service on committees

Dr C. E. Taylor	Journal of Horticultural Science Publications Committee University of Strathclyde/West of Scotland Agricultural College Degree Advisory Board West of Scotland Agricultural College Glasshouse Advisory Committee NFU Soft Fruit Working Group Committee SNSA – Adviser to Committee SADC Crops Committee Member of Scientific Council of the Laboratorio di nematologia agraria, University of Bari, Italy. NFT Advisory Committee
Dr C. North	Eucarpia Member of Board of Directors Eucarpia Chairman Vegetable Section Dundee University Botanic Garden Committee
Mr M. M. Anderson	NFT Black currant Sub-Committee
Mr J. I. Campbell	City and Guilds of London Institute 344/345 Objective Examination Item Writing City and Guilds of London Institute Item Writing Workshop
Mr R. A. Fox	Chairman, Pathology Section, EAPR
Dr H. J. Gooding	NFT Strawberries Sub-Committee NFU Soft Fruit Working Group NFT Ad hoc Committee on soft fruit breeding City and Guilds of London Institute Advisory Panel on Tropical Agriculture
Dr B. D. Harrison	International Society for Plant Pathology Member of Council British National Committee for Biology Member of Microbiology Sub-Committee
Dr W. R. Jarvis	Chairman, European Botrytis Group
Mr H. M. Lawson	ISHS Working Group on Weed Control in Vegetables British Crop Protection Council Sub-Committees, weed control meetings and publications

Dr J. L. Jennings	NFT Raspberry Sub-Committee NFT Scottish Trials Committee SNSA – Adviser to Committee
Mr K. C. McConnell	HEA Scottish Branch
Dr I. G. Montgomerie	International Society for Plant Pathology European Discussion Groups on: *Phytophthora* pathogens of Strawberry; Cytology and Genetics of *Phytophthora* spp.
Dr A. F. Murant	International Organisation of Citrus Virologists Liaison Committee on Citrus and other fruit plant virus diseases
Dr D. A. Perry	International Seed Testing Association, Vigour Test Committee
Mr R. Thompson	ADAS Vegetable Storage Panel NIAB Vegetable Trials Advisory Committee; Vegetable Trials Advisory Committee on Brassicas
Dr D. L. Trudgill	Nematology Group Association of Applied Biology
Dr P. D. Waister	Scottish Council/DAFS Joint Committee on Food Processing SADC Chairman Working Group (Horticulture)

Farm and Experimental Crops

W. I. A. JACK

While an open winter ensured that land work was well advanced and an early start to spring work anticipated, a wetter February than usual together with the lack of any appreciable frost left the soil in poor condition and delayed the start to barley sowing. Crops grew slowly in the cool and sometimes wet months of April and June but later conditions improved considerably and none could have wished for a better second half to the year which finally resulted in excellent crops of hay, barley and soft fruits. Once the fields were cleared of straw the routine management programme of stubble cleaning and sub-soiling went ahead. By 2 November winter wheat was sown (see 1971 report). Ploughing was done whenever conditions were suitable and was mostly finished by the end of the year.

Farm crops included 68 acres barley, 35 acres of grass for hay, 10 acres permanent grass and 1 acre field beans. Eleven acres were fallowed to combat perennial weed problems. The acreage under grass was increased at the expense of barley and the field beans which had been included as a possible break crop were encouraging, yielding 34·6 cwts/acre. The hay crop grew slowly at first but rapid growth in May and early June resulted in a start to cutting on the 27 June; 123 tons of good quality hay was made. The barley exceeded expectations and with little evidence of disease harvesting began on the 21 August; the yield averaged 47·9 cwts/acre of low moisture content grain all of which went for malting.

Field experiments included 36 acres raspberries, 14 acres black currants, 11 acres strawberries, 1 acre blueberries, 16 acres vegetables, 10 acres potatoes, 4 acres ornamentals and 2 acres of other crops; this shows an increase of 18 acres over the 1971 figure. Strawberry picking started on the 7 July followed by raspberries and black currants on the 18 July, a week later than the previous year. The weather was fairly settled throughout the fruit season and the crops of strawberries and raspberries were good. The soft fruit crop was 11 tons more than in 1971, and included some 17½ tons strawberries, over 33½ tons raspberries–mostly from an outstandingly good plot of third season Glen Clova which cropped at over 6 tons/acre–and almost a ton of black currants. Perhaps the crop most affected by the dry conditions was potatoes, and the yield from experimental plots averaged 16 tons/acre, well down on the previous year. Vegetable trials provided small quantities of Brussels sprouts, cabbage, calabrese, carrots and onions, all of which were marketed locally.

General estate work included planting the east side of the main drive with ornamental trees and shrubs and routine maintenance of lawns, fences, dykes and roadways. The bank was removed and part of a disused ditch filled in along the boundary between Lade and Haugh fields.

Acknowledgment is made to the estate staff who have worked well over the past year to provide the service necessary for the smooth working of a large and varied programme of work.

Glasshouse Section

J. CANTWELL

The Section's duties of providing and maintaining plant material for the Scientific sections has continued to increase this year. It is interesting to compare figures for 1966 and 1972 which show that the number of Scientific staff has increased by 40%, glasshouse area by 30%, plant production by 40% and the glasshouse labour force by 20%. Due to reductions in hours of work, output per worker has increased considerably more than the figures indicate.

During the year the glasshouse staff erected 5 new glasshouses. Three were wooden Dutch light houses, and these completed the block of this type of structure planned for in the reconstruction programme. The fourth was a 30 ft x 80 ft aluminium glasshouse erected on an east-west axis on the northern boundary of the existing glasshouse area. This will be used for growing strawberry plants under red-core free conditions and also provide space for the Plant Breeding Section to grow transplants. The siting of this house will provide shelter for the standing ground which is to be developed immediately to the south. A metal hoop type structure supporting an insect proof mesh was also erected to provide a seed production area for the Plant Breeding Section.

As the meteorological records in this report show, the glasshouse complex was subjected in December to a gale gusting up to 124 miles per hour and surprisingly the only damage was a few broken sheets of glass.

The glasshouse whitefly *Trialeurodes vaporariorum* was introduced into the Institute in late 1971. A series of screening tests in conjunction with the Virology Section showed that fumigation with propoxur smoke followed by a Resmethrin spray controlled the pest, did not damage any plant species used by the Section, and permitted aphid feeding on the third day after treatment. Propoxur was found to damage Poinsettia and oak seedlings.

Symptoms similar to those produced by some viruses appeared on plants of *Chenopodium quinoa* in the Virology Section glasshouse. This was shown to be due to dispersal of contaminants from metal insect screens positioned at roof ventilation, when rain coincided with ventilation.

The Section uses a large number of high wattage lamps to maintain plant production in winter and consequently tests new lamp designs which are potentially more efficient. Because of its shape the 140 watt low pressure linear sodium lamp was thought to be a possible substitute for the comparatively inefficient fluorescent tube used in the growing-rooms. The lamp was tested using *Chenopodium quinoa*, *C. amaranticolour* and *Nicotiana clevelandii*. It was found to be unsuitable as the sole light source but may have an application for supplementary lighting.

Other work included the screening of insecticides and fungicides for use on raspberries grown under protected cultivation for research purposes and the design of a prototype automatic irrigation unit for use with container-grown plants.

Information Services

R. J. A. EXLEY

Appropriately for the first appointee as Information Officer the year began with attendance at a 2 day press relations seminar in company with representatives from 24 other Research Institutes. Organised by the ARC Press Officer, and held at Headquarters, this first meeting of its kind provided useful first hand insight into the particular requirements of news media.

During the year there have been visitors to the Institute from home and abroad with many and varied interests. Also, requests for information of a major and trivial nature have been frequent from both the public and the press and more than 120 press mentions were recorded, excluding articles attributed to members of staff. The majority were in horticultural trade papers.

The Institute was represented at 5 'Career Consultations' organised by Perth and Kinross Youth Employment Service. Constraints upon the opportunities to learn about different careers have resulted in these meetings being organised to enable pupils and parents to discuss entry qualifications, salary scales, job profiles, and opportunities offered by various types of prospective employment.

Space in the library is now at a considerable premium and cramped seating accommodation for only 4 people is available in the reading room. Although plans are being prepared for a new library building no firm starting date has been given. In 1972 there was a big increase in the number of books borrowed from outside libraries. Approximately 1,500 loans were made from the National Lending Library for Science and Technology and about 150 from East Malling Research Station, Rothamsted Experimental Station and the Department of Applied Biology, Cambridge University. We extend our thanks to these organisations for their co-operation. Internal borrowing reached approximately 2,800 items and the use of the Xerox photocopier increased with about 40,000 pages being copied.

Although considerable cost inflation occurred with books and journals during the year our finances allowed a modest number of new books to be purchased and 6 new journal subscriptions to be entered.

A Raspberry Literature collection was started in May and by the end of 1972 this contained approximately 1,500 entries.

After due appraisal of the Institute's existing photographic procedures, it is probable that some rationalisation will be possible. As a basis for a critical assessment, the service provided to the 5 research sections has been monitored for the first time. A total of 367 jobs involving almost 1,400 negatives and transparencies were completed, and in addition, over 3,400 electron-microscope prints for the Virology and Zoology Sections.

One service provided by the section which often remains unrecorded is the provision of drawings, diagrams, and demonstration boards for use in publications and exhibits. Although much is of a routine nature, the quality of this work is nevertheless important because clear presentation of results is an integral part of good research work.

Each year the Institute is an appropriate and convenient venue for meetings of such bodies as the Scottish Nuclear Stock Association and the Scottish branch of the National Fruit Trials Committee. Other meetings which have been convened here during the year included one with the Advisers and bulb growers for the purpose of exploring the problems affecting the production and profitability of the crop, and relating these to research and development programmes. On another occasion the advisers for the 3 Scottish colleges gathered to hear about current research work and joined in discussion with Institute staff.

Crops Research

P. D. WAISTER

The record acreage of raspberries in Scotland, coupled with difficult weather at picking time, resulted in serious labour shortages during this year's harvest. The dominant effect of this labour factor on raspberry production fully justifies the major emphasis given to investigations of problems associated with mechanical harvesting. Introduction of a machine will have repercussions on many aspects of the growing of the crop and these are being examined in a comprehensive programme of cultural experiments and cultivar assessments. Objective methods of measuring quality of fruit have been developed as a basis for assessing the impact of engineering modifications on machine performance.

CROP ENVIRONMENT

Crop response to shelter

Measurements of leaf water potential of strawberries growing in both sheltered and exposed plots showed that exposure to wind was not inducing greater water stress. This result was supported by regular measurements of soil moisture using a neutron probe, which disclosed no greater moisture depletion in the exposed plots. As in a previous shelter experiment, the yield increase in the sheltered plots was mainly attributable to increase in truss numbers, rather than in berry size or numbers per truss.

These results were obtained using cv. Cambridge Favourite. The response of ten strawberry cultivars has been recorded in a separate experiment this year and there are indications of appreciable differences in behaviour. Cambridge Favourite showed easily the largest increase following protection against wind, while four cultivars either showed no response or a small decrease in yield. However, only two of the ten cultivars produced fewer crowns in the sheltered plots than in the exposed. Interactions between fruiting and vegetative vigour are being examined.

Following two years of differential exposure to wind in the field, plots of three cultivars of narcissus were lifted, graded, and weighed. There were no differences in total weights harvested from sheltered and exposed plots of Fortune and Golden Harvest but there was evidence of a difference in bulb size distribution in the latter cultivar. There was a significant increase in the total weight of Actaea harvested from sheltered plots.

The flowers harvested this year had significantly larger stems in shelter, unlike the first year of the experiments, but again differences in earliness were negligible.

As in 1971, the tulip Rose Copland showed no response to shelter either in earliness or in weight of bulbs produced.

(D. K. L. MacKerron and P. D. Waister)

Winter injury

Weather conditions during the winter months have been suspected as a contributory cause of two disorders of soft fruit–crown necrosis in strawberries and bud failure in raspberries. Low temperature itself may be the major determinant of injury but may equally be only one of a complex of factors. As an aid to elucidating causes, a portable frost chamber has been built, which can be programmed to simulate natural frosts on plants growing in the field. Cooling within the chamber is effected by the vaporisation of liquid nitrogen, which is sprayed on to a blackened plate positioned horizontally 0·8 metres above the test plants. The flow of nitrogen is regulated by a solenoid valve controlled by a thermistor/bridge circuit, which maintains a rate of fall equal to a drop in grass minimum of 4°C/h. The plants are cooled primarily by radiation, although some conduction and convection does occur.

Starting in the autumn of 1972, two frost cycle treatments have been applied to Cambridge Favourite strawberry plants in the field at regular intervals. One treatment involves exposure to the lowest grass minimum temperature recorded at the Institute since 1952 (–16°C), and the second is based on the lowest minimum recorded for the month of the treatment. Crown temperatures are recorded by hypodermic thermistor probes. Low temperature damage will be assessed by crown dissection in the spring.

Initial experiments were carried out to determine whether the double freezing point exhibited by living tissue could be utilised as a dependable indication of viability in raspberry canes. Canes were cooled at two different rates in a freezing chest, and temperature changes of thermocouples in the pith were recorded on a potentiometer.

The shape of the freezing curve varied according to several parameters, including cane diameter, moisture content and rate of cooling, but all indicated a double freezing point. Cane killed by immersion in liquid nitrogen showed only a single freezing point.

(P. A. Gill and P. D. Waister)

Soil conditions and field emergence

Seeds of beetroot, Brussels sprout, cabbage, calabrese, carrot, cauliflower, leek and onion were sown weekly from 21 March to 25 July to see how changing environmental conditions would affect field establishment. Analysis of the levels of emergence for genotype × environment interaction indicated that in general those of calabrese were most sensitive to environmental con-

ditions and onions the least. The importance of soil crusting has again been demonstrated, and indications obtained of the way in which its effects interact with soil moisture content, temperature, and possibly with seed type or size.

For the third successive year a good linear relationship ($r = 0{\cdot}97$) was found for carrots between rate of emergence in the field and mean soil temperature from sowing to 50% emergence. With the exception of leeks, which were difficult to measure because of slow emergence, linear relationships were also found for the other vegetables mentioned. The identification and quantification of such relationships will clearly prove useful in the formulation of cropping programme models which rely on heat units or linear relationships between growth and temperature.

Mulches and anticrustants

Seeds of beetroot, calabrese, carrot and onion were sown on six occasions between 4 April and 6 June; after sowing, the seedbed was rolled lightly and then left untreated or sprayed with either a bitumen, polybutene or polyvinylacetate (PVA) emulsion as an anticrustant. None of these mulches proved to be of benefit in counteracting the effect of soil crusting this season and, at the strength used, the PVA mulch appeared to have phytotoxic properties which also affected crop emergence. There were no significant effects on soil moisture retention, but temperature was increased significantly by the bitumen mulch in particular. The mean temperature increase of 1°C at seed depth resulted in a 1½ day decrease in time to 50% emergence in carrots at 10°C, in line with expectations from the temperature/emergence relationship described earlier.

The same four species were sown on two occasions, 5 May and 9 June in heavier soil, and covered either with soil or with vermiculite before the seedbed was lightly rolled. The effect of vermiculite in preventing emergence losses varied between species and between sowing dates, ranging from no effect with carrots to 19% higher emergence of calabrese at the first sowing.

It appears that useful responses are to be obtained from reducing soil crusting but there remains the question of how to achieve it economically.

(T. W. Hegarty)

WEED INVESTIGATIONS

Weed competition

When strawberries were exposed to weed competition for varying periods in the year of establishment, there were appreciable decreases in yield of fruit in the subsequent first cropping year. Failure to control weeds for the first 8 weeks after planting, produced a yield depression of 13% and this increased to 34% when weeding was delayed a further 6 weeks. Reductions in yield were due mainly to reductions in crown and truss numbers. Berry size and yield per truss were unaffected.

Herbicide evaluation

In 2 consecutive years phenmedipham has been applied to spring planted Cambridge Favourite strawberries at varying rates up to 3 lb a.i./ac and at varying times after planting. Although treatments at all dates caused varying degrees of chlorosis on the leaves present at the time of spraying, new leaves were unaffected and there was no effect on plant size, runner production, or crown numbers. Yields in 1972 were similarly unaffected. The results suggest that this cultivar should have adequate tolerance to this herbicide at the recommended rate of 1 lb a.i./ac.

No herbicide damage was found over a two year period in terms of any aspect of crop growth or fruit yield of raspberries (Malling Jewel) following single applications of simazine or atrazine at rates up to 8 lb a.i./ac. Rate for rate in other experiments atrazine has given better control than simazine of both annual and perennial weeds.

Several pre- and post-emergence weed control programmes for canning carrots were tested in 1972. Excellent control was achieved on a weed population dominated by *Stellaria media*, *Polygonum aviculare* and *Fumaria officinalis*, when post-emergence application of metoxuron (3·2 lb a.i./ac) followed pre-emergence treatment with any of 4 residual herbicides, trifluralin, chlorbromuron, linuron, or prometryne.

Weed control in the rotation

Bromacil at 2 lb a.i./ac was applied overall in early April 1969 and 1970 to an established raspberry plantation for the control of perennial weeds. The plantation was ploughed in autumn 1970 and sown to barley in 1971 and 1972. Varying ploughing depths down to 15 inches failed to prevent herbicide damage to the grain crop in 1971, with the shallower ploughing showing the highest degree of injury. After a uniform ploughing to 10 inches for the following crop, yields in 1972 were again affected. These results confirm previous findings that at least two years are needed before a fully normal barley crop is likely to be obtained after treatment with bromacil at rates of application needed for perennial weed control.

Following an 8 year comparison of the effects of weed control systems in raspberries based either on simazine application or on soil cultivation, the area was test-cropped for 2 years with barley. Grain yields were little affected by previous treatment. Plots which had received annual treatment with simazine but no cultivation yielded 11% less grain in 1971 and 5% more grain in 1972 than those which had been regularly cultivated without herbicide application. Examination of the weed flora of the 2 cereal crops disclosed no differences in the population of perennial weeds but there were approximately twice as many annual weeds on plots which had been cultivated without simazine for 8 years compared with the uncultivated herbicide plots. Populations of *Urtica urens*, *Veronica persica*, *Capsella bursa-pastoris* and *Senecio vulgaris* were higher on the cultivated plots, and *Chenopodium album* and *Galium aparine* populations were higher on the simazine treated plots.

(H. M. Lawson and J. S. Wiseman)

The major part of the year's work was again concentrated on investigation of methods of producing crops to processors' specifications, in terms both of quality and season of supply.

Calabrese

A population experiment, using a new F_1 hybrid Royal Sluis 69349, showed that the required small heads could be produced by increasing plant density but that yield was restricted by the number of plants which failed to head at high populations. As the plants were grown on a nearly square pattern of arrangement, this failure to head could not be attributed to effects of unbalanced competition. The lack of uniformity appears to be environmental in origin, rather than genetic.

Dense stands, giving small individual spears, offer the best prospects for mechanical harvesting provided cultivars can be selected in which stem length and leaf arrangement permit cutting without subsequent excessive trimming or sorting. When 6 cultivars were harvested using a cutter bar, trimmed spear yield as a proportion of the total weight cut ranged from 25% to 83%, this latter figure being obtained from the F_1 69340 in which the spears were borne well above the foliage. This same hybrid was the best of 26 cultivars assessed for uniformity of heading, uniformity of bud size, spear length and general appearance.

Onions

Though growth is usually satisfactory, drying of main crop bulb onions in the field in Scotland is frequently difficult because of adverse climatic conditions later in the season. Accelerated maturity can be achieved by using high plant populations, which give a product suitable for pickling. The cultivar Perla Prima yielded at a rate equivalent to over 11 tons/acre at populations between 40 and 100 plants/ft^2 when grown in 10 inch mini-beds. At the lower end of this population range 81% of the yield was in the $\frac{3}{4}$–$1\frac{1}{4}$ inch size grade, and at the upper end 39% was in the $\frac{1}{2}$–$\frac{3}{4}$ inch size grade. At these high populations foliage began to senesce in mid-August, the bulbs were undercut on 22 August and lifted on 31 August by which time the dead foliage was easily burned off by flame gun.

Red beet

The main processing demand is for the $\frac{3}{4}$–$1\frac{1}{2}$ inch diameter grade known as 'baby beet.' There are no cultivars available that are genetically as small as this, and root size has to be controlled by population density. Unfortunately at densities high enough to give the required root diameter, yields are reduced to an uneconomic level. In the past this has been thought to be caused by lack of uniformity in the crop. In an attempt to estimate this restriction, rubbed and graded seed of cv. Avonearly was sown in paper

pots, and those with a single seedling of uniform size were transplanted on a square pattern of arrangement to give a range of population densities. A considerable range in size grades of roots, however, was recorded at harvest and yield of 'baby beet' was only just over 6 tons/acre. In view of this, and the high cost of seed necessary to establish the required high population densities, production of this small grade will probably continue to be based on outgrades from maincrop production.

(R. Thompson and H. Taylor)

Variability in root size in beetroot crops may in part be attributable to lack of uniformity of emergence and of plant spacing. To investigate these factors, beetroot clusters with differing numbers of seeds per fruit were sown by hand at constant depth to give approximately the same plant population in each case, but with different inter-plant spacings. There were no differences in uniformity of emergence in terms of time but, as expected, clumping in the row was a function of seed number in the cluster. A sample of Avonearly rubbed and graded to give a germination count of 100 seedlings per 100 clusters gave a distinctly more uniform spacing than a sample with a count of 200 seedlings per 100 clusters. Despite this, no differences were detected in the mature crop in terms of uniformity of size grade distribution or of total yield.

(T. W. Hegarty and R. Thompson)

Vining peas

Processors require vining peas as early in the season as possible and the two main factors which may be manipulated to achieve earliness are cultivar and sowing date. Sprite is the earliest cultivar at present used commercially in Scotland, and its date of maturity was compared this year with that of the new cultivar Beagle, at 2 sowing dates. From a sowing on 24 February, Beagle reached tenderometer 100 on 18 July only 1 day earlier than from a sowing 18 days later on 13 March. It was 2 days earlier than Sprite from the first sowing, and 1 day from the second sowing.

(R. Thompson and H. Taylor)

Tulips

To achieve the earliest flowering of forced bulbs, lifting must be sufficiently early to enable the lengthy pre-conditioning treatments to be completed prior to housing. The extent to which early lifting reduces the weight of bulbs harvested, and affects their forcing quality, has been investigated this season, using the cultivars Paul Richter, Merry Widow and Apeldoorn lifted at 14-day intervals. At the earliest harvest date, 6 June, yields were depressed but increased thereafter until 4 July after which they remained unchanged. Following the same conditioning regime the earliest lifted bulbs reached internal stage of development (ISD) 'G' 2 weeks to 4 weeks (depending upon cultivar) before bulbs lifted one month later, but the yield penalty was a mean of 41%.

Effects of tissue nitrogen status on dormancy have been reported in potato and onion, and 'carry-over' effects of soil nutrient levels on subsequent growth have been detected in tulip. As no reports were known of the effects of field nutrition on subsequent forcing behaviour, three tulip cultivars were grown in soil supplied with two levels of nitrogen, 100 and 600 units/acre. The higher level reduced bulb yield by an average of 14%, but on forcing no differences between treatments were detected in stem length, flower quality, or time to 50% harvest. Bulb samples from the field plots have been replanted and again subjected to differential nitrogen levels to produce bulbs for further assessment of forcing behaviour, in view of the known lag effects of treatments applied to flower bulbs. (R. Thompson and H. Taylor)

FRUIT CROPS

Raspberries

If raspberry spawn beds could be successfully and economically established from root cuttings it would simplify the present system of multiplication for virus-tested stocks. A series of experiments has shown that cuttings planted in October establish and grow better than when planted later in the year or in the spring, and that weight for weight the thicker root (>1 mm) is more productive than the fibrous roots trimmed from it. However, the yield of fibre from a glasshouse grown mother plant is appreciably greater than that of thicker roots, and by using both types of planting material each mother plant of Malling Jewel has yielded in excess of 100 shoots in the field. This is still well below the figure necessary to better the present system of multiplication in the glasshouse.

Raspberries usually crop lightly in the first fruiting year. The National Fruit Trial showed two exceptions, Malling Delight and an Institute seedling, M31, both of which yielded at a rate equivalent to over 3 tons/acre. Both are unusual in having very large fruits.

Investigations of mechanical harvesting continued in collaboration with the Scottish Station of the National Institute of Agricultural Engineering. Following engineering modifications made in 1971, machine performance was appreciably improved but some ripe fruit is still being missed by the machine at each pass. In the absence of any mechanical sorting device to separate broken and whole fruit, the samples obtained would be suitable only for the broken fruit market.

Of the cultivars tested this year an Institute seedling, M14, gave the best mechanically harvested sample in terms of unbroken ripe fruit.

Several experiments involving manipulation of cane populations have shown that yield per cane decreases as cane numbers increase beyond a certain figure. Formerly it was suspected that this decrease might be associated with the incidence of bud failure due to increased disease at high cane densities. Analysis of yield components this year suggests that this may be only part of the problem and that more attention must be concentrated on reasons for decreased yield per cropping node.

(M. R. Cormack and P. D. Waister)

As fruit ripens it becomes easier to detach from the receptacle. Berries left behind by the machine may therefore either be slightly under-ripe, abnormally strongly held by the receptacle, or inadequately shaken by the machine. Separation of these effects demands some objective criterion of fruit ripeness. Examination of titratable acidity, pH, and percentages soluble solids of the juice of raspberries at varying ripeness stages showed that titratable acidity was the most sensitive indicator.

The force required to remove individual berries of Malling Jewel from their receptacles was measured with a Correx tension gauge applied to the shoulders of the berry. The fruit removal force decreased from 300g for under-ripe (pink) fruit to 25g for over-ripe (blue-red) fruit. The $\log_e$ of the fruit removal force was linearly related to the titratable acidity of the juice.

Prolongation of the post-harvest life of raspberries would be advantageous both in supplying distant fresh markets and in smoothing the flow of fruit to the processor. Further experiments using dichlofluanid and benomyl as field sprays have shown that both may help in delaying mould growth after harvest but their effectiveness varies at different harvest dates in an as yet unpredictable fashion unrelated to time of season. In one experiment there was some indication of the presence of strains of fungus resistant to benomyl, and this was investigated further by the Mycology Section.

(D. T. Mason)

Strawberries

Following the initial screening of nearly 200 cultivars, a routine system of testing has now been established. New material is planted in 6 plant units for screening, the most promising are carried forward into 20 plant units, and the best from these will be included with the National Fruit Trial cultivars and seedlings. In 1972 there were just over 100 cultivars in the screening block, 46 in the 20 plant units, and 12 in NFT.

Cultural experiments have been concentrated on examining cultivar response to differing crown densities. Cambridge Favourite gave its highest yield at the highest crown densities achieved in matted rows, in contrast to Merton Princess which yielded best on a spaced system at low crown densities. Fruit size in Cambridge Favourite was unaffected by crown density, but was reduced in Merton Princess as density increased.

The cultivars Crusader and Talisman are known to show a yield response to defoliation. Crown densities were varied by altering plant spacing, to determine whether increased competition could substitute for defoliation through its effect on plant vigour. At all spacings defoliated plants outyielded intact in both cultivars, but intact plants showed no yield increase from increased density.

Nitrogen applications were made to half of the plots of all treatments in these experiments, and in each case resulted in reduced yields relative to the controls.

(M. R. Cormack and P. D. Waister)

Blueberry

A cultivar trial of highbush blueberries, *Vaccinium corymbosum*, conducted under the auspices of the International Society of Horticultural Science, was cropped for the first time. Yields were low but cv. Ivanhoe gave almost double the crop of any of the other 11 cultivars.

The blueberry demands a low pH and plots in which acidity has been adjusted by applications of sulphur gave about four times the yield obtained from the untreated control plots.

Some trouble has been experienced with the fungus *Godronia cassandrae* which also occurs in this crop in the northern areas of the USA and in Canada.

Blackberry

Further additions were made to the collection of blackberries. A single test of the raspberry harvester on cv. Ashton Cross produced a very good sample and suggested that this crop will be much easier to harvest than the raspberry, presumably because unlike the latter the drupelets do not have to be detached from the receptacle.

(M. R. Cormack and P. D. Waister)

STATISTICS AND COMPUTING

There has been an increase in volume and complexity of work in both statistics and computing. The introduction of new facilities seems to have attracted new users or different types of work without decreasing the use of more familiar techniques of data processing and appraisal. Thirty-four members of staff have either submitted computing jobs or had data analysed on their behalf and the number with Edinburgh Regional Computing Centre (ERCC) numbers has doubled. The number of computing jobs rose to 603, an increase of 53% on last year. Genstat, the Rothamsted general statistical program, was used to carry out analysis of variance on 631 variates whilst 5,348 were analysed using Edex, an increase of 63%.

The advent of a Wang programmable desk calculator with plotting output writer has provided the Institute with a very valuable facility. At the moment few programs exploit its full capabilities but a one-way analysis of variance with written output has been developed. The numbers of staff asking for tuition sessions on its use suggests that its value is widely appreciated as a machine intermediate in power between desk calculators and a computer.

A course of basic Fortran programming was given to members of staff in spring 1972 and this, together with the acquisition of a teletype terminal to the ERCC multi-access system (EMAS) has caused the number of Fortran jobs to increase from 69 in 1971 to 181 in 1972. The EMAS terminal is used by relatively few members of staff, but it is invaluable for people developing Fortran programs; it has also been used effectively for routine data vetting.

Two projects involving information retrieval by computer have been started, one a bibliography of *Botrytis* in collaboration with Dr Jarvis, the other the maintenance of progeny and seedling records to assist Dr Gooding. Members of staff engaged on a NATO project have begun computer mapping of the distribution of virus vector nematode species in the British Isles with the co-operation of Monks Wood Biological Records Centre.

(P. B. Topham and J. B. Cowan)

PUBLICATIONS

HEGARTY, T. W. (1973). Temperature sensitivity of germination in carrots: its frequency of occurrence and response to seed advancement. *J. hort. Sci.* **48**, 43–50.

(Almost 40% of Chantenay carrot seed lots investigated showed temperature sensitivity of germination, *i.e.* reduced germination at 10°C compared to 20°C. Seed advancement (alternate wetting and drying of the seeds before sowing) increased the germination at 10°C of some temperature-sensitive seed lots but did not appear to be generally applicable as a method for improving seed quality).

HEGARTY, T. W.[1] (1973). Seedling growth in controlled nutrient conditions. *J. exp. Bot.* **24**, 130–137.

(An apparatus is described in which seedlings can be grown on a non-polar substrate in continuously flowing nutrient solutions giving a constant and defined root environment. Nutrient treatments were shown to exert both rapid and substantial effects on seedling root and shoot growth).

LAWSON, H. M. (1972). Objectives of weed control in vegetables–a review. *Proc. 11th Br. Weed Control Conf.* (1972). 919–924.

LAWSON, H. M. (1973). Weed control in raspberries and other cane fruit. *Proc. 2nd Symp. Herbicides in British Fruit Growing* (1973), 15–18.

LAWSON, H. M. (1973). Programmed weed control for fruit crops. *Proc. 2nd Symp. Herbicides in British Fruit Growing* (1973), 38–41.

LAWSON, H. M. and WISEMAN, J. S. (1972). Experiments with pyrazone and chlorbufam in narcissus. *Proc. 11th Br. Weed Control Conf.* (1972), 608–614.

LAWSON, H. M., WISEMAN, J. S. and WAISTER, P. D. (1972). Tolerance of established raspberry plantations to a range of residual herbicide treatments. *Proc. 11th Br. Weed Control Conf.* (1972), 430–436.

MASON, D. T., TOMALIN, A. W. and FARRIMOND, A. (1972). Transporting Scottish raspberries to the south of England. *The Grower* **78**, 131–132.

MASON, D. T. (1973). The effects of fungicides on the shelf life of raspberries. *SHRI Assoc. Bulletin* **No. 7**, 32–38.

THOMPSON, R. (1972). Components of yield in peas. *Scott. Agric.* **51**, 490–492.

THOMPSON, R. (1973). Calabrese harvester needs new variety. *Arable Farmer 8*, **No. 5**, 38–40.

[1]Based on work done at Cambridge University.

THOMPSON, R. and TAYLOR, H. (1973). The effects of population and harvest date on the yields and size grading of an F_1 and an open pollinated Brussels sprout cultivar. *J. hort. Sci.* **48**, 235–246.

(Grown at four populations and harvested on three occasions both Peer Gynt (F_1 Hybrid) and Roem van Kloosterburen produced higher yields of freezing grade sprouts at higher populations the later the harvest date. Although the general plant form of the F_1 hybrid appeared to be more uniform than that of the open pollinated cultivar, examination of the size grading of sprouts failed to demonstrate differences in the uniformity of the sprouts).

WAISTER, P. D. (1972). Wind damage in horticultural crops. *Hort. Abstr.* **42**, 609–615.

(A survey of recent world literature on wind damage, listing crops affected and their responses with a discussion on variability of wind damage and an analysis of the factors which predispose crops to damage; the underlying causes of damage are examined).

WAISTER, P. D. (1972). Wind damage to soft fruit in Scotland. *Scott. Agric.* **51**, 457–461.

WAISTER, P. D. (1973). Climatic limitations on horticultural production, with particular reference to Scottish conditions. *Int. J. Biometeor.* **17**.

(Crop production in Scotland is compared with that in England, and the part played by climatic factors in determining differences is discussed. Results are presented from experiments designed to measure the responses of crops to specific weather conditions or combinations of conditions).

Plant Breeding

C. NORTH

Largely due to the initiative of the SHRI representative, the Directors Advisory Committee of the National Fruit Trials decided to set up a Scottish Trials sub-committee. Its function is to ensure that full consideration is given to the performance in Scotland of new raspberry and strawberry clones before recommendations are made for their release as new cultivars. A meeting held at the Institute on 9 August enabled membership proposals to be put forward and approval has been given to a sub-committee under the chairmanship of Mr D. H. Turner. On the occasion of this meeting new breeding material was inspected and enthusiasm was shown for our exceptionally large fruited raspberry clone M31. A failing of this selection is that its ripe fruit is pale and not always uniformly coloured. Nevertheless, arrangements are in progress for its rapid propagation together with M14 which showed promise in machine harvesting tests. Either or both of these selections can therefore be released at a relatively early date if, after more adequate testing, this is thought to be desirable.

Facilities at the West of Scotland Unit have been slightly expanded. Two of the existing seven acres are useless for growing strawberries due to proximity to woodland and insufficient land is available for the present strawberry breeding team to utilise fully its seedling screening capacity. However, the West of Scotland Agricultural College have kindly agreed to allow us to use an additional 3½ acres in an adjoining field and this will provide a unique opportunity for a co-operative project with the Mycology Section to study the spread of red core disease by using bait plants. It is hoped that it will eventually become sufficiently infested for us to extend our screening facilities. Red core free land has also been rented from a farmer near Auchincruive to ensure adequate supplies of healthy runners as standards for comparison with new seedlings.

Additional facilities at the West of Scotland Unit include a new insect-proofed glasshouse for virus testing and alterations to the main buildings to provide more laboratory space and a document store.

BLACK CURRANT

Selections from the cross (Consort x Magnus) x (Brödtorp x Janslunda) maintained their early promise in trials at Luddington Experimantal Horticulture Station and the National Fruit Trials, Brogdale. In their second

year of cropping yields equalled or exceeded that of Baldwin, and tests by Beecham Products Ltd. showed that the most productive of them was an acceptable alternative to Baldwin in respect of flavour and ascorbic acid content. Two of the other selections were inferior to Baldwin in these respects.

Twenty-four clones of widely different parentage were surveyed for their ascorbic content by Beecham Products Ltd. Values ranging from 78 to 285 mg/100 g of fresh fruit were obtained compared to 210 g for Baldwin, but only two *Ribes nigrum* clones had a higher content than Baldwin. Derivatives of *R. dikuscha*, *R. bracteosum* and *R. hudsonianum* and the Swedish cultivar Ojebyn had low contents.

Second and third backcross progenies of *R. nigrum* x *R. dikuscha* cross gave their second crop in 1972. The third backcross material showed a big improvement in productivity and six selections combining disease resistance, productivity and good growth habit were chosen for further testing. Further improvement in growth habit is required for machine harvesting and one outstanding selection was used extensively in breeding to obtain improvement in this and other characters.

Cold winds and low temperatures prevailed at flowering time in 1972 and it was notable that a progeny of complex origin derived from crossing between the 3 species *R. nigrum*, *R. dikuscha* and *R. hudsonianum* was more capable of setting its fruit under such conditions than hybrids of *R. nigrum* and *R. dikuscha*. Selections with fully furnished strigs and resistance to leaf diseases were chosen for further breeding. In another progeny, late flowering as a spring frost escaping mechanism was successfully combined with resistance to leaf diseases derived from *R. dikuscha*. However, a protracted period of over 100 days was required for fruit development and there were no selections of sufficient merit for further testing. Selections were crossed with the relatively new Dutch cultivar, Black Reward, which combines later flowering with a more rapid fruit development.

Resistance to Gall Mite and Reversion disease

R. ussuriense and cultivars of *R. nigrum sibiricum* have now been in a gall mits infested plot for 5 years without developing any galled buds. The cultivar Rus and a number of its F_1 hybrids have also remained free of symptoms of reversion disease. The virus status of the latter was studied in a glasshouse experiment: leaves of plants produced from cuttings of the symptom free plants were slightly abnormal on the base of the plant and on short axillary shoots produced from lower-middle regions, but upper leaves were normal. Scions of Rus behaved similarly when grafted onto reversion infected stocks. These results suggest that Rus and its hybrids are highly tolerant of reversion disease. The results of graft inoculation tests will become available in 1973.

First backcross progenies of Rus and *R. ussuriense* segregated for mildew susceptibility in 1972 and the resistant segregates were planted adjacent to

galled and reversion infected bushes to facilitate selection for resistance or tolerance to galling and reversion.

(M. M. Anderson)

BLACKBERRY

Although many of the progenies derived from Early Harvest or Darrow were notable for their erect spinefree habit and early flowering, they required an average of 80 days to ripen their fruits and were therefore not ripe until late September or October. By comparison the earliest cultivar observed was Bedford Giant, which was relatively late to flower but was ready in late August because it required only 45 days to ripen. A parent which proved a good source of rapid ripening was obtained by crossing the octoploid Austin Thornless with a tetraploid, and then crossing a selection from this cross with a diploid. This parent is believed to be a tetraploid and some of its progeny were highly fertile, several individual selections ripening in less than 50 days. Austin Thornless is a form of *Rubus ursinus* and its derivatives have inherited the undesirable trailing habit of that species. Further breeding is being done to combine this capacity for rapid fruit ripening derived from *R. ursinus* with the improved habit of selections from the Early Harvest and Darrow progenies.

In other material an attempt is being made to transfer early ripening from tetraploid raspberries; this approach is suggested because Bedford Giant is a hexaploid blackberry-raspberry hybrid which has probably inherited its rapid ripening from the raspberry.

Promising selections were obtained by crossing the octoploid blackberry Aurora with a tetraploid raspberry. Hybrids of this cross are similar in genetic constitution to the Loganberry, whose fruits they resembled in appearance and flavour. Several of them are being propagated for trial.

RASPBERRY

Two advanced selections showed sufficient merit to be considered as potential new cultivars. One of them, M14, has fruit qualities which enabled it to be harvested successfully by machine, and the other, M31, has exceptionally large fruits and is therefore suitable for marketing as fresh or quick-frozen fruit. Propagation of both of them has been initiated, but since both have certain failings the results of further tests will be awaited before decisions are made to release them. Propagation was also begun of further selections to be tested in the National Fruit Trials; several of these have shown the good fruit qualities of M14.

M31 is the most advanced of our selections carrying gene L_1, which confers large fruit size and has pleiotropic effects on plant growth. Many families segregating for this gene are now available for study of the gene's effects on yield components other than fruit size. Such studies confirmed that the gene

reduces the proportion of cane nodes which bear fruiting laterals, and showed that it also reduces the ability of canes to produce more than one lateral per node. However, there was variation in its effect on fruit number per lateral: earlier work showed that the gene reduced the number of fruits per lateral but the opposite effect was found in 1972 in two particularly vigorous families related to interspecific hybrids. Other studies on yield components showed that the proportion of lateral-bearing nodes in Glen Clova was negatively correlated with cane diameter, but that the proportion of such nodes furnished with more than one lateral ('multilaterals') was positively correlated with cane diameter; the total number of laterals present was consequently unaffected by variation in cane diameter. Since large cane diameter favours fruit production per lateral, it is desirable to select genotypes combining large cane diameters with a capacity to produce multilaterals, thereby obtaining the benefits of the large diameter and neutralising the latter's unfavourable effects on the proportion of lateral-bearing nodes present.

Previous work has suggested that early cessation of cane growth favours hardiness. It was shown that this characteristic was expressed strongly in 1972 in families related to Carnival, and that there were also large differences in autumn growth among selections in a yield trial. It is hoped that the incidence of winter injury in 1973 will be sufficient to assess the value of this variation.

The last Annual Report recorded that resistance to the beetle *Byturus tomentosus* had been obtained in a family obtained by selfing second backcross material derived from *R. phoenicolasius*. The resistance of this material was confirmed in 1972 by further tests in which beetles were caged on leaves or unopen flower buds. In other tests beetles were caged on open flowers and counts made of the larvae subsequently present in the fruits. The results suggested that resistance to beetles in the leaf was associated with resistance to larvae in the fruit.

(D. L. Jennings, Barbara M. M. Tulloch and Eleanor Carmichael)

Segregation of yellow or orange fruit has occurred in several families derived from *R. phoenicolasius*, and appears to be determined by segregation of a dominant gene, designated gene Y, whose expression is suppressed in *R. phoenicolasius* itself and in F_1 hybrids between this species and *R. idaeus*. Up to 4 anthocyanins were present in the yellow or orange fruits, as in red ones, but their total content ranged from only 0·01 to 5·86 mg per 100 g fruit compared to a range of from 14·2 to 22·9 mg for a sample of red fruits. Progenies were produced to investigate whether the action of gene Y is modified by genes which intensify anthocyanin production in the black raspberry *R. occidentalis*.

(D. L. Jennings and Eleanor Carmichael)

STRAWBERRY

The season at Auchincruive was short, and poor yields often contained large proportions of malformed fruit probably due to the unusually low May/June

temperatures and the below average sunshine hours during the pollination period. By contrast crops from plants grown under cloches were very good and amongst them some 4th generation selections derived from *Fragaria virginiana* clone I seemed very promising with firm, easily decapped, red fleshed fruit. A number of seedlings derived from a Gorella cross also appeared particularly promising and selections of both series are being propagated at an early stage for virus testing so that material may be available for extensive trials as soon as possible.

Five selections from crosses made between 1961 and 1963, and sent to the N.F.T. in 1968 have almost completed their trials at 5 regional centres. Although there is evidence of variation in adaptation, the best selection, 63AF86, has frequently given yields in excess of Cambridge Favourite and is usually larger fruited. However, fruit with a bright red skin and red flesh is now in demand and it is unfortunate that these characteristics are insufficiently developed in this selection to make it an obvious choice for naming and release. Nevertheless in view of its good qualities, virus-tested stocks will be held in reserve in case the need arises to release it at a later date.

The cultivar Montrose released in 1969 has grown successfully at Auchincruive on the site heavily infected with *Phytophthora fragariae*, after the land had been subsoiled. The plants were not defoliated. Yields from this cultivar were then comparable to Cambridge Favourite and in excess of Redgauntlet. These results suggest that, although it was earlier assumed that Montrose has a low level of field resistance to red core, its usefulness on infected land may be greater than has been anticipated.

Upright fruiting stalks

A rather exciting development has been the discovery of an octoploid seedling, from a cross made in 1969, which ripens its fruit whilst still held erect by a strong woody peduncle. This material provides additional germplasm to the diploid sources from *F. vesca* which are being used to incorporate this character into higher 'ploidy' levels. Of further interest is that the 1969 seedling, being partly derived from *F. virginiana* clone I, is likely to have a fairly high degree of resistance to red core disease.

Late fruiting strawberries

Several double cropping selections obtained from crosses of Nisqually with Redgauntlet or Tioga produced a promising second crop of good quality fruits in early September 1971. They were propagated in 1972 and planted in small trials at Mylnefield and Auchincruive to compare their performance with the double cropping cultivar Rabunda and some late summer fruiting selections. Late fruiting forms also segregated from crosses made in Canada by Dr Daubeny with derivatives of the North American Yaquina A clone of *F. chiloensis*; although these had small fruit, some were firm, good flavoured and showed good field resistance to red core disease.

(H. J. Gooding and D. L. Jennings)

Fruit quality

Measurement of juice loss and degree of collapse of frozen fruit, when thawed under standard conditions, showed that large differences exist between selections but none was significantly superior to Cambridge Favourite in these respects, although their juice colour was frequently better. The facilities for 'blast' freezing for these tests were provided by the West of Scotland Agricultural College who are also assisting by modifying a penetrometer for measuring fruit firmness.

In collaboration with Dr Topham an information retrieval system for a wide range of plant characteristics has been evolved. It is hoped that this will eventually help in the selection of parents having combinations of complementary characters from amongst our large collection of breeding lines.

(H. J. Gooding, K. C. McConnell and Patricia R. Irons)

BEAN

When several of the Institute's anthracnose resistant lines were compared with cv. Provider and Glamis in a replicated field trial they were found to be still segregating for pod quality characters. This programme is now under discussion and may be discontinued within the next few years. In the meanwhile field selections from 1971 were screened for resistance and multiplied for possible continuation of the project.

Glenlyon has now received Plant Variety Rights and will be entered in PGRO trials in 1973. A final decision on its release will be based on the results of these trials. Another selection which had been entered for Rights was temporarily withdrawn owing to lack of uniformity.

(A. J. Redfern)

BRASSICAS

Isozyme analysis in B. oleracea

Six enzymes, acid phosphatase, alkaline phosphatase α–and β–acetylesterases, alcohol dehydrogenases and peroxidase were examined electrophoretically for their isozyme complement in a tris/glycine buffer system at pH 8·6 using either 10% or Gradipore acrylamide gels. Of these acid phosphatase, α–and β–acetylesterases and peroxidases were detected in extracts of dry seeds and acid phosphatases and α–acetylesterases in leaf extracts. Only acid phosphatase and the esterases showed isozymes under these conditions.

Proportions of inbred seed in batches of Gleneagles Brussels sprout were estimated by their acid phosphatase isozyme. However, in Celtic Cross cabbage seeds of the parent inbred lines and the hybrid of Celtic Cross showed a common acid phosphatase isozyme and thus sibs could not be

detected, although a small difference was observed in the acid phosphatase isozyme complement of the leaves. It seems probable that a set of allelic esterase isozymes for distinguishing between sibling and hybrid seeds in Celtic Cross may be isolated by the use of different substrates and inhibitors.

(Sheena K. Fyfe)

Serology of incompatibility

The antiserum to $S_{45}S_{45}$ Brussels sprout stigmas raised in 1971 was found to contain an S_{45}–specific antibody. The antiserum to $S_{23}S_{23}$ kale stigmas also gave promising results but these could not be verified by immunoelectrophoretic procedures. Rabbits producing these antisera were given booster injections and the antibody response was measured by testing the serum from frequent bleeds. The S_{45}–specific antibody did not become easier to identify after the booster, because the antiserum as a whole became more complex. The titre of all antibodies increased between 2 and 32 times between 2 and 10 days after the booster. Titre of all antibodies then began to fall, but subsequent booster injections maintained titre for longer periods.

Five further antisera were prepared in 1972 using both Californian and New Zealand white (N.Z.W.) breeds of rabbit. An antiserum specific to Brussels sprout stigma S_2S_2–protein (intermediate dominance) was raised in a N.Z.W. but was poor compared with an antiserum specific to $S_{16}S_{16}$ (high dominance) kale stigma S-protein raised in a Californian. The antibody response of all 5 rabbits was followed by bleeding at weekly intervals, both during and after the injection schedule.

The rabbit which produced the S_{16}-specific antibody was given an injection schedule of 3 months as compared with the normal 1 month. During the third month the character of the S-protein appeared to change, but this may be an artefact produced by incomplete absorption.

A total of 13 rabbits injected has given only 2 definite and 2 questionable S-protein specific sera, all from plants with S-alleles of intermediate or high dominance. It is concluded, therefore, that unfortunately present serological techniques are unsuitable as a standard S-allele diagnostic procedure during the breeding programme.

(Margaret Sedgley)

Inheritance and measurement of partial self-compatibility

Three separate diallel experiments to investigate the inheritance of partial self-compatibility have been designed and production of seed for these was a major task in 1973. One diallel is between lines that were all homozygous for the S-allele S_{15} but showed different levels of self-compatibility; and the second is similar but utilises parent lines homozygous for S_{45}. The third was constructed from 5 pairs of lines, each pair homozygous for a different S-allele. The seed obtained will be sown in 1973 for self-compatibility analysis in 1974.

Seed has also been obtained of backcross and F_2 families derived from crosses between inbred lines with high and low levels of self-compatibility. These crosses have been chosen to cover a range of S-alleles and self-compatibility levels. In general, the degree of self-compatibility in the F_1 plants is below that of the mid parental value in any particular cross. However, such results should be interpreted with caution until all the progeny and parents have been grown in a single experiment.

Experiments of the type planned will require more space than is available under glass because of the number of families and plants that must be grown together, and the need for adequate replication. It has therefore been necessary to re-examine the techniques we use to measure self-compatibility in the glasshouse to determine whether they are equally applicable under field conditions. At present the number of pollen tubes penetrating the stigma in a series of self pollinations is taken as a measure of the degree of self-compatibility. In a greenhouse environment variability in the number of pollen tunes is within acceptable limits but was found to be so great in the field that the results were often meaningless. In a search for an alternative measurement for self-compatibility numbers of seeds produced on bagged inflorescences were compared with those on un-bagged inflorescences using field grown plants. In addition, counts were made of some other factors that may affect the total number of seed set, such as the number of flowers produced on the inflorescences tested. The results are being analysed to determine the most reliable estimates of self-compatibility in the field.

Full self-compatibility

Twelve plants of Brussels sprouts obtained in an attempt to produce autodiploids, as reported in the last Annual Report, were found to be completely self-compatible. They were all from 1 family derived from a plant heterozygous for S-alleles S_{15} and S_5. Although self-compatible, the S-alleles of the plants could be identified by tests against pollen from plants of known S-allelic constitution and the group was found to include S_{15}, S_5 heterozygotes and $S_{15}S_{15}$ homozygotes. Three plants belonging to the same family were found to be self-incompatible and homozygous S_5S_5.

The self-compatible plants were self pollinated and outcrossed to unrelated self-incompatible plants homozygous for a range of S-alleles. Preliminary results obtained at the end of 1972 have shown the presence of the self-compatible character in the selfed progeny but not in plants derived from outcrosses to unrelated lines.

(J. R. T. Hodgkin)

Cytology of B. oleracea

Encouraging results have been obtained from experiments in which anthers were incubated during meiotic prophase with various inhibiting agents. After such treatment it was possible to discern whole bivalents at pachytene and it is expected that the technique will be a useful aid to studies of chromosome morphology.

Experiments were begun using fluorescent dyes, together with other techniques, to assist discrimination of mitotic chromosomes. After staining with quinacrine dihydrochloride chromosomes were weakly fluorescent but no specific banding was observed.

Raphanus-Brassica hybrids

The F_4 diploid generation derived from triploid F_2 is now indistinguishable from the original *Raphanus* parental type, following the apparent loss of all *Brassica* chromosomes. By pollinating *B. oleracea* with F_4 pollen, ovary stimulation and some seed set was obtained but these seeds failed to germinate. Further attempts are being made to achieve the cross in this direction to allow transfer of desirable characters from *R. sativus* to *B. oleracea*.

Genetics of B. oleracea

A majority of seedlings germinated this year were in F_1 families to be used to obtain backcross and F_2 progenies. However linkage data for seedling mutants were available from 12 groups of families. One group comprised 4 backcross families for Fn (fern-leaf), gl-3 (glossy foliage), Hr-1 (hairy leaf) and c-2 (anthocyanin suppressor). All agreed in showing highly significant ($P<1\%$) linkage between Fn and c-2 but gave no indication of linkage in any other combination. These progenies were derived from material kindly supplied by Dr D. R. Sampson (Canada Department of Agriculture) and the data confirm his findings of Fn–c-2 linkage but fail to reveal his reported linkage of Fn and gl-3. Two families had significant deficiencies of Gl-3 phenotypes, not accountable for by differential seed germination, and one of these was also deficient for Hr-1.

The remaining groups segregated the following gene combinations: gl-3–A; gl-3–Hr-1 (2 families); gl-3–Fn (2 families); Hr-1–Fn (5 families); Hr-k–Go-b (glossy foliage); Hr-d–gl-e2. There was no evidence of linkage in any of these families.

Floral characters were scored in families planted in 1971. Linkage between cp-1 (crinkly petal) and As (anther spot) was confirmed but no other linkages were detected in 2 groups segregating pg-b (pale green), gl-b, Wh (white petal), cp-1 and As in backcross and F_2 families. Linkage ($P=2\%$) was also detected between cp-1 and A° (pigmented ovary) in an unrelated family. However in yet another family there was no evidence for the expected linkage between cp-1 and As; the cause of this anomalous result is not yet known.

A family in which linkage between gl-y and A (pigmented hypocotyl) was previously noted (Ann. Rept. 1971) also segregated As. Linkage between A and As was indicated ($P=2\%$) but not between gl-y and As. Although A/As linkage was confirmed in an independent family, it could not be detected in a further family segregating for these genes.

Wh, gl-e3 and As segregated in yet another family and significant linkage values ($P=2\%$) were obtained for gl-e3 and As. In other families As was shown not to be linked with gl-3.

There was no evidence of linkage in any combination in a group of families that segregated Hr-x, Wh, As and a pg gene. However in another group in which Hr-y was present significant linkage values were obtained for Hr-y–Wh but not for Hr-y with As nor Wh with As.

Finally, there was no evidence for linkage of Go-b, As or Wh in another backcross family.

These data therefore confirm some linkages in linkage group 1, already known to comprise ap (abortive pollen), S (incompatibility), ps (persistent sepal), As, A and cp-1 and indicate that it may be extended by the addition of gl-y and gl-e3. To linkage group 3, Wh and gl-1, may now be added Hr-y.

(A. B. Wills and P. Smith)

BRUSSELS SPROUTS

Ninety-seven progenies, comprising hybrids produced either by crossing 2 glossy inbred lines (each homozygous for one of 4 different recessive glossy-foliage genes as sib markers) or by crossing a glossy inbred with a normal inbred, were grown in 2 similar trials. These were destructively harvested on different dates and assessed for sprout quality, stem characteristics and yields. The results showed that several hybrids, of both 'double' glossy and 'single' glossy combinations, compared favourably with many commercial cultivars. It is anticipated that relatively little further breeding will be necessary to produce high grade hybrids from the glossy lines, and discussions are now taking place to decide how they may be released. It is also intended that large scale trials will be grown to demonstrate the advantages of using marker genes and enable assessment by the seed trade. Hybrid seed for these trials will be produced in 1973 from parent plants grown this year.

At the beginning of the year it was not known whether any of the hybrids would be of adequate agronomic standard, so work was continued on the improvement of the glossy and other inbred lines. Crosses have been made between some of these inbreds and heterozygous tester lines to enable combining ability to be assessed. Crosses were also made between inbreds to measure self-compatibility and associated sibbing rates.

The number of inbred lines that can be developed concurrently is limited by available space and personnel. For this reason he advanced selection parent material now available represents a rather narrowly based gene pool. It was considered necessary to provide material with increased genetic diversity for future work on the induction of autodiploids and therefore plants selected from commercial stocks in trial and selected plants were selfed.

(A. J. Redfern)

NVRS/SHRI Co-operative project

A total of 79 test F_1 hybrids of Brussels sprouts produced by intercrossing NVRS and SHRI inbred lines were grown during 1972 at either one or

both stations. Sixty-one lines were grown at Invergowrie, 38 of them in a replicated trial. The crop was serially harvested and assessments of sprout quality and plant characteristics were made.

Although the yield of some lines was fairly good, sprout quality was, in general, disappointing. Nevertheless the results are sufficiently encouraging to continue with the project and selected lines will be resown in order to assess the hybrid seed and sib seed production rates.

(J. R. T. Hodgkin)

S-allele analysis of SHRI cv. Gleneagles

Much effort has been expended in an attempt to find satisfactory solutions to the problems associated with the production of sufficient sib-free seed of Gleneagles. Both parent lines of this cultivar are known to be heterozygous at the S-locus but this has been the first year in which it has proved possible to isolate S-allele homozygotes in material that would be used for production of the cultivar. Twenty-eight plants of 1 parent were tested against known S-alleles and a small stock of seed homozygous for S_{14} obtained. This will be used as a basis for further multiplication.

Tests on plants obtained by selfing S-allele heterozygotes of other parents have revealed no S-allele homozygotes; all 32 plants tested being found to be heterozygous S_{15} S_{45}. Currently this parent produces few sibs in hybrid seed lots and it appears that this situation may be stable. However, until reasons for the absence of S-allele segregation have been found tests will be carried out at each stage of seed multiplication to ascertain that no change has occurred.

(A. J. Redfern and J. R. T. Hodgkin)

CABBAGE

Plants of 1 parent line of Celtic Cross were tested in 1971 and 1972 for self-compatibility by pollen tube counts. The results indicated that all plants had low self-compatibility. However, when similar plants together with plants of the other parent line were exposed to bee pollination to produce hybrid seed, considerable sib pollination occurred. Counts of sibs in the hybrid progenies indicated that there was variation in sib-rates between individual plants. Further experiments were devised so that selection for low self-compatibility could be continued utilising bee pollination followed by seed counts rather than pollen tube counting.

Celtic Cross has the potential to become a popular cultivar and it was decided that, to give a maximum return on the breeding investment, the possibility of producing similar cultivars of differing maturity dates should be examined. Therefore hybrids between Glenfarg and each of the parent lines of Celtic Cross were grown for observation. One of these showed promise as an autumn maturing type similar in appearance to Celtic Cross. Hybrid seed was produced from crosses between the savoyed parent of Celtic Cross and selections of several Savoy varieties. F_2 progenies derived

by selfing Celtic Cross were grown to observe their characteristics. Head type was very variable, as had been anticipated, but variation in size was less marked and no rosetting was observed. However, this material was not considered to be suitable for further examination as a potential cultivar.

The relatively low level of seed production continues to be a problem in producing Celtic Cross. This could possibly be alleviated by using a three-way or double-cross system based on isogenic lines having different S-alleles. Earlier generations of the parental lines were therefore screened for additional S-alleles but all the stocks proved to be homozygous.

CALABRESE

A small feasibility study in the breeding of calabrese has been started. Because of the unusually mild winter of 1971-72 no useful information was derived from a winter hardiness trial comprising various crosses and back-crosses between early heading selections of 2 commercial calabrese lines and sprouting broccoli. However, some selections were made and will be retained for further breeding. Another winter hardiness trial is again planned in the hope of colder winter conditions in 1972-73.

(A. J. Redfern)

LILIUM

The Royal Horticultural Society has kindly agreed to accept potential new lily cultivars from SHRI for trial at Wisley and bulbs of 12 different clones have been sent there for testing in 1973 and 1974. One of these clones was voted as the best new hybrid in the exhibition of the Lily Group of the R.H.S. at a flower show in the Society's Halls in London. Discussions have taken place with the Plant Variety Rights Office for the introduction of Rights for *Lilium*, and 5 of the above clones have been sent for uniformity and distinctness trials. At the same time these clones are being propagated and 1000 flowering size bulbs of each will be available for distribution and further propagation by the end of 1974 when Rights will probably be granted to them, and the results of the Wisley trials known. Two of the 5 clones are hybrids with *Lilium lankongense* obtained by embryo culture and the other 3 are from crosses within the Asiatic hybrid group. All have been selected for vigour and apparent virus resistance though none has been subjected to exhaustive inoculation tests with different viruses.

A few plants of the crosses between European species obtained by embryo culture flowered for the first time, notably *L. pyrenaicum* x *monadelphum*. Several of the plants of hybrids within this group showed quite severe virus symptoms indicating that they may not be so useful virus tolerant material as had been expected. Some of the hybrids unexpectedly produced apparently normal seed which will be sown in 1973.

(C. North and Barbara M. M. Tulloch)

PUBLICATIONS

GOODING, H. J. (1973). Methods of evaluating strawberry plants as parents for transmission of field resistance to *Phytophthora fragariae*. *Euphytica* **22**, 141–149.

(Nine cultivars and 4 unnamed seedlings were assessed for their potency as parents in breeding for red core resistance. Field resistance was assessed by scoring the plants for survival on a site heavily infected with *Phytophthora fragariae*. As a generalisation it was found that the field resistance of the parents was closely related to that of their progenies.

The information gained from analysis of data obtained from families raised in routine breeding was at least as useful as that obtained from a diallel cross or from a selfing experiment designed specifically to test the parents.

Two unnamed *Fragaria viginiana* I derivatives (53Q13 and 60BQ8) and a Siletz derivative (60CE5) were the most resistant and proved to be the most potent sources of resistance, but their fruit quality was poor. Cambridge Favourite, despite its lack of vertical resistance, was at least as potent as Redgauntlet.

General combining ability for red core resistance was more important than specific combining ability though the latter was evident with a few of the crosses).

GOODING, H. J. (1973). Strawberry varieties for Northern Climates. *Scottish Gardener* March (2), 37.

JENNINGS, D. L., CARMICHAEL, E. and COSTIN, J. J. (1972). Variation in the time of acclimation of raspberry canes in Scotland and Ireland and its significance for hardiness. *Hort. Res.* **12**, 187–200.

(The incidence of winter injury in raspberry canes tends to be high in certain genotypes, and, within a genotype, higher in southern Ireland than in Scotland. Canes of injury prone genotypes ceased growth and entered their rest period later than those of hardy ones, and the water content of their canes remained high for longer. Their first stage of acclimation therefore occurs later, and is associated with poor winter hardiness. Genotypes which are moderately hardy in Scotland began their acclimation processes later in Ireland than in Scotland. These processes also started late in newly established plants and in plants defoliated prematurely. The hardy cultivar Carnival began its acclimation especially early and may therefore be hardy under a wide range of conditions).

JENNINGS, D. L., GOODING, H. J. and ANDERSON, M. M. (1973). Recent developments in soft fruit breeding. *Fruit Present and Future*, Vol. II. R.H.S. 121–135.

(Reviews progress in the breeding of raspberries, strawberries, black currants and blackberries).

MURANT, A. F.[1], JENNINGS, D. L. and CHAMBERS, J. (1973). The problem of crumbly fruit in raspberry nuclear stocks. *Hort. Res.* **13**, 49–54.

[1]Virology Section.

Mycology

R. A. FOX

The raspberry crop in Scotland is unique in British, European, and possibly world horticulture in relation to acreage and yield. Up to and including 1969, no disease had been considered sufficiently important in Scotland to warrant routine control measures despite the intensive cultivation of the crop. Only one condition, known locally as Rueben's die-back, had been investigated other than superficially. Recent investigations of this condition, now associated with *Fusarium avenaceum*, have revealed new potential pathogens and called into question the status of others. Trials by the Crop Research Section, using fungicides as tools to investigate components of yield, raised similar doubts. As a result a complete reassessment of the position and of the impact on it of new cultivars is now under way.

Many isolates of *Botrytis cinerea* were found during the year to be resistant to benomyl following its widespread use to control grey mould of soft fruits and attempts to control raspberry cane diseases. These findings confirmed reports elsewhere as did observations of its effects on plant growth. Benomyl and other fungicides yielding or containing methyl benzimidazol-2-carbamate persist for long periods as residues in plant parts and in soil. In view of this and their very wide spectrum of activity their use on the Institute's farm will be restricted in future to minimise unpredictable responses in experimental crops.

During the year, soil baiting techniques for *Phytophthora fragariae* have shown promising results in detecting very low populations of this pathogen. Two large Fison's growth cabinets have been installed and current modifications to them will allow 2 separate sets of root temperature control within each cabinet. This facility should greatly assist work on soft fruit and will be particularly useful for investigations on strawberry red core.

We have pleasure in acknowledging assistance from Dr A. H. S. Onions, Commonwealth Mycological Institute for cultures and identifications, to Dr R. Watling, Royal Botanic Garden, Edinburgh, for identifications, and to several growers for access to their farms.

RED CORE OF STRAWBERRY

Three pre-planting treatments consisting of no cultivation, deep ploughing (360 mm) and rotovation (230 mm) at monthly intervals for 10 months had no effect on the incidence (number of diseased plants) or severity (percentage number of diseased roots) of red core developing in a susceptible cultivar.

When rooted runners of cvs. Redgauntlet and Cambridge Favourite became available in July, samples were lifted at monthly intervals until the following June. When these were inoculated and incubated under the same environmental conditions the only seasonal change was a decreasing susceptibility of plants samples in April, May and June.

The effect of low levels of inoculum was examined as one of the factors which could be associated with field resistance. Differences between the percentage of roots infected at various inoculum levels were significant only at zoospore concentrations of less than 200/ml. At these levels, there were differences in susceptibility between cultivars which were not evident at higher levels.

Several fungicides were screened for activity against *Phytophthora fragariae* by applying them as drenches to 4-week-old strawberry runners in potting compost in the glasshouse and inoculating the plants with mycelial discs and zoospore suspensions of the fungus. Fourteen compounds produced a significant decrease in the percentage of diseased roots but only terrazole and an analogue of drazoxolon were better than Dexon which was included as a standard.

Increasing the pH of solutions irrigating colonies of *P. fragariae* decreased the number of motile zoospores. To assess the influence of pH of the rooting medium on primary infection, runner tips were rooted into peat/vermiculite mixtures of pH 4·7, 5·7, 6·7, 7·3 and 8·5. The percentage diseased roots after inoculation (by dipping roots in a zoospore suspension) was similar in all treatments. Infected runners were replanted in mixtures at the same pH as those in which they had been rooted and held for 3 weeks in conditions optimum for secondary infection. Only those in the pH 8·5 compost developed a significantly lower percentage of diseased roots. Infection levels in the other treatments did not differ. Transferring plants from rooting mixtures of pH 4·7 and 7·3 to those of pH 7·3 and 4·7 respectively did not influence the amount of disease which developed.

(I. G. Montgomerie and D. M. Kennedy)

Most stock isolates of *P. fragariae* produced oospores on French Bean Agar and Red Kidney Bean Agar. The numbers were generally few and nearly always associated with starch grains present in larger fragments of the bean material, as they may be with the strands of glass fibre tape if this material has overlain the colony during growth. One isolate produced large numbers of oogonia on French Bean Agar but many appeared to have aborted contents. Substituting the agar with 8% w/v of gelatine as a solidifying agent increased the numbers of oogonia and more had normal contents.

Although *P. fragariar* will grow on a range of selective media, recommended for isolating other *Phytophthora* spp. and *Pythium* spp. from soil, it has not yet been isolated from infected plant material or from infested soil using these media. A programme of screening antibiotics and fungicides which may be suitable for a selective medium is continuing.

Soil samples from an infested site at Mylnefield were planted with runners of the very red core susceptible clone V51 of *Fragaria vesca*. After 5 weeks in the glasshouse at 16± 2°C, with thrice daily watering, red core infection was consistently detected.

By mixing infested field soil with a solid diluent (autoclaved sand) levels of infection of *F. vesca* were related to the degree of dilution, in one case infection was detected even at a dilution ratio of 1:599. It is hoped to quantify this system by adding to soil known numbers of oospores which can be obtained by comminuting roots of infected plants in distilled water and sieving the preparation. Large numbers of oospores within their oogonial walls but unattached to large root fragments were obtained using this technique.

(J. M. Duncan)

INTERNAL NECROSIS OF STRAWBERRY CROWNS

Two-year-old strawberry plants cv. Cambridge Favourite grown in pots in the glasshouse, were inoculated with conidial suspensions of *Fusarium avenaceum* applied to petiole stubs, stolon stubs, roots damaged slightly with a scalpel, undamaged roots, and to the undamaged crowns. By January 1973 there were significantly more dead crowns on the inoculated plants than on their respective damaged or undamaged controls, but *F. avenaceum* proved difficult to isolate from those which died.

Isolations from dead or diseased crowns have failed to reveal *Phytophthora cactorum* which is sometimes associated with strawberry crown death. Inoculations with an isolate of *Coniothyrium fragariae* obtained from crowns of diseased Cambridge Favourite failed to produce symptoms.

(W. R. Jarvis and A. J. Hargreaves)

RASPBERRY WILT AND BUD FAILURE

Canes of potted raspberry plants, cv. Malling Jewel, were inoculated in various ways with a spore suspension of *Fusarium avenaceum* in the glasshouse in autumn 1971. The results could not be analysed because of a high incidence of bud failure in uninoculated check plants, possibly because the canes did not become fully dormant over the winter. In addition, apical dominance appears to have a larger effect in the glasshouse than in the field. However, the results did indicate that it is possible for the fungus to enter the cane through leaf scars in the autumn and affect buds the following spring. This hypothesis is being tested in the field and the results should be available in spring 1973. Roots and canes have been inoculated in the field to identify other possible sites of infection. In glasshouse grown material the fungus penetrates cortical cell walls in the root, induces the formation there of lignitubers and of tyloses in the xylem vessels and of gum deposits in the stem xylem vessels.

Attempts are being made to set up a method of screening new cultivars for resistance to *Fusarium* diseases but these cannot be further developed until more is known of the sites of penetration by the fungus and of factors affecting its pathogenicity.

During the late summer and autumn of 1972 a large number of midge larvae (*Thomasiniana theobaldi*) were found on canes and dark brown lesions were associated with them. A number of fungi have been isolated and work is continuing on interactions between the midge and these fungi (Zoology report p. 80).

(W. R. Jarvis and A. J. Hargreaves)

AUTECOLOGY OF FUSARIUM AVENACEUM

Resting bodies of *F. avenaceum* have now survived for 18 months in fallow soil in the field. Investigations on the effects of soil moisture showed that in saturated field soils there is almost total lysis of both mycelium and conidia. At normal field rates the fungicides captan, dichlofluanid, thiram and dodine prevented conidial germination *in vitro*, whereas dicloran, zineb and the herbicide simazine allowed germination. Conidia treated with benomyl also germinated but the germ tubes failed to grow. The optimum temperature range for conidial germination and mycelial growth on agar was 22–25°C and the optimum pH for growth was between pH7 and 8.

A plot of cv. Glen Clova severely affected by lateral wilt at Auchincruive was estimated in May to have 9,800 propagules/g of wet soil compared with an estimate of only 50 in a plot of cv. Malling Promise recently sterilized with dazomet.

(A. J. Hargreaves)

EFFECT OF BENOMYL ON RASPBERRY PLANTS

At Kirriemuir, rows of a commercial raspberry plantation, cv. Malling Jewel, were sprayed by the grower during 1971/72 with Benlate (50% benomyl) at the normal rate and at twice the normal rate, and with Elvaron (50% dichlofluanid) at the normal rate. Some rows were left unsprayed as a check. The canes sprayed with Benlate showed little of the silver colouration usually associated with spur blight (*Didymella applanata*) and they also retained their leaves about 3 weeks longer in the autumn. Benlate at both rates resulted in a higher mean number of live lateral buds per cane, a higher mean number of canes per stool and hence a higher mean number of laterals per stool than did both other treatments but the results could not be statistically analysed as the rows had not been replicated.

(W. R. Jarvis and A. J. Hargreaves)

TOLERANCE OF BENOMYL BY BOTRYTIS CINEREA AND PENICILLIUM CORYMBIFERUM

During the 1972 soft fruit season, hearsay reports suggested that grey-mould fruit rot was not being controlled by the fungicide benomyl to the

same extent as in the previous 2 years. In August 1972 isolates of *Botrytis cinerea* were obtained from diseased raspberry fruits from plots at Mylnefield which had been sprayed in November 1970, February, April, May and November 1971, and in February, April and May 1972. In both 1971 and 1972 3 sprays were given in June for fruit grey mould control. All isolates from treated plots grew and sporulated on potato dextrose agar incorporating 1,000 ppm benomyl and tolerant isolates were also obtained from adjacent untreated check plots. Further tolerant isolates were obtained in November and December 1972. Similar isolates were obtained from a commercial plantation in Angus, including 1 from a plot which had received no benomyl in 1972, and some which were 50 m distant from benomyl treated plants and separated from them by a poplar windbreak.

In November 1971 plots of strawberries showing marked symptoms of Verticillium wilt (*Verticillium dahliae*) were treated with benomyl as a soil drench. A year later isolates of *B. cinerea* were obtained from rotted fruit on some of these plants and these also grew and sporulated on media containing 1,000 ppm benomyl, but isolates of *V. dahliae* from petioles of the same plants did not grow even in the presence of only 1 ppm benomyl.

In September 1971 tulip bulbs from plots at Mylnefield receiving regular sprays of benomyl through the growing season for the control of tulip fire (*Botrytis tulipae*) were dipped for 30 min in benomyl and, contrary to the manufacturer's recommendation, were not dried before being stored at 9°C. Soon they were rotting and covered with a profuse growth of *Penicillium corymbiferum* from which isolates proved to be tolerant *in vitro* to 1,000 ppm Benlate.

(W. R. Jarvis and A. J. Hargreaves)

PLANT ESTABLISHMENT STUDIES

Seed lots of barley, cv. Golden Promise, of variable quality were produced by harvesting seed at moisture contents ranging from 15–44% and drying to ca. 12% moisture content at 25, 35, and 45°C, and by storing mature seed at various relative humidities. Seed germination and vigour of coleoptile growth was determined in rolled paper towels and emergence and crop yield were recorded from field sowings on 21 March and 3 May.

All of the prematurely harvested seed, germinated satisfactorily, had high vigour, emerged well in the field and produced plants which yielded similar quantities of grain as those from mature seed.

Germination and emergence were reduced by most treatments after seed had been stored in 70, 79·5 and 90% r.h. for 7 weeks at room temperature and in 100% r.h. either at 30°C for 16–19 days or 40°C for 5–6 days. Grain yields of plants from deteriorated seed were compared with those from normal seed at similar plant populations. Plants from seed deteriorated at 40°C, yielded less than those from other treatments or controls. These results showed that deterioration in store after harvest is a more probable cause of poor seed quality than premature harvesting and rapid drying at high temperatures.

Emergence of 12 seed lots of varying vigour selected from the previous experiments, and sown on 1 May in soil maintained close to field capacity throughout the pre-emergence period, was compared with that from non-irrigated seed. The average moisture contents of the non-irrigated plots were 18·7% (–0·3 bar) and 25·5% (–0·1 bar) and mean emergence was 89·7 and 77·4% respectively. Although there was no significant interaction between seed lot and irrigation, correlation between laboratory germination and emergence was poorer on the irrigated plots (r=0·81) than on the non-irrigated (r=0·98). At harvest the numbers of ears per plant were 12·7 and 8·4 and the yield of grain was 2·8 and 2·1 kg from the non-irrigated and the irrigated plots respectively.

The emergence of 12 lots each of pelleted and non-pelleted seeds of monogerm sugar beet cultivars sown on 24 April and 16 May respectively in soil maintained close to field capacity was compared with that in normal soil conditions. Mean percentage emergence was reduced from 77·9 to 52·5 and from 75·2 to 51·9 on the irrigated plots for the two types of seed respectively. There were no interactions between soil conditions and seed lots and the pelleting process did not affect the sensitivity of the seed to high soil water. The mean fresh weights of roots harvested in November were 11·4 kg from both the non-irrigated plots and 8·9 and 8·2 kg from the irrigated plots.

There was a marked similarity in the reaction of barley and sugar beet to high soil moisture conditions during the pre-emergence period. Percentage emergence was reduced, rate of growth was retarded and crop yield was less. The mode of action of high soil water is not known and will be the subject of continuing investigations in barley.

(D. A. Perry and J. G. Harrison)

CAVITY SPOT OF CARROTS

The low incidence of cavity spot in carrot crops of East Scotland in 1972 was associated with lower than average rainfall from July onwards and confirms observations from previous years that the occurrence of the disorder may be in some way related to the amount of rainfall during the growing season.

A glasshouse experiment in which potassium levels of 200 ppm and 1,000 ppm were maintained in combination with nitrogen concentrations of 40, 200, 400 and 1,000 ppm in pots of soil containing 2,000 ppm available calcium failed to produce any significant levels of the disorder, showing that these ratios of N, K and Ca are not solely responsible for the induction of the disorder. In other experiments roots grown in pots placed in saucers of water had significantly more cavity spot than those in pots receiving minimal quantities of water necessary to sustain plant growth. Roots developed characteristic symptoms at maturity after they had been bruised by striking with a glass rod when they were ca. 10 mm diameter at the crown, and re-planted.

(D. A. Perry and J. G. Harrison)

The continuing study of factors affecting the development of black leg was adversely affected by a prolonged drought during the latter part of the summer which reduced both plant growth and disease incidence. The susceptibility of 9 cultivars was compared in an experiment similar to that described in last year's report with similar results. It appears that the incidence of black leg is affected by two factors: the susceptibility of the seed tuber to breakdown in the soil–which may be further affected by site and season, and the resistance of the haulm to infection or symptom expression. If the mother tuber rots early the young plant may be affected before emergence, leading to blanking and a 'non-record' of black leg. At a somewhat later stage the mother tuber may rot so rapidly that the young plant may escape infection either because the inoculum level falls quickly to an ineffective level *per se* or one which is ineffective in relation to the resistance of the stem. In cultivars where the mother tuber is more resistant to breakdown, little black leg develops if the haulm is resistant, but if it is susceptible, the incidence tends to increase throughout the growing season.

Seed size also affects the observed black leg incidence, which was three times greater in cv. Majestic plants grown from large (>100 mm) than when grown from small (ca. 25 mm) seed; the latter, however, gave twice as much blanking as the former.

When seed of cv. Majestic were planted on 6 different dates at fortnightly intervals black leg incidence was higher in plants planted in late March and progressively lower for later planting dates.

Studies on sources of re-contamination of black leg free stocks were continued. Half of the potato field examined in 1971 for tubers which had been missed at harvest (see 1971 Annual Report) was harrowed twice during the winter, and the other half was not. In June the estimated number of groundkeepers from these areas was 11,000 and 18,000 per acre respectively. Since soil temperature at 100 mm never fell below freezing point this comparative reduction in numbers was probably due to ground frost damaging tubers brought to the surface by harrowing.

After ploughing, many tubers remained buried or were re-buried at depths beyond the reach of frost action. There they can annually regenerate and so persist for at least 6 years in almost undiminished numbers so long as the following crops are cereals. Their numbers appear to drop markedly only when a more open crop is grown subject to repeated applications of herbicides and inter-row cultivation. Re-contamination may also occur by insect transmission and *Erwinia carotovora* has occasionally been isolated from insects, mainly fruit flies. It can also be wind-dispersed because the bacteria have been isolated from aerosol droplets generated when haulm is destroyed by pulverising.

The quantal assay referred to in the Annual Report for 1971 was used to determine the susceptibility to rotting of tuber tissue during the growing period and in storage. Susceptibility to rotting by *E. carotovora* var. *atroseptica* at 15°C in air was least when tubers were immature and progressively increased throughout the growing season in the field and later in storage. Depending on cultivar, susceptibility to rotting is from 10 to 1,000-fold greater in the spring than early in the previous growing season.

(M. C. M. Pérombelon and R. Lowe)

GANGRENE OF POTATO

The results of the 1971 field experiments, assessed by the incidence of gangrene (*Phoma exigua* var. *foveata* and var. *exigua*) at the end of the storage season in 1972, have again shown that haulm pulling results in less disease than other methods of haulm destruction. In general, disease incidence increases with later dates of haulm kill and longer intervals to harvest. Despite year to year variability, it seems reasonable to state that there is an inherent contradiction in attempting to grow a crop largely for ware and then expecting to grade from it good quality seed reasonably free from gangrene. The contribution of the stem in the gangrene disease complex clearly needs more study and, in particular, the relationship between the inoculum load produced by stems as opposed to the inherent susceptibility of tubers at the time of harvest and as assessed by laboratory tests.

In 1972, in contrast to earlier observations, the stems of cv. Record proved relatively resistant to infection by wound inoculation with var. *foveata*, as did those of cv. Golden Wonder. Surprisingly, stems of cv. Pentland Crown, already becoming known for its tuber susceptibility, were not only highly resistant to infection whether wounded or not, but failed to develop internal lesions in contrast to Majestic and Pentland Falcon on which the lesions become covered with masses of erumpent pycnidia. Natural wounds on check plants adjacent to those inoculated with the var. *foveata* were unexpectedly found to be colonized almost exclusively by the var. *exigua*.

In vitro tests have shown that the interactions and antagonism between the var. *exigua* and the var. *foveata* are affected by temperature, and it now appears that not only must account be taken of stem as opposed to tuber susceptibility to the var. *foveata*, but of factors affecting stem colonization by the var. *exigua* and probably also by *Phoma eupyrena*.

Continuing studies on apparent tuber susceptibility as affected by the nutritional status of minute inocula have confirmed that significant differences are induced by varying absolute carbon and nitrogen levels in the media as well as by varying C:N ratios. In addition, different isolates of the var. *foveata* do not always react to such changes in the same way and second generation subcultures may show significant decreases in pathogenecity. Detailed observations *in vitro* suggest that large scale bulk experiments may be subject to hitherto unsuspected variables and that the viability of inocula, and therefore presumably the development of lesions, may be affected by volatile compounds produced by bacteria isolated from soft rotted tubers.

Work continued on attempts to prepare fluorescent antisera against var. *foveata* as an aid to identifying its mycelium in potato stems from which we

can isolate several other fungi, and in alternative hosts such as barley. As yet, only relatively low titres have been achieved and specificity is not adequate. Adsorption against *P. exigua* var. *exigua* and potato stem and tuber tissue removed the non-specific reaction with potato tissue, but only partially reduced the cross-reaction with the var. *exigua*.

(R. A. Fox, E. Patricia Dashwood and H. M. Wilson)

MISCELLANEOUS

Bibliography of Botryotinia and Botrytis species

An annotated bibliography of the taxonomy, physiology and pathogenecity of this group has been prepared and a TRIAL information retrieval program has been compiled for the computer. Most of the important past and recent references are now stored in an EDIT master file at the Edinburgh Regional Computing Centre and they can be retrieved by a SEARCH system using either key words or authors.

(W. R. Jarvis, Pauline B. Topham in co-operation with the Edinburgh Regional Computing Centre)

PUBLICATIONS

ATHERTON, L.[1], DUNCAN, J. M. and SAFE, S. (1972). Isolation and biosynthesis of Ergosta-5, 7, 9(11), 22-tetraen-3B-ol from *Mucor rouxii*. *J.C.S. Chem. Comm.* (Com. 732).

BREWER, D.[1], DUNCAN, J. M., SAFE, S. and TAYLOR, A. (1972). Ovine ill-thrift in Nova Scotia. 4. The survival at low oxygen partial pressure of fungi isolated from the contents of the ovine rumen. *Can. J. Microbiol*, **18**, 1119–1128.

BREWER, D.[1], DUNCAN, J. M., JERRAM, W. A., LEACH, C. K. *et al.* (1972). Ovine ill-thrift in Nova Scotia. 5. The production and toxicology of chetomin, a metabolite of *Chaetomium* spp. *Can. J. Microbiol.* **18**, 1129–1137.

FOX, R. A. and DASHWOOD, E. Patricia (1973). Some factors affecting infection by and survival of the potato gangrene fungus. *European Assoc. Potato Res. Proc. Triennial Conf., 5th*, Norwich, 1972, pp. 138–139.

(The apparent susceptibility of potato tubers to infection may be affected by the nature, positioning, nutritional and cultural history of the inocula and by possible interactions between pathogens and the tuberplane microflora. In the field tuber infection may be affected by the extent of stem infection, the susceptibility of different parts of the same plant not necessarily being related. A large number of non-solanaceous weed and crop plants have proved susceptible to infection and the pathogen has been recovered from field grown barley).

HARRISON, J. G. (1972). Studies on hollow heart of peas (*Pisum sativum L.*). Ph.D. Thesis, University of Dundee.

[1]National Research Council of Canada, Atlantic Regional Laboratory, Halifax, Nova Scotia.

HARRISON, J. G. and PERRY, D. A. (1973). Effects of hollow heart on growth of peas. *Ann. appl. Biol.* **73**, 103–109.

(Hollow heart delayed germination and reduced seedling growth. Plants from affected seeds were smaller and yielded less than those from normal seeds. Affected cells were dead but immobilization of starch reserves within them could not wholly account for the reduced growth and evidence suggested the presence of a germination and growth inhibitor).

HAWTHORNE, B. T.[1] and JARVIS, W. R. (1973). The differential effects of some fungicides on various stages in the life cycle of *Sclerotinia sclerotiorum* and *S. minor*. *N.Z. Jl. agric. Res.* **16**.

(The fungicides benomyl, thiophanate, thiophanate-methyl, captan, dicloran, and dichlofluanid had different effects on ascospore germination of sclerotia to form mycelium, and on apothecial stipe production).

MONTGOMERIE, Isabel G. and KENNEDY, Diana M. (1972). Red core–is it in plant or soil? *Comml. Grow.* **No. 3988**, 960.

PÉROMBELON, M. C. M. (1972). The extent and survival of contamination of potato stocks in Scotland by *Erwinia carotovora* var. *carotovora* and *Erwinia carotovora* var. *atroseptica*. *Ann. appl. Biol.* **71**, 111–117.

(When 57 bulk and crate stored commercial seed potato stocks from the East of Scotland were examined in 1966-68 for contamination by pectolytic *Erwinia* spp, most tubers of all the cultivars and stocks examined, irrespective of whether they were obtained from blackleg infected or blackleg free crops, were contaminated with *E. carotovora*. Some 80% of the *Erwinia* isolates obtained were identified as var. *atroseptica*, the rest being var. *carotovora* and the organisms survived in and on tubers for 6–7 months of bulk storage over the winter and up to planting time the following spring. Contrary to what is generally thought, the high incidence of contamination of all stocks, while suggesting that the seed itself is the major source of *E. carotovora* for the growing crop, emphasizes that other factors affect manifestation of blackleg in the field and soft rot in store).

PÉROMBELON, M. C. M. (1972). A reliable and rapid method for detecting contamination of potato tubers by *Erwinia carotovora*. *Plant Dis. Reptr.* **56**, 552–554.

(Invariably, potato tubers (*Solanum tuberosum*) are rotted rapidly by bacteria when incubated anaeobically at room temperature (ca. 17°C) and a relative humidity of 100%. These conditions favour the growth *Erwinia carotovora*, which, if present, can readily be detected by plating rotting tissue on a semi-selective medium with an overlayer of pectate gel, in which it forms diagnostic cavities).

PÉROMBELON, M. C. M. (1973). Sites of contamination and numbers of *Erwinia carotovora* present in stored seed potato stocks in Scotland. *Ann. appl. Biol.* **74**, 59–65.

(Forty-eight bulk and crate stored commercial seed potato stocks from the east of Scotland were examined for contamination by *Erwinia carotovora* in 1967 and 1968. Both *E. carotovora* var. *carotovora* and *E. carotovora* var. *atroseptica* were present, the latter, the blackleg pathogen, being detected 4 times more frequently. Most contamination was located on the tuber surface and in the lenticels; it was rare in the vascular ring and the organism was never detected in the cortex. The level of contamination of lenticels was only slightly affected after winter storage, which, however, substantially reduced surface contamination. More than 10^3 cells were detected on the surface of tubers in over half the stocks, and in half the stocks each lenticel sampled contained more than 10^2 bacteria).

[1]D.S.I.R. Plant Diseases Division, Auckland, New Zealand.

PÉROMBELON, M. C. M. (1973). Factors leading to the initiation of bacterial soft rot in potato tubers. *European Assoc. Potato Res. Proc. Triennial Conf. 5th*, Norwich 1972, p.142.

(When their surface is wet, non-inoculated whole tubers rot more readily under anaerobic than aerobic conditions. The sequence of events leading to soft rot is related to leakage of sap and the absence of tuber resistance under anaerobic conditions).

PÉROMBELON, M. C. M. and GRAHAM, D. C. (1973). Recontaminated problems in blackleg free seed potato stocks in Scotland. *European Assoc. Potato Res. Proc. Triennial Conf. 5th*, Norwich 1972, pp.136–137.

(The high incidence (22% in 1971) of recontamination of virus tested stem cutting stocks by the blackleg bacterium caused much concern as the tolerance level for such stocks had been set at zero. Possible sources of contamination were considered in relation to the biology of the pathogen).

PERRY, D. A. (1973). Interacting effects of seed vigour and environment on seedling establishment. In *Seed Ecology* (Heydecker, W. Ed.), pp.311–323, Butterworths, London.

(Field emergence of peas was least and correlations between laboratory germination and emergence were poorest in early sowings. Low vigour seed was more affected by adverse soil conditions than high vigour seed and they responded more to fungicide treatments particularly in the earliest sowings. The existence of vigour differences were also suggested in carrot and sugar beet seed. The concept and manifestation of seed vigour were discussed).

PERRY, D. A. (1973). Infection of seeds of *Pisum sativum L.* by *Pythium ultimum* Trow. *Trans. Brit. mycol. Soc.* **61**, 135–144.

(Susceptibility of seed lots to *P. ultimum* was correlated with field emergence and quantity of carbohydrate and nitrogenous compounds leached into sand. Pathogenesis was enhanced when seeds were coated with leachate and glucose but not when nutrients were added to sand. Macroscopic and microscopic cracks in the seed coat were regarded as important factors controlling both the infection by the fungus and the amount of material leached from the seeds).

PERRY, D. A. (1973). Studies on field emergence of monogerm sugar beet. *J. agric. Sci., Camb.* **81**, 245–252.

(Field emergence of monogerm sugar beet was reduced by high soil moisture and compaction, but unaffected by soil temperature. Seed lots were differentially affected when conditions were very adverse. Pelleted seed emerged slightly better and was not more sensitive to high soil water than raw seed).

PERRY, D. A. and HARRISON, J. G. (1973). Causes and developments of hollow heart in pea seed. *Ann. appl. Biol.* **73**, 95–101.

(Pre-disposition to hollow heart was caused by high ambient temperatures during seed maturation on the plant and by drying immature seeds. Symptoms developed during germination and the proportion of seeds affected depended on the rate of water imbibition. It was suggested that pre-disposed cells died during rehydration).

Virology

B. D. HARRISON

During the year a programme was started to produce virus free clones of narcissus cultivars for eventual release to propagators, and this should complement the Department of Agriculture and Fisheries for Scotland certification scheme in helping to improve the health of narcissus stocks. Research on the aphid borne latent viruses of raspberry, and on the mechanism of transmission of parsnip yellow fleck virus by aphids, has begun to yield very promising results. In work on multi-component viruses, the first hybrid isolates of raspberry ringspot virus were prepared, and a virus-induced RNA polymerase was detected in leaves infected with tobacco rattle virus. Projects involving ultrathin sectioning were helped by the purchase of a second ultramicrotome, and the installation of an additional ultracentrifuge will benefit much of the laboratory work.

MULTICOMPONENT VIRUSES

Comparison of some tobravirus isolates

Several isolates of tobraviruses were compared by serology, electron microscopy, the molecular weights of their coat proteins were determined by polyacrylamide gel electrophoresis, and their symptoms in pea and French bean recorded. Most tobacco rattle virus (TRV) isolates could be distinguished from pea early-browning virus (PEBV) isolates by the 4 criteria. However, 2 isolates were obtained, code named RQ and IT6, which induced TRV-like symptoms in pea and bean, but which had modal particle lengths and protein molecular weights more similar to those of PEBV. IT6 was serologically related to an English isolate of PEBV but not to TRV, and RQ did not react with antiserum prepared against either PEBV or TRV. These results emphasize the variability of viruses within the tobravirus group and somewhat blur the distinction between TRV and PEBV.

(J. I. Cooper and M. A. Mayo)

Proteins of tobraviruses

When preparations of tobacco rattle virus are stored without a bacteriostatic agent, the coat protein of the virus is partially degraded. The protein of pea early-browning virus was similarly affected by storage, with the estimated molecular weight of the protein changing from 24000 for freshly

purified preparations to 21000 for stored preparations. The enzyme that degrades the protein of tobacco rattle virus (strain CAM) was found in the supernatant fluid produced when a stored and degraded virus preparation was centrifuged to remove bacteria and virus particles. Several attempts were made to isolate a micro-organism producing this enzyme and one was obtained that had this ability when grown in a basal salts plus glucose medium.

(M. A. Mayo and J. I. Cooper)

Both fresh and stored forms of strain CAM reacted with CAM antiserum in agar gel immunodiffusion tests. The stored virus formed a spur, indicating that it carried an antigenic determinant not possessed by fresh virus. Treatment of the virus with formaldehyde did not destroy its antigenicity, nor did it prevent degradation by the bacterial enzyme.

(D. J. Robinson)

Multiplication of tobacco rattle virus

A defective strain of tobacco rattle virus that does not synthesize coat protein or nucleoprotein particles, was used to study the sites of RNA multiplication in the infected cell. Infective RNA in leaf homogenates was rapidly inactivated even when high pH buffers were used to inhibit leaf nucleases. However, when dithiothreitol was added to the buffer used to make extracts, infectivity was retained for several hours. When such extracts from *Nicotiana clevelandii* leaves were fractionated by centrifugation in sucrose gradients prepared in dithiothreitol-containing buffer, infective RNA was associated with fractions containing mitochondria. Work is continuing on the possible role of mitochondria in the replication of tobacco rattle virus RNA.

(M. A. Mayo)

RNA polymerase in tobacco rattle virus infected tissue

An assay was developed for measuring the incorporation of ribonucleoside triphosphate into acid insoluble material by plant tissue extracts. Most extracts from plants infected with a defective strain of the virus contained 2 to 3 times as much activity as healthy extracts. Actinomycin D (30 μg/ml) inhibited the activity from healthy tissue by 70%, and in the presence of this drug about 5 times as much activity was obtained from most samples of infected as from healthy material. Three-quarters of the activity obtained from infected tissue was sedimented in 5 minutes at 1000 *g*. The activity was not dependent on added RNA.

(D. J. Robinson)

Mutants of tobacco rattle virus

Investigation of the properties of N8 and N10, 2 previously described temperature sensitive mutants of the CAM strain of tobacco rattle virus, was continued; N10 is temperature sensitive in *Chenopodium amaranticolor*

but not in *Nicotiana clevelandii*, whereas N8 is temperature sensitive in both species. Production of infectious RNA in both species by both mutants was found to parallel production of infectious virus. The difference between the behaviour of N10 in *N. clevelandii* and in *C. amaranticolor* was not associated with a difference of leaf temperature between the 2 species. Local lesion formation by N10 in French bean was affected by temperature as in *C. amaranticolor*.

In experiments in which infected plants were kept at 30°C for varying periods and then transferred to 20°C, the ability of N8 to produce local lesions in *C. amaranticolor* was lost rapidly and monotonically with time at 30°C. N10, in contrast, after an initial sharp decline, lost its remaining lesion forming capacity only slowly. Two mechanisms seem involved in the inactivation of N10 infective centres at 30°C.

Mixtures of long particles from N8 or N10 with wild-type short particles gave rise to lesions containing mutant virus, whereas the progeny of mixtures of wild-type long particles and mutant short particles were wild-type. This indicated that both mutations are in the RNA of the long particle. The coat protein gene is in the RNA of the short particle, so both mutants and wild-type should have the same coat protein. Supporting evidence was obtained from immunodiffusion tests, where antiserum against CAM gave single precipitin lines against purified particles from each of the isolates, with reactions of identity between each pair of lines. Furthermore, purified particles of each mutant were indistinguishable from wild-type in their sensitivity to heat under various conditions.

Two additional temperature sensitive mutants, S36 and T24, were obtained. At 30°C, S36 produced few lesions in *C. amaranticolor* and little infectious virus or RNA in *N. clevelandii*.

(D. J. Robinson)

Raspberry ringspot virus hybrids

In work to identify the functions of the 2 pieces of RNA (RNA-1 = $2{\cdot}4 \times 10^6$ daltons; RNA-2 = $1{\cdot}4 \times 10^6$ daltons) produced by raspberry ringspot virus, hybrid isolates were made by infecting plants with RNA-1 from one strain of the virus together with RNA-2 from a second strain and then propagating the isolates from single lesions. In several different crosses, the serological specificity of the hybrids was that of the parent contributing the RNA-2. Similarly, the ability to produce yellowing symptoms in systemically infected leaves of *Petunia hybrida* also was determined by the RNA-2 of an English blackberry strain and a Dutch redcurrant strain of the virus. In contrast, RNA-1 determined lesion type in inoculated leaves of *Chenopodium amaranticolor*, severity of symptoms in systemically infected leaves of *Nicotiana clevelandii*, and ability to infect *Phaseolus vulgaris* systemically. When reciprocal hybrids which had markers on each piece of RNA were crossed, the parental strains were regenerated.

Two other phenomena were observed in these crosses. In one, reciprocal hybrids were respectively more virulent and less virulent than either of their

parent strains. This suggests that in one parent a gene for high virulence in RNA-1 is to some extent counteracted by a gene in the RNA-2, and that in the other parent the lower virulence conferred by its RNA-1 is enhanced by the homologous RNA-2.

The second phenomenon was the non-expression of the gene that determines yellowing in *P. hybrida* when in combination with the RNA-1 of a raspberry ringspot virus strain from Lloyd George raspberry. Thus it seems that the ability to produce yellowing in *P. hybrida* depends on more than one gene. Ultrastructural studies of *P. hybrida* leaf cells showed that the yellowing induced by various strains and hybrids was associated with radical changes in the chloroplasts, which became devoid of starch and contained only a few disorganized grana. They also contained many small membrane bounded sacs which were not seen in chloroplasts from virus free *P. hybrida* leaves or from leaves infected with strains or hybrids that do not induce yellowing. It remains to determine how the virus RNA induces this ultrastructural effect.

(B. D. Harrison, A. F. Murant, M. A. Mayo, I. M. Roberts, R. A. Goold, H. Barker and Aileen M. Hutcheson)

Tomato black ring virus

Tomato black ring virus (TBRV) particles contain a single protein species which, like those of nepoviruses previously studied, has a molecular weight ca. 57,000. Preparations of the virus RNA contain 3 molecular species with mol. wt. of $2{\cdot}5 \times 10^6$ (RNA-1), $1{\cdot}5 \times 10^6$ (RNA-2) and $0{\cdot}5 \times 10^6$ (RNA-3). RNA-1 preparations have some infectivity but preparations of RNA-2 or RNA-3 do not. Infectivity of RNA-1 preparations was increased by addition of RNA-2 but decreased by addition of RNA-3. By propagating from lesions produced by RNA-1 inocula it was possible to eliminate RNA-3, but not RNA-2, from the culture. RNA-3 did not spontaneously recur, suggesting that it is not a normal by-product of viral replication. No evidence was obtained that it multiplies on its own but when inoculated together with RNA-1+RNA-2 it re-appeared in the viral product. It seems that TBRV resembles other nepoviruses in having 2 essential RNA components (RNA-1 and RNA-2). RNA-3 may be analogous to the satellite RNA that occurs in some cultures of tobacco ringspot virus, although its mol. wt. is about 6 times greater. In contrast to other nepoviruses, preparations of the type culture of strawberry latent ringspot virus yielded 2 proteins of mol. wt. about 30,000 and 44,000.

(A. F. Murant, M. A. Mayo, B. D. Harrison and R. A. Goold)

Cherry leaf roll virus

The cherry, elder, elm and rhubarb strains of cherry leaf roll virus were found to be similar in host range, symptomatology and properties in sap or purified preparations. However, they differed in stability, the elm strain being the least stable. In plant protection tests, one-way protection occurred in tobacco cv. Xanthi-nc between tomato ringspot virus and each of the 4 cherry leaf roll virus strains and whereas the elder, elm, and cherry strains protected against one another, they did not protect against infection with the rhubarb strain which, however, protected against the other 3 strains.

(A. T. Jones)

Similar ultrastructural effects were induced in differentiated leaf cells of *Nicotiana clevelandii* by each of the 4 strains. The most notable features of infected cells were the inclusion bodies near the nucleus and the invaginations of the cell wall into the cytoplasm. These invaginations closely resemble those induced by bean pod mottle virus.

(A. T. Jones, Aileen M. Hutcheson and I. M. Roberts)

Elm mottle virus

This virus was found to have at least 3 nucleoprotein components, with sedimentation coefficients of 83, 89 and 101*S* (extrapolated to infinite dilution). Maximum infectivity was associated with the fastest sedimenting component but this infectivity was enhanced by adding the 2 slower sedimenting components. Polyacrylamide gel electrophoresis of protein and of RNA extracted from unfractionated virus resolved a single polypeptide of estimated mol. wt. 22,000 and 3 major RNA species (1, 2 and 3) of mol. wt. about $1{\cdot}3$, $1{\cdot}1$ and $0{\cdot}8 \times 10^6$ together with 2 minor RNA species of mol. wt. of $0{\cdot}4$ and $0{\cdot}3 \times 10^6$. Tests on the separated nucleoprotein components indicated that 101*S* particles contain RNA-1 and 83*S* particles contain RNA-3. These and other properties are similar to those reported for tobacco streak virus. However, no serological reaction occurred between elm mottle virus and antisera to 5 strains of tobacco streak virus, or to antisera prepared against several viruses of the prunus necrotic ringspot type.

(A. T. Jones and M. A. Mayo)

VIRUSES OF FLOWER BULBS

Survey of narcissus stocks

Since 1969, narcissus growers in Scotland have been able to submit stocks for certification of their health status, under a scheme run by the Department of Agriculture and Fisheries for Scotland. To assess the need to produce virus free stocks of the cultivars grown in eastern Scotland, a survey was begun of virus incidence in representative stocks of these cultivars. Stocks of 10 cultivars were collected, and those of 4 cultivars were tested in 1972. Thirty plants of each of 3 stocks of Golden Harvest and of Carlton, and of 2 stocks of Sempre Avanti were examined by infectivity tests and by electron microscopy of sap. Two stocks of Fortune were examined by electron microscopy only.

Filamentous virus-like particles were found by electron microscopy in all plants of Golden Harvest and Fortune, in half those of Carlton and in about

15% of Sempre Avanti. Narcissus mosaic virus was confined to 2 of the stocks of Carlton but some isolates produced inconspicuous symptoms on test plants, suggesting that others may have been overlooked and the incidence of the virus under-estimated. Tobacco rattle virus occurred in all stocks of Golden Harvest, Carlton and Sempre Avanti and was commonest in Golden Harvest. Arabis mosaic virus, the only nepovirus detected, occurred in the 3 stocks of Carlton. It is interesting that neither tomato black ring nor raspberry ringspot viruses, nepoviruses which occur in Scotland more frequently than arabis mosaic, were detected, although as mentioned in the 1969 report, the cultivars tested are susceptible to infection.

(W. P. Mowat, J. Chambers and Aileen M. Hutcheson)

Production and propagation of virus-tested narcissus clones

A method of rapid propagation of narcissus (twin-scaling) was recently developed elsewhere. Using this method, it is aimed to produce nuclear stocks from virus free mother plants of those cultivars in which virus infection is common. Initially, these mother plants will be seemingly virus free selections from the commercial stocks examined in the survey. Later, virus-tested mother plants obtained by meristem tip culture will be used.

About 1,000 twin scales were obtained from apparently healthy selections of Carlton, and also of Sempre Avanti. These were cut in August and kept at 24°C for 6 weeks followed by 6 weeks at either 24 or 17°C. They were then potted individually. At this stage about 80–90% of the twin scales from each bulb had developed a bulbil. Although known to contain filamentous virus-like particles, 7 vigorous plants of Golden Harvest, free from tobacco rattle virus and severe virus-like symptoms, were similarly propagated.

(W. P. Mowat and J. Chambers)

Work has been started to obtain virus free plants of Fortune, Golden Harvest and Sempre Avanti by meristem tip culture.

(J. Chambers)

Lily viruses

It was previously reported that a filamentous virus about 650 nm long from *Lilium formosanum* was transmitted by *Myzus persicae* in a non-persistent manner, as would be expected of a member of the carlavirus group. Further tests confirmed this and also showed that the virus is transmissible by *Aulacorthum solani*, *Macrosiphum euphorbiae* and *Aphis fabae* when given short acquisition feeds. The virus resembles the lily symptomless virus described by Brierley and Smith[1] because in mixed infection with cucumber mosaic virus it causes symptoms resembling necrotic fleck disease in *Lilium longiflorum*. However, lily symptomless virus was claimed to be transmitted in a persistent manner by *Aphis gossypii* and was not transmitted by *M. persicae* or *A. fabae*. More recently, virus isolates named lily symptomless virus were reported to have particles about 640 nm long and to infect *Tulipa gesneriana* cv. Rose Copeland. Attempts to infect Rose Copeland and Turner tulips with our isolate failed.

During 1971, the amount of virus spread occurring between July and October in a 4-year-old field planting of Asiatic lily hybrids was assessed by exposing *L. formosanum* seedlings for 3 to 4 weeks. Few of these seedlings developed symptoms of tulip breaking virus, whereas many became infected with a filamentous virus about 650 nm long which spread most rapidly in the first 3 weeks of September.

(W. P. Mowat)

[1]Brierley & Smith (1944) *Phytopathology* **34**, 529.

RASPBERRY VIRUSES

Aphid borne viruses

Observations on commercial plantations of Glen Clova raspberry showed that the mosaic disease reported previously (Annual Report 1970) was most prevalent around the edges of the plantations and in crops adjacent to other cultivars, such as Malling Jewel, which carry the causal virus(es) symptomlessly. The observations suggest that most infected plants may represent primary infections and that spread from plant to plant of Glen Clova is slow, possibly because it has some resistance to the aphid *Amphorophora rubi*. Where possible, it therefore seems best to plant Glen Clova in a square area to minimise the proportion of edge to middle, and not close to other raspberry cultivars that may act as virus sources.

Further results from the field experiment planted in 1971 to study the spread of aphid borne viruses in raspberry, and to assess how well *A. rubi* resistant raspberry selections resist virus infection supported last year's findings. Graft indexing to *Rubus* indicators showed that cultivars with good resistance to *A. rubi* had little virus infection. However, one plant of the *A. rubi* resistant cultivar Malling Orion contained several viruses. Plants of several cultivars yielded isolates that produced different responses in *Rubus* indicators. One isolate gave symptoms in Malling Landmark but not in Norfolk Giant and thus resembles raspberry leaf mottle virus. On its own this isolate seems not to induce mosaic in Glen Clova raspberry, although it was found, together with raspberry leaf spot virus, in all mosaic-affected Glen Clova plants.

Counts of aphids occurring on new cane growth of raspberries in this experiment during 1972, indicated that *A. rubi* populations reached a maximum in early August. In the cultivars Glen Clova, Lloyd George, Malling Jewel and Norfolk Giant, *A. rubi* were mainly on the upper leaves of the plants at the beginning of the season but on the lower leaves later in the season. The few aphids found on Malling Orion and 888/49 were distributed apparently at random on all parts of the plants throughout the season.

(A. T. Jones and A. F. Murant)

Black raspberry latent virus

A virus antiserum with a titre of 1/16 was prepared. Gel diffusion tests with this and other antisera suggest that black raspberry latent virus is serologically related to some strains of tobacco streak virus. Further evidence of this affinity was obtained by electrophoresis of the nucleic acid of black raspberry latent virus in polyacrylamide gels. Purified virus preparations yielded 3 major RNA species, of estimated mol. wt. 1·4, 1·1 and 0·9 x 10^6, and a minor RNA species of estimated mol. wt. 0·4 x 10^6. These virus preparations contained 3 nucleoprotein components with sedimentation coefficients (at infinite dilution) of 82, 97 and 108*S*. Some evidence was obtained that these components differ in size, but have the same density in caesium chloride solution.

(A. T. Jones and M. A. Mayo)

POTATO VIRUSES

Tobacco rattle virus

It was reported previously by Cooper & Harrison[1] that the incidence in potato tubers of spraing caused by this virus is greatest in the parts of fields where the topsoil is shallowest, and that vector nematodes are most numerous at the boundary between topsoil and subsoil. To see whether this distribution of vectors could be related to differences in soil structure, peds from topsoil, subsoil and the boundary between the two were embedded in resin and sectioned by Dr L. Robertson, Macaulay Institute for Soil Research. The sections were used to produce photographic enlargements (x 250) of 1 cm^2 regions. The mean area of the interparticle spaces in topsoil was significantly smaller than that for subsoil, with the value for the boundary not differing significantly from either. The range of areas of interparticle spaces in topsoil was narrower than that for the other 2 zones but in each zone about 90% of the spaces were large enough to allow the free passage of vector nematodes.

(J. I. Cooper)

Continuing an experiment started in 1969, it was found that *Trichodorus* nematodes were substantially controlled in the third year after applying D-D at 224 kg/ha in autumn. By the end of the third year, *Trichodorus* numbers had increased to 4·5% of those in control plots; half this dose of D-D, or either quantity applied in spring had little residual effect.

Because the effects of D-D are unlikely to persist from one potato crop to another in most rotations, and D-D is costly to buy and inject, emphasis was changed to finding treatments that simply protect crops from spraing in the first year after their application to infested land. An experiment was started in collaboration with T. J. W. Alphey, Zoology Section in which 2 systemic nematicides were used. These can be applied as granules without special equipment and, being insecticidal, should prevent the build-up of aphid populations. Both phenamiphos at 15 or 30 kg/ha a.i. and oxamyl at 8 kg/ha a.i. decreased spraing as effectively as D-D at 224 kg/ha, but D-D had the most rapid effect on nematode numbers (*see* Zoology Section). Thus the 2 systemics prevent *Trichodorus* inoculating the virus to tubers, apparently without necessarily killing the nematodes.

(J. I. Cooper, B. D. Harrison and R. W. Boyne)

[1]Cooper, J. I., Harrison, B. D. (1973). *Ann. appl. Biol.* **73**, 53–66.

Potato mop-top virus

The incidence of potato mop-top virus was examined in seed-potato stocks throughout Scotland. Most stocks were seen as growing crops, but some stocks of those cultivars that develop obvious tuber symptoms were examined in store. Where the virus was detected, an effort was made to locate the field in which infection was contracted. Infection was found in 66 cultivars, but more than half the number of stocks examined were free from the virus. Infection usually occurred in fewer than 2·5% of plants in a stock, but in one 48% were affected. Infested fields occurred in 13 Scottish counties including all the main potato growing areas, but the virus was not found in Orkney. Occurrence of the virus was not associated with any particular soil type and was not related to accumulated temperature. Infestation increased as potential water deficit decreased, and was strongly related with annual rainfall. There was little infestation where the rainfall was less than 30 in (760 mm), and its probability increased with increase of rainfall to 45 in (1,140 mm).

In a further test of possible control measures on infested land, zinc oxide was applied to a medium-heavy loam. Infection of Arran Pilot tubers was decreased from 44% to 5·6% by the heaviest dose (1,200 kg/ha). This also prevented infection of *Nicotiana debneyi* seedlings grown in the glasshouse in soil from the treated plots, but infection occurred when the same soil was diluted with autoclaved control soil, indicating that some virus-carrying resting spores of the fungus vector *Spongospora subterranea* remained viable. Treatment with zinc oxide seems unlikely to be economically worthwhile.

In an experiment on virus free land, zinc sulphate and zinc frit were applied to the soil in 1971, and the plots used to grow potatoes followed by ryegrass. The treatments did not greatly affect the zinc content of the potato tubers, but that of ryegrass foliage was increased up to fourfold. Eighteen months after application, the zinc content of the soil of treated plots was only about a tenth of its initial value, suggesting that the effect of zinc compounds on spread of potato mop-top virus is unlikely to persist for more than a year or two.

A test was made to see whether the establishment of virus-carrying *S. subterranea* in soil could be prevented by fungicide treatments of virus-infected seed tubers bearing powdery scabs. The fungicides were applied 7 months before planting the tubers, and establishment of the virus was assessed by

growing *N. debneyi* seedlings in pots of soil after the potatoes. Treating tubers with formaldehyde or organic mercurial compounds greatly minimized establishment, but secondary butylamine had little effect.

(J. I. Cooper, B. D. Harrison and R. W. Boyne)

MISCELLANEOUS VIRUSES

Parsnip yellow fleck virus

Light and electron microscopy of ultrathin sections of systemically infected leaf tissue of chervil, spinach and *Nicotiana clevelandii* plants revealed large inclusion bodies, usually 1 per cell, in palisade, mesophyll and bundle parenchyma tissue. In the electron microscope they were seen to consist of membranous tissue, densely-staining material resembling nuclear chromatin, and randomly distributed clusters of rigid tubules ca. 15 nm in diameter. Virus-like particles were seen, usually not in the inclusion bodies, but in tubules ca. 45 nm in diameter which occurred in the cytoplasm or passed through the plasmodesmata. Some of the tubules associated with plasmodesmata became surrounded along part of their length with new cell wall material growing out from the original cell wall and forming projections similar to but less extensive than those previously found with carrot mottle virus. Numerous tubules about 45 nm in diameter, both with and without virus particles, were seen in the sieve tubes.

(A. F. Murant, I. M. Roberts and Aileen M. Hutcheson)

Studies on the vector relations of parsnip yellow fleck virus (PYFV) and its 'helper' virus, anthriscus yellows (AYV), showed that the aphid *Cavariella aegopodii* can transmit both viruses after minimum acquisition feeding times (AFT) of 10 min, although transmission efficiency increases with increasing AFT up to 60 min, or even 24 h in some experiments. The aphid retains ability to transmit both viruses for 3 to 4 days. This result with AYV contrasts with those obtained previously, which suggested that AYV was a persistent virus. In preliminary experiments, neither PYFV nor AYV was transmitted by aphids that moulted after acquiring the viruses, and nor were the viruses transmitted from adult females to nymphs. It is concluded that both PYFV and AYV should be regarded as semi-persistent viruses.

When virus free *C. aegopodii* were allowed to feed either on plants containing PYFV alone, or through Parafilm membranes on purified preparations of PYFV, they did not transmit the virus. However, aphids that had first fed on plants containing AYV alone readily acquired and transmitted PYFV, both from plants and from purified preparations. Present evidence suggests that the 'transmission factor' in AYV infected plants may be the virus itself, because its minimum AFT and its persistence time in the vector are the same as those of AYV.

(S. El Nagar and A. F. Murant)

Elderberry latent virus

Although the protein and RNA components of elderberry latent and tomato bushy stunt viruses are of similar size, it was previously suggested that the polypeptide subunits are differently arranged in particles of the 2 viruses. Further evidence for this suggestion comes from determinations of the buoyant density of the 2 viruses in caesium chloride solutions. The density of elderberry latent virus was 1·363 g/cm^3 whereas that of tomato bushy stunt virus was 1·348 g/cm.^{3} Calculations based on the difference between the densities, or those based on the difference between the sedimentation coefficients of the 2 viruses, resulted in an estimated difference between the virus particle weights of 1·5 to 3 x 10^6 daltons. Whereas particles of tomato bushy stunt virus are reported to contain 180+12 protein subunits, the number estimated for elderberry latent virus is 120 to 157, and assuming the particle has icosahedral symmetry the most likely number is 120.

(M. A. Mayo and A. T. Jones)

Viruses in Dioscorea alata

We reported previously that extracts of mosaic-affected yam leaves, produced by tubers with internal brown spot disease, contain filamentous and bacilliform virus-like particles, whereas extracts from leaves produced by normal looking tubers contain only filamentous particles. We have now observed both kinds of particle by electron microscopy of sections of leaf tissue. The filamentous particles occur in the cytoplasm, mainly in bundles in cells of many types, whereas the bacilliform particles are found in the cytoplasm singly, or in small clusters embedded in amorphous material. These clusters are not numerous, and are commonest in vascular bundle tissue.

(B. D. Harrison and I. M. Roberts)

Mulberry ringspot virus

In collaboration with Dr T. Tsuchizaki, Institute for Plant Virus Research, Chiba, serological tests were made for possible relationships between this virus, which is transmitted by *Longidorus martini*, and a range of nepoviruses. No relationship was detected to arabis mosaic, cherry leaf roll, grapevine chrome mosaic, grapevine fanleaf, raspberry ringspot, strawberry latent ringspot, tobacco ringspot, tomato black ring or tomato ringspot viruses. Mulberry ringspot virus therefore seems to be a new nepovirus.

(B. D. Harrison)

PUBLICATIONS

COOPER, J. I. and HARRISON, B. D. (1973). The role of weed hosts and the distribution and activity of vector nematodes in the ecology of tobacco rattle virus. *Ann. appl. Biol.* 73, 53–66.

(At a site in eastern Scotland, nine common species of arable weeds were infected with tobacco rattle virus (TRV), and some of these, notably *Viola arvensis* and *Stellaria media*, comprised an overwintering reservoir of the virus. TRV was seed-borne both

in naturally and in experimentally infected *V. arvensis* (2–10%), and occasionally in other weed species. In the glasshouse at 20°C a naturally infective population of vector nematodes (*Trichodorus* spp.) kept in soil free of plants retained its infectivity for 20 wk, although few *Trichodorus* survived for this period. In the field, the incidence of TRV infection in potato (spraing disease) in plots kept free of weeds for 1·5 years was 3·4 times that in weed-infested plots but *Trichodorus* numbers did not differ appreciably between the two treatments. Presumably the virus is retained for long periods in its vectors and these feed on potato more frequently when other hosts are not available. Weeds are probably important in the long term as hosts of both TRV and its vectors, but in the short term weed control seems unlikely to prevent potato spraing because of the long persistence of TRV in vector populations.

In the field, *Trichodorus* accumulated near the interface between topsoil and subsoil, and the incidence of spraing was greatest where the topsoil was shallowest. When cucumber seedlings were exposed to virus-carrying *Trichodorus*, TRV reached a greater concentration in roots at 20°C than at 24°C, and the virus was not detected in roots at 29°C. In a sandy soil, TRV was transmitted only when the water content exceeded 15%, and at least 30% water was needed for maximum transmission. Annual records of rainfall and spraing disease suggest that spraing is most prevalent when the summer is wettest.

TRV is not confined to cultivated land. Stabilized sand dunes supporting a pure stand of *Ammophila arenaria* were colonized by *Trichodorus pachydermus*, but TRV was detected only where the plant community had enlarged to include *V. arvensis* and other dicotyledons. In such situations, TRV may be introduced in the seed of *V. arvensis*, and the movement of soil by wind probably contributes to the dispersal of *Trichodorus*).

COOPER, J. I. and HARRISON, B. D. (1973). Distribution of potato mop-top virus in Scotland in relation to soil and climate. *Pl. Path.* **22**, 73–78.

(Although more than half the potato stocks examined seemed free of potato mop-top virus (PMTV), infection was found in 66 cultivars. In the field up to 48% of plants in a stock were affected, and in the store up to 38% of tubers. PMTV-infested fields occurred in 13 Scottish counties on several types of both freely drained and imperfectly drained soil. The occurrence of the virus seems unrelated to accumulated temperature but is strongly related to annual rainfall. Little PMTV occurred where the rainfall was less than 30 in (760 mm) but its prevalence increased with increase of rainfall from 30 to 45 in (1140 mm) and above 45 inches the probability of infection was great).

COOPER, J. I. and MAYO, M. A. (1972). Some properties of the particles of three tobravirus isolates. *J. gen. Virol.* **16**, 285–297.

(When centrifuged in caesium chloride solutions, purified preparations of uncloned cultures of the CAM and PRN strains of tobacco rattle virus contained more than one component but single lesion isolates of each strain contained only one component with buoyant densities of 1·306 and 1·324 g/ml respectively. The buoyant density of the SP5 strain of pea early-browning virus was 1·310. As determined by electron microscopy the diameters of the particle and the core were respectively 23 and 5 nm for PRN and about 21·5 and 4 nm for both CAM and SP5. The mol. wt. of the single virus protein, obtained from each freshly purified virus and estimated by polyacrylamide gel electrophoresis, were 28,500 (CAM and PRN) and 24,000 (SP5). Each virus produced nucleoprotein particles of two predominant lengths and these yielded two RNA species whose mol. wt. were proportional to those lengths. The mol. wt. (x 10^{-6}) estimated by polyacrylamide gel electrophoresis were 0·7 and 2·5 (CAM), 1·0 and 2·5 (PRN) and 1·3 and 2·5 (SP5).

At pH 8·6 the electrophoretic mobility of the long particle of CAM was 16% greater than that of the short particles. However, the long particles of CAM have few if any antigenic determinants not possessed by short particles).

HARRISON, B. D. (1973). Viruses and nematodes. In *Viruses and Invertebrates*, edit. Gibbs, A. J. Amsterdam; North Holland. pp.512–525.

(A review of work on the transmission of viruses by nematodes).

HARRISON, B. D., MURANT, A. F. and MAYO, M. A. (1972). Evidence for two functional RNA species in raspberry ringspot virus. *J. gen. Virol.* **16**, 339–348.

(Preparations of top (T), middle (M) and bottom (B) component particles were made by centrifuging purified raspberry ringspot virus in sucrose density gradients. Only B particles were infective alone, but infectivity was increased by adding excess M particles to B particles. RNA obtained from purified virus was fractionated by centrifuging in density gradients and by polyacrylamide gel electrophoresis. Preparations of the larger RNA species (RNA-1, mol. wt. 2·4 x 10^6) were infective but those of the smaller species (RNA-2, mol. wt. 1·4 x 10^6) were not; infectivity of RNA-1 was greatly increased by addition of RNA-2. RNA-2 from M and B particles behaved similarly. The effect of RNA-2 was not mimicked by yeast RNA and was abolished by u.v. irradiation. The RNA-1 and RNA-2 of tobacco ringspot virus behaved like those of raspberry ringspot virus in infectivity tests, but no interaction was detected between RNA species from the two viruses. It is suggested that RNA-1 and RNA-2 carry different pieces of genetic information.

HARRISON, B. D., MURANT, A. F. and MAYO, M. A. (1972). Two properties of raspberry ringspot virus determined by its smaller RNA. *J. gen. Virol.* **17**, 137–141.

(The RNA of raspberry ringspot virus has molecules of two predominant sizes, 2·4 x 10^6 daltons (RNA-1) and 1·4 x 10^6 daltons (RNA-2). Both RNA-1 and RNA-2 are needed for infection. Hybrid isolates were obtained using inoculum containing RNA-1 from one virus strain and RNA-2 from another strain that differed serologically and symptomatologically from the first. The serological behaviour of these hybrids, obtained from single local lesions, and the systemic symptoms they induced in *Petunia hybrida*, were those of the parent contributing RNA-2 to the original inoculum. It is concluded that the RNA-1 and RNA-2 of raspberry ringspot virus (and, by analogy, of other nepoviruses) are the two parts of a divided genome, and that RNA-2 contains the cistron(s) coding for the virus coat protein and the ability to cause yellowing in *P. hybrida*.

IWAKI, M.[1], KOMURO, Y.[1] and HARRISON, B. D. (1972). Viruses isolated from narcissus in Japan V. Tomato black ring virus. (In Japanese). *Ann. phytopath. Soc. Japan* **37**, 363.

(The Scottish serotype of tomato black ring virus was found infecting narcissus in Japan).

JONES, A. T. (1973). A comparison of some properties of four strains of cherry leaf roll virus. *Ann. appl. Biol.* **74**, 211–217.

(The elm mosaic and golden elderberry strains of cherry leaf roll virus (CLRV), one from cherry and one from rhubarb were very similar in their host range, symptomatology and properties *in vitro*. However, only the rhubarb isolate infected rhubarb systemically and only the golden elderberry isolate infected *Sambucus nigra* systemically. Purified preparations of all strains contained isometric particles which sedimented as two nucleoprotein components with sedimentation coefficients of about 115*S* and 128*S*. The elm mosaic strain was the least stable *in vitro* and was the most difficult to purify. In plant-protection tests, one-way protection occurred between tomato ringspot virus and each of the four CLRV strains. However, whereas the elm mosaic, golden elderberry and the cherry strains protected against one another, they did not protect against infection with the rhubarb strain).

[1]Institute for Plant Virus Research, Chiba, Japan.

JONES, A. T., KINNINMONTH, A. M. and ROBERTS, I. M. (1973). Ultrastructural changes in differentiated leaf cells infected with cherry leaf roll virus. *J. gen. Virol.* **18**, 61–64.

(Studies of differentiated leaf cells of *Nicotiana clevelandii* infected with the virus indicated that four strains induced similar ultrastructural changes. Seven days after infection inclusion bodies were formed in palisade cells, and the cell wall was characterised by thickening and protrusions into the cytoplasm. These cell wall protrusions frequently contained virus-like particles contained within narrow tubules. Tubules were commonly found in the cell wall but rarely in the cytoplasm. Many of these ultrastructural changes resemble those reported for some beetle-transmitted viruses).

JONES, A. T. and MAYO, M. A. (1972). The two nucleoprotein particles of cherry leaf roll virus. *J. gen. Virol.* **16**, 349–358.

(Purified preparations of the golden elderberry strain of cherry leaf roll virus contain two spherical nucleoprotein components with sedimentation coefficients of 115*S* and 128*S*. Purification of the components by centrifuging several times through sucrose density gradients decreased their specific infectivity. The original specific infectivity of unfractionated virus was restored by mixing the separated components, indicating that both components are necessary for maximum infectivity. The components were indistinguishable serologically, in their extinction spectra and in their appearance in the electron microscope. Polyacrylamide gel electrophoresis of preparations from each component indicated that both contained a single protein species of 54,000 mol. wt., but that whereas the 115*S* component contained a RNA molecule of $2{\cdot}1 \times 16^6$ mol. wt. the 128*S* component contained one of $2{\cdot}4 \times 10^6$. These and other properties suggest that cherry leaf roll virus can be considered a member of the nepovirus group. The present cryptogram of the golden elderberry strain is R/1:2·1/40+2·4/43:S/S:S/*).

JONES, A. T. and MURANT, A. F. (1972). Some properties of a mechanically transmissible virus widespread in raspberry (*Rubus idaeus*) in Scotland. *Pl. Path.* **21**, 166–170.

(A virus, code-named 52V, was obtained from 16 cultivars and seedlings of red raspberry by inoculation of sap to *Chenopodium quinoa* during spring or autumn. Some raspberry plants were infected with 52V after six months in the field, and more than 50% of the plants of some cultivars were infected after four years. The virus was also obtained from *Rubus occidentalis* plants previously infected with virus from red raspberry by means of aphids (*Amphorophora rubi* and *Aulacorthum solani*). These aphids transmitted 52V from red raspberry to *C. quinoa*.

52V was transmitted by inoculation of sap to six herbaceous species but induced symptoms only on Chenopodiaceae. In *C. quinoa* sap, 52V lost infectivity after dilution to 10^{-2}, heating for 10 min at 52·5°C, storage at 18°C for 24 h or treatment with *n*-butanol to 8·5%(v/v). Preparations made by clarifying extracts with chloroform or ether followed by differential centrifugation contained a few isometric particles ca. 30 nm in diameter which may be those of the virus).

JONES, R. A. C. and HARRISON, B. D. (1972). Ecological studies on potato mop-top virus in Scotland. *Ann. appl. Biol.* **71**, 47–57.

(Plants with symptoms of potato mop-top virus (PMTV) occurred in many commercial seed stocks of Arran Pilot and Red Craig's Royal potato in Scotland but their incidence rarely exceeded 5%. In nuclear stocks of seed potatoes, most cultivars examined in 1967 and 1968 were infected at one or more locality, but infected plants did not occur in all clones or at all stages of propagation of any one cultivar. Infection of nuclear stocks resulted both from propagation on virus-infested land and from unwitting selection of infected plants to start new clones. PMTV was detected in farm soils ranging from light sands to heavy loams, in five Scottish counties. Soil was infested throughout the ploughed layer but the severity of infestation varied greatly within any one field; some sites of former potato clamps were heavily infested. PMTV was detected in field soil 12 years after potatoes were grown.

In glasshouse tests many British crop and wild plants were colonized by *Spongospora subterranea*. Within some families all species tested were moderate to good hosts (Solanaceae, Chenopodiaceae and Cruciferae), in others, species differed greatly in susceptibility (Compositae and Umbelliferae), and in a few, species were poor hosts or were not infected (Caryophyllaceae and Gramineae). Of the British crop and weed species that were moderate to good zoosporangial hosts of *S. subterranea*, only *Solanum nigrum*, potato, spinach and sugar beet were hosts of vector-borne PMTV. Potato seems to be the only important field host of PMTV in Scotland and the virus probably survives between potato crops mainly in the resting spores of *S. subterranea*. PMTV was probably first brought to Europe with potatoes from South or Central America.

MAYO, M. A. and COOPER, J. I. (1973). Partial degradation of the protein in tobacco rattle virus during storage. *J. gen. Virol.* **18**, 281–289.

(When purified preparations of the CAM isolate of tobacco rattle virus were stored the protein in the virus particles underwent limited proteolysis. Using polyacrylamide gel electrophoresis a change was observed in the mol. wt. of the virus polypeptide from 28,500 to 23,500, and in some instances a possible intermediate of 26,000 mol. wt. was detected. Polypeptides of mol. wt. 13,500, 11,500 and 9,000 were also detected after prolonged storage. Virus protein was not degraded when virus preparations containing sodium azide or antibiotics were stored, but it was degraded in the presence of azide when incubated with the supernatant fluid obtained by centrifuging preparations of virus which had been stored for several months without bacteriostatic additive. The proteolysis was probably caused by microbial exoenzyme(s). The conversion of polypeptide from mol. wt. 28,500 to 23,500 did not affect sedimentation coefficient, behaviour when centrifuged to equilibrium in caesium chloride, appearance in the electron microscope, serological reactivity, infectivity, heat stability or resistance of infectivity to pancreatic ribonuclease.

Purified virus was not affected by treatment with trypsin or chymotrypsin whereas the virus polypeptide was degraded by pronase and by papain. Papain had effects similar but not identical to those of storage. These enzyme treatments did not greatly affect infectivity or alter the appearance of virus particles in the electron microscope.

Isolate PRN was affected by storage, and by papain treatment, in the same way as isolate CAM, but much more slowly).

MAYO, M. A., HARRISON, B. D., MURANT, A. F. and BARKER, H. (1973). Cross-linking of RNA induced by ultraviolet irradiation of particles of raspberry ringspot virus. *J. gen. Virol.* **19**, 155–159.

(When purified preparations of raspberry ringspot virus were irradiated with ultraviolet light, RNA-2 ($1{\cdot}4 \times 10^6$ daltons) was converted to RNA with an electrophoretic mobility in acrylamide gels slightly less than that of RNA-1 ($2{\cdot}4 \times 10^6$ daltons). RNA-2 was affected only when it was within bottom component particles (sedimentation coefficient = 130*S*). There was no evidence of protein in the photoproduct, and it was suggested that the effect of ultraviolet irradiation was to induce the formation of dimers by cross-linking RNA-2 molecules. This therefore provides evidence that whereas some particles of bottom component contain one molecule of RNA-1, others contain two molecules of RNA-2. When a virus preparation was centrifuged to equilibrium in caesium chloride at 2°C, bottom component was resolved into two bands, but when the solution was allowed to warm only the denser band was observed. The initial resolutions in caesium chloride may reflect the different RNA contents of the two classes of bottom component particle. Cross-linking of RNA induced by ultraviolet irradiation may prove useful for determining which RNA molecules occur together within virus particles).

MAYO, M. A. and JONES, A. T. (1973). The protein and nucleic acid components of elderberry latent virus. *J. gen. Virol.* **19**, 245–252.

(The protein and nucleic acid components of elderberry latent virus (ELV) were of similar size to those of tomato bushy stunt virus (TBSV) when examined by electrophoresis in polyacrylamide gels. Estimates of the mol. wt. of the proteins were 40,000 (ELV) and 42,000 (TBSV), and the estimates of the mol. wt. of the nucleic acids were $1{\cdot}55 \times 10^6$ (ELV), and $1{\cdot}8 \times 10^6$ (TBSV). Buoyant densities in caesium chloride were 1·369 g/cm^3 (ELV) and 1·356 g/cm^3 (TBSV). To account for differences in sedimentation coefficient and in buoyant density between ELV and TBSV, and in comparison with the structure of 180+12 protein subunits proposed for TBSV, we suggest that the most likely number of protein subunits in particles of ELV is 120).

MOWAT, W. P. (1972). A necrotic disease of tulip caused by tomato bushy stunt virus. *Pl. Path.* **21**, 171–174.

(An isolate of tomato bushy stunt virus was obtained from a tulip plant affected by a necrotic disease. The isolate differs from the type strain in virulence in some experimental hosts and serologically is more closely related to a pelargonium leaf curl strain than to the type strain. When transmitted manually to tulip plants, both the tulip isolate and the type strain of tomato bushy stunt virus produced leaf symptoms indistinguishable from those caused by tobacco necrosis virus, but tomato bushy stunt isolates had effects on flowers different from those caused by tobacco necrosis virus).

MURANT, A. F., JENNINGS, D. L. and CHAMBERS, J. (1973). The problem of crumbly fruit in raspberry nuclear stocks. *Hort. Res.* **13**, 49–54.

(Crumbly-fruited mutants may arise at any stage in the production of raspberry nuclear stocks and may be unwittingly propagated in cane nurseries. The procedures for checking fruit quality of virus-tested raspberry stocks in the United Kingdom have therefore been revised to permit identification of mutant stocks as early as possible in the propagation programme).

MURANT, A. F., MAYO, M. A., HARRISON, B. D., and GOOLD, R. A. (1972). Properties of virus and RNA components of raspberry ringspot virus. *J. gen. Virol.* **16**, 327–338.

(Particles of raspberry ringspot virus were homogenous in immunoelectrophoresis tests but sedimented as three components, T, M and B, with sedimentation coefficients of 52, 92 and 130*S* respectively, and containing 0, 30 and about 44% RNA. The three components were serologically indistinguishable. In CsCl gradients, M and B were each homogeneous, with buoyant densities of 1·43 and 1·52 g/cm^3 respectively. Infectivity was associated with B. RNA extracted from the virus preparations was single-stranded and showed about 20% hyperchromicity in 0·1 M-sodium phosphate buffer at pH 7·0, indicating about 40% base-pairing. Analysis of RNA preparations by polyacrylamide gel electrophoresis revealed two predominant RNA species with mol. wt. of $2{\cdot}4 \times 10^6$ (RNA-1) or $1{\cdot}4 \times 10^6$ (RNA-2); RNA-2 was indistinguishable in mol. wt. from the RNA-2 of tobacco ringspot virus but RNA-1 migrated slightly more slowly than the RNA-1 of tobacco ringspot virus. M particles of raspberry ringspot virus contain one molecule of RNA-2; B particles contain either one molecule of RNA-1 or, probably, two molecules of RNA-2. Whereas B particles of raspberry ringspot virus were apparently homogeneous in CsCl gradients, B particles of tobacco ringspot virus formed two buoyant density classes.

MURANT, A. F., MAYO, M. A., HARRISON, B. D. and GOOLD, R. A. (1973). Evidence for two functional RNA species and a 'satellite' RNA in tomato black ring virus. *J. gen. Virol.* **19**, 275–278.

(Tomato black ring virus preparations yield three RNA species with mol. wt. $2{\cdot}5 \times 10^6$ (RNA-1), $1{\cdot}5 \times 10^6$ (RNA-2) and $0{\cdot}5 \times 10^6$ (RNA-3). RNA-1 and RNA-2 seem essential for infection and presumably comprise the genome of the virus. RNA-3 is not essential but is replicated when inoculum also containing RNA-1 and RNA-2 is used. RNA-3 may be a 'satellite' RNA, analogous to that associated with tobacco ringspot virus.

ROBINSON, D. J. (1973). Inactivation and mutagenesis of tobacco rattle virus by nitrous acid. *J. gen. Virol.* **18**, 215–222.

(The rate of inactivation of tobacco rattle virus RNA by 0·2 M-nitrous acid at pH 4·0 is comparable to that of tobacco mosaic virus RNA. In 0·0025 M-nitrous acid at pH 6·0 this rate was greatly diminished, and was slower than that of intact virus. Possible reasons for this are discussed. Methods are described for the induction of mutants of tobacco rattle virus by nitrous acid, and for the selection of temperature-sensitive mutants that are not characterized by changes in the coat protein gene).

Zoology

D. L. TRUDGILL

Dr C. E. Taylor was appointed as Director of the Institute in March 1972 and Dr T. J. W. Alphey acted as temporary Head of Section until the appointment of Dr D. L. Trudgill in October 1972.

During the year soil sampling continued as part of the NATO financed European survey of distribution of *Longidorus* and *Xiphinema* nematodes. In this report mention is also made of the first results of investigations on the nematodes associated with trees. Further electron microscopy studies of nematode anatomy are also reported. Winter surveys of raspberry cane nurseries have revealed surprisingly high levels of infestation of aphid eggs despite regular spray applications during the summer, and the presence in Scotland of the first breeding population of raspberry cane midge is recorded.

Assessment of new chemicals has been continued as well as investigations into rates and times of application of commercially available pesticides in order to achieve improved control of pest species such as raspberry beetle, raspberry midge and red spider mite.

NEMATOLOGY

NATO-financed survey

As part of the NATO financed European survey of the distribution of *Longidorus* and *Xiphinema*, a further 540 soil samples were collected from within the UK. The Science Department of Scottish Island Schools assisted, collecting 114 soil samples. *Longidorus elongatus* was found in samples from the Orkney and Shetland Islands, and in 5 samples from gardens in Islay, Mull and Skye. It seems likely that these populations were introduced with planting material from the mainland.

Nearly 2,000 soil samples have been collected and tested during the 3 years of the survey. *Longidorus* or *Xiphinema* were found in 51% of samples from grassland, 36% from arable soil and deciduous woodland, and 25% of samples from coniferous woodland. *X. diversicaudatum* accounted for 98% of the records for the genus with only a few isolated populations of *X. coxi* and *X. vuittenezi* being found. *X. mediterraneum* was not found during the survey but is known to occur in the extreme south east of England from previous samplings. *L. caespiticola* was frequently found in arable and grassland soils in Wales and southern and central England. *L. elongatus*, *L. goodeyi* and *L. leptocephalus* were relatively common in grassland and arable soil from eastern Scotland and England. Both *L. macrosoma* and *L. profundorum* were restricted to southern England and *L. attenuatus*, common in samples from East Anglia, was rarely found in samples from other parts of England.

Each sample was tested for nematode transmitted viruses, but few populations of *Xiphinema* and *Longidorus* proved to be viruliferous. Arabis mosaic virus was transmitted to bait plants in only 13 and strawberry latent ringspot in 2 of 217 tested samples containing *X. diversicaudatum*. Two further samples transmitted both viruses. Only 4 samples containing *L. elongatus* were infective with tomato black ring virus. No virus transmission was associated with other *Longidorus* species. All but 2 of the samples which proved viruliferous were from grassland sites or sites where grass had been recently ploughed up.

The distribution of the *Longidorus* and *Xiphinema* species is being related to soil type, pH, dominant vegetation, topography and climate, using the facilities of the Edinburgh Regional Computing Centre. Maps of the distribution of *Longidorus* and *Xiphinema* species are to be produced on a 10 km grid using the line printer facilities available at the Biological Records Centre, Monks Wood Experimental Station.

Tests of soil samples from prospective raspberry cane nursery sites in eastern Scotland showed 7 with *L. elongatus*, 2 with *L. leptocephalus*, 4 with both, and 1 with *X. diversicaudatum*, but none of these populations were found to be viruliferous.

(C. E. Taylor and D. J. F. Brown)

Nematodes and trees

In conjunction with the Institute of Tree Biology and funded by the National Environment Research Council the first year of investigations into the nematodes associated with trees has been completed. Over 500 samples have been analysed, 11 major genera of plant parasitic and 4 genera of fungal parasitic nematodes have been found associated with trees. Populations of nematodes were greater and more genera were found in deciduous than in coniferous forests. *Helicotylenchus*, *Rotylenchus* and *Pratylenchus* species were present in many of the samples examined but the family Criconematidae seemed to have marked preference for deciduous trees. A host range study using 11 tree species did not indicate any marked preference by any of the nematodes tested.

A survey of 6 tree nurseries showed all had moderate populations of plant parasitic nematodes. Populations of *Rotylenchus* species within 1 nursery, were similar to those that caused growth retardation of Sitka Spruce in pot tests.

(B. Boag)

Chemical control

Until recently few effective nematicides have been available to the British farmer. The cheapest and most widely used is D-D (dichloropropane-

dichloropropene) which often has to be applied several weeks before planting because of its phytotoxicity. The last decade has seen the introduction of several organophosphate and oximecarbamate nematicide/insecticides which are relatively non-phytotoxic and have some systemic action. These compounds act mainly by inhibiting acetylcholinesterase activity and nematodes are killed only slowly; this results in a gradual decline of nematode populations in field trials. Laboratory studies suggest that although high concentrations of these chemicals paralyse nematodes, in practice lower concentrations are mainly responsible for disruption of nematode behaviour and feeding patterns.

Virus vector nematodes *Longidorus elongatus* and *Xiphinema diversicaudatum* showed abnormal stylet protrusion in solutions of oxamyl (Vydate) (5 ppm). In pot tests 1·0 mg of oxamyl in 500g of soil did not decrease numbers of live *X. diversicaudatum* extracted 1 week after treatment, although numbers had decreased 70% compared with the untreated controls 1 month after treatment. Virus transmission, however, was almost completely prevented. Oxamyl (4500 ppm) applied as foliar spray to cucumber was translocated to the roots and a nematicidal exudate released into the soil. Virus transmission to plants sprayed immediately after transplanting into infested soil was not prevented although numbers of live nematodes extracted 1 month after treatment were decreased by 70% compared with the untreated control.

(T. J. W. Alphey, L. B. Forer and C. E. Taylor)

The action of phenamiphos (Nemacur), 13·4 lb a.i./ac, (15·0 kg/ha) and oxamyl 5 and 10 lb a.i./ac, (5·6 and 11·2 kg/ha) on *X. diversicaudatum* was compared in a field experiment with D-D, 330 lb/ac, (369·6 kg/ha) and with 2 experimental nematicides CGA 13527, 18·8 lb a.i./ac, (20 kg/ha) and CGA 10576 8·9 lb a.i./ac, (10 kg/ha). Oxamyl and D-D were ultimately equally effective in controlling nematode numbers, but whilst numbers of live nematodes decreased rapidly in D-D treated plots, the decrease was much slower in oxamyl treated plots. Oxamyl at 5 lb a.i./ac, phenamiphos and CGA 13527 and 10576 were less effective and did not achieve good control.

(T. J. W. Alphey and S. C. Gordon)

In a second field experiment oxamyl, phenamiphos and D-D were applied to soil containing viruliferous populations of *Trichodorus pachydermus* and *T. cylindricus*, vectors of tobacco rattle virus which causes spraing in potatoes. Application of oxamyl, 7 lb a.i./ac, (7·84 kg a.i./ha) broadcast on to the soil surface at planting time and incorporated into the ridge, decreased the incidence of spraing in potato tubers cv. Pentland Dell, from 14·0% in the untreated control to 1·4%. Phenamiphos, 13·4 lb a.i./ac, (15 kg/ha) and D-D, 200 lb a.i./ac, (224 kg/ha) were also effective in diminishing the incidence of spraing in potatoes. Populations of *Trichodorus* decreased only slowly in the oxamyl and phenamiphos plots compared with the D-D treated plots. Three months after application all treatments had decreased populations to similar low levels.

(T. J. W. Alphey and J. I. Cooper[1])

Electron microscopy

Previous observations of *Longidorus* species showed 2 distinct arrangements of oesophageal radial and stylet retractor muscles. The first group (*L. africanus*, *L. caespiticola* and *L. macrosoma*) now includes *L. profundorum* and *L. brevicaudatus*. These all have 3 sets of radial muscles throughout the length of the oesophagus. In the second group (*L. attenuatus*, *L. elongatus*, *L. goodeyi*, *L. leptocephalus* and *L. vineacola*) the radial muscles are mainly absent from the anterior oesophagus and the retractor muscles are shorter, except in *L. elongatus* where they are absent. Preliminary findings with *L. martini* suggest this species fits neither group. It is most similar to *L. elongatus* but differs by having a stoma and guide sheath arrangement similar to that found in *Xiphinema* species.

Detailed studies of the structure of the feeding apparatus of *Longidorus* species suggest the 'amorphous liquid tissue' between the guide sheath and the support membrane for the stylet protractor muscles, preserves the cylindrical shape of the support membrane. When the stylet is retracted the slack guide sheath is folded down one side making it appear keyhole shaped in cross section. On protraction 'amorphous liquid tissue' is probably displaced into the lateral lobes or reservoirs to allow for the volume changes that occur in the tissues surrounding the stylet. How virus particles are drawn into the space between the stylet and guide sheath when *L. elongatus* feeds has still to be determined.

(C. E. Taylor and W. M. Robertson)

Sites of virus retention

Previous work showed the site of retention of the Scottish strain of raspberry ring spot virus (RRV) particles in *L. elongatus* was between the stylet and guide sheath. To determine the site of retention of the English strain of RRV, transmitted by *L. macrosoma*, a non-viruliferous population was fed on *Stellaria media* (Chickweed) seedlings which had been manually inoculated with either the English or Scottish strains of RRV or left uninoculated. After 4 weeks feeding at 18°C specimens from each pot were extracted and processed for electron microscope studies. The remaining nematodes were tested for their ability to infect healthy *S. media* with English or Scottish strain of RRV. Specimens fed on seedlings infected with English or Scottish strain of RRV contained virus-like particles lining the lumen of the anterior part of the stylet and the space between the stylet and guide sheath, but only those nematodes that fed on plants containing the English strain of RRV transmitted virus to healthy *S. media* seedlings. This is the first evidence of a plant virus being retained, adsorbed to parts of the feeding apparatus,

[1]Virology Section.

but not transmitted. These results emphasise that for a nematode to act as a vector, not only must the plant virus particles be adsorbed to a specific membrane within the feeding apparatus, but for transmission the virus particles must be undamaged and the bond must be such that particles can also become detached when the nematode feeds again.

(C. E. Taylor and W. M. Robertson)

ENTOMOLOGY

Raspberry beetle

Previous investigations suggested that the control of the raspberry beetle (*Byturus tomentosus*) could be improved by relating the timing of insecticidal spray applications more closely to the behaviour and development of the insect on the host plant.

In 1972, adult beetles first emerged from the soil on 16 May and peak populations were reached by 7 June after which the numbers of beetles declined and few were found on any raspberry crops after the beginning of July. The beetles were inactive during several cool periods and as a result eggs were laid over a period of several weeks. Eggs, approximately 1·2 mm long and 0·4 mm wide, were observed attached to the flower style and to the stamen filaments, mainly to the former. In the field only rarely was there more than 1 egg per flower, but in a 'Tygan' cage where the density of adult beetles was greater, as many as 6 eggs per flower were found. Egg hatch commenced at the beginning of July, somewhere between 75% petal fall and the green fruit stage, and continued over a period of 2 to 3 weeks.

Three field trials were undertaken to examine the control of larval infestations of the fruit in relation to the timing of insecticide applications. Applications of fenitrothion at 7·5 fl. oz a.i./100 gal/ac (0·53 1 a.i./1123 1/ha) were made in combinations of treatments at 80% petal fall, early green fruit or first pink fruit stage. The rate of application was increased to 10·75 fl. oz a.i./100 gal/ac (0·75 1 a.i./1123 1/ha) when only 1 spray was applied. The interval between sprays at each site was 7 to 9 days.

Single spray applications at early green fruit or first pink fruit stage, when most of the eggs would have hatched, were more effective in preventing larval infestations of fruits than a single spray applied at 80% petal fall. Two or 3 sprays were more effective than a single spray in most instances, but 3 sprays were not significantly better than 2 sprays. Although 2 sprays gave slightly better control than a single post flowering insecticidal spray, the differences were not sufficient to suggest that in commercial plantations there is a need for more than 1 spray, applied between the green fruit and first pink fruit stage i.e. 9–12 days before the first harvest (see Annual Report for 1971).

DDT was withdrawn for use against raspberry beetle because of its persistence and possible contamination of harvested fruits. Fenitrothion and malathion are suitable replacements for DDT, but have effective persistence of only 6 to 7 days. It seemed likely that an insecticide with slightly greater

persistence might give better control. The more persistent compound PP484 (25% w.p., Plant Protection Ltd.) at rates of 1 or 2 lbs product/ac (1·12 kg or 2·24 kg/ha) was compared with fenitrothion at 15 fl. oz product/ac (1·05 1/ha) on Malling Promise and Malling Enterprise raspberries. Single applications of each insecticide were made at 80% petal fall and the degree of control estimated by examination of fruit for larvae at harvest. Both PP484 at 2 lbs/ac and fenitrothion gave slightly greater control than PP484 at 1 lb/ac but little advantage was gained by using an insecticide with only marginally greater persistence than fenitrothion.

In another trial PP484 at 2 lbs/ac (2·24 kg/ha) was compared with carbaryl (85% w.p.) at 14 oz/ac (0·89 kg/ha), fenitrothion (50% e.c.) at 22·5 fl. oz/ac and chlorpyrifos (40·8% e.c. Dursban M-3019, Dow Chemical Co.) at 0·1% and 0·05% (2 and 1 lb/ac). Single sprays were applied at 80% petal fall, except for chlorpyrifos which because of late delivery was applied 6 days later at the early green fruit stage. Fenitrothion, carbaryl and PP484 gave equally good control. Both chlorpyrifos treatments were slightly better than the others but this was perhaps due to later application, supporting the earlier suggestion that insecticidal sprays produce greatest control of raspberry beetle if applied between the green fruit and first pink fruit stage.

(C. E. Taylor and S. C. Gordon)

Raspberry aphids

To decrease aphid borne virus infestation, Scottish Nuclear Stock Association raspberry nurseries are sited away from the main raspberry growing areas and are sprayed monthly during the summer with systemic insecticides. For the past 3 years raspberry canes from S.N.S.A. nurseries have been examined in winter for aphid eggs to assess the success of these measures in preventing aphid infestation. In 1970 aphid eggs were found on canes from 9 of 14 nursery blocks examined (range 10–100% canes with eggs); in 1971 8 blocks out of 10 examined had eggs (range 5–95%) and in 1972 of 11 blocks examined 7 had canes on which over-wintering aphid eggs were found (range 1–68%). Eggs were normally few in number but almost all eggs were found on the bottom 20 cm of cane, the portion of cane normally retained for planting.

Although some of these eggs might have been laid by aphids migrating into the plantations late in the season, there is clearly scope for improved aphid control. The decrease in numbers of overwintering eggs found in 1972 may reflect an increasing awareness of need for more careful timing and application of insecticides to obtain good aphid control.

(S. C. Gordon)

Potato aphids

Whilst investigating the control of *Trichodorus* nematode species using chemicals with systemic, nematicidal and insecticidal properties, their effect on aphid populations was also recorded. The chemicals tested were oxamyl

(Vydate) at 7·0 and 3·5 lbs a.i./ac (7·84 and 3·92 kg/ha), phenamiphos (Nemacur) at 13·41 lb a.i./ac (15 kg/ha) and 2 experimental compounds CGA 13527 at 18·78 lb a.i./ac (20 kg/ha) and CGA 10576 at 8·94 lb a.i./ac (10 kg/ha). All were applied to potato ground at planting and incorporated into the ridge. Aphid numbers when sampled 3 months after treatment were decreased, compared with the untreated control, by more than 85% by the higher rate of oxamyl and 75% by phenamiphos. Oxamyl at 3·5 lbs; CGA 13527 and 10576 produced smaller decreases. Estimates of aphid numbers 4 months after treatment suggested that phenamiphos and both rates of oxamyl had decreased aphid numbers by more than 80% compared with the untreated control. Clearly oxamyl and phenamiphos are translocated to the foliage where their effects persisted for several months.

(T. J. W. Alphey and A. T. Dickson)

Aphid non-persistent viruses

Transmission experiments showed that *Myzus persicae* acquired tobacco severe etch virus in 10 sec probes on infected *Nicotiana tabacum* L. cv. Xanthi-nc. In a single probe adult or larval *M. persicae* acquired sufficient virus to inoculate up to 5 successive test plants in a series of 10 sec inoculation probes. Electron microscopy of thin sections of *M. persicae* given short acquisition probes on infected leaf tissue showed filamentous virus-like particles lining about 20μ of the distal part of the maxillary food canal.

(C. E. Taylor and W. M. Robertson)

Raspberry cane midge

Raspberry cane midge (*Thomasiniana theobaldi*) is a common pest of raspberries in England, and in association with the fungus *Leptosphaeria coniothyrium*, it causes a disease called 'cane blight.' Although the presence of cane midge has been suspected on planting material imported from England and has occasionally been found in plantations there are no published records of its occurrence in Scotland. In September 1972 an infestation was discovered on raspberries, cv. Glen Clova, at the Institute and this represents the first record of a breeding population of *T. theobaldi* becoming established in Scotland. Sixty five feeding lesions were examined for fungi but although *Alternaria* spp. were regularly isolated, no *L. coniothyrium* was found.

(S. C. Gordon and A. J. Hargreaves[1])

Raspberry mite

Raspberry mite (*Eriophyes gracilis*) is widespread in raspberry plantations in Scotland, but normally populations are small. Shelter increases mite numbers and a plot of Malling Jewel raspberry behind an artificial windbreak had populations 4 times greater than that of the surrounding plots. In such a situation mite numbers can be sufficient to cause damage and the terminal buds of canes may be killed with the result that lateral growth is promoted and the cane becomes bushy and difficult to manage.

A sheltered plantation with a large mite population was chosen to test the effects of 3 acaricides on mite numbers and yield. Endosulfan, vamidothion and tricyclohexyltin hydroxide (Plictran, Dow Chemical Co.) applied as sprays on 20 April and again on 15 May at the recommended rates, 40 and 20 fl. oz/ac and 12 oz w.p./ac (2·81 and 1·40 l/ha and 0·84 kg/ha) respectively, were compared.

Yields and numbers of fruits in the first year were not significantly different, but mite damage was greatly decreased in plots sprayed with vamidothion. The overwintering populations of mites are still being determined and the experiment is being continued for an assessment of fruit yields in the second year when greater differences might be expected.

(S. C. Gordon)

Strawberry red spider mite

Strawberry red spider mite (*Tetranychus urticae*) populations can increase sufficiently to cause damage in years with warm dry springs. Populations in 1972 remained low because of the cool wet spring but a preliminary investgation showed that mites could be adequately controlled by dimeton-s-methyl, dicofol, 1, 5-di-(2,4- dimethylphenyl)-3-methyl-1-1, 3, 5-triazapenta-1,4-diene (Mitac, Boots) and tricyclohexyltin hydroxide (Plictran 25w, Dow Chemical Co.) applied in mid and again in late May.

(S. C. Gordon)

PUBLICATIONS

PARROTT, D. M.[1] and TRUDGILL, D. L. (1972). The resistance of hybrids of *Solanum tuberosum* spp. *andigena* and *S. multidissectum* to *Heterodera rostochiensis* Pathotype E. *Pl. Path.* **21**, 86–88.

(Some F_1 progeny of crosses between resistant and susceptible cultivars of potato contain resistance to *Heterodera rostochiensis* pathotype E (British notation) supplementary to that conferred by genes H_1 and H_2. This resistance in hybrid K2/6 was equal to that of its parent D40 and could be incorporated in a useful resistant cultivar).

TAYLOR, C. E. and ALPHEY, T. J. W. (1973). Aspects of the systemic nematicidal control of *Longidorus* and *Xiphinema* virus vector nematodes. *Ann. appl. Biol.* **75**.

(This paper reports laboratory experiments which form part of an investigation on nematicidal effectiveness and mode of action of Du Pont 1410 in relation to the control of *Longidorus elongatus* or *Xiphinema diversicaudatum* and the viruses they transmit. Results show that Du Pont 1410 applied to the soil decreased nematode numbers and prevented virus transmission by residual populations. Experimental evidence is presented to show that following foliar application Du Pont 1410 is translocated downwards in plants and that a nematicidal root exudate is produced in the soil).

[1]Mycology Section.

[1]Based on work done at Rothamsted Experimental Station.

TAYLOR, C. E. and ROBERTSON, W. M. (1973). The structure and musculature of the feeding apparatus in *Longidorus* and *Xiphinema*. The Longidoridae: Workshop manual produced by the Nematology Group, Association of Applied Biologists.

THOMAS, R. J.[2] and BOAG, B. (1973). Epidemiological studies on gastro-intestinal nematodes of sheep. IV. Control of parasitism in lambs on contaminated pasture. *Res. vet. Sci.* **14**.

TRUDGILL, D. L.[1] and PARROTT, D. M. (1972). Disc electrophoresis and larval dimensions of British, Dutch and other populations of *Heterodera rostochiensis* as evidence of the existence of two species, each with pathotypes. *Nematologica* 18, 141–148.

(Larval measurements, female colour and the results of electrophoresis in polyacrylamide gel indicate that *H. rostochiensis* should be split into two species. Each of these species contains pathotypes, so a modified scheme of pathotype nomenclature is suggested. Although we used different test hosts, our results indicate that Dutch and British pathotypes A are identical, and the Dutch pathotype D is the same as the British E. Populations such as the Dutch pathotypes B and C, and a population from Bolivia, which all have pathotype A characteristics but can reproduce on ex *andigena* hybrids, have not so far been found in Great Britain).

TRUDGILL, D. L.[1] (1972). Electrophoresis of proteins from different populations of the potato cyst nematode. *Ann. appl. Biol.* **71**, 278–280.

(Populations of potato cyst nematode from South America, India and Europe were compared with British populations. Larval stylet lengths, female colour, ability to reproduce on resistant potato cultivars and protein patterns after electrophoresis in polyacrylamide gel were determined. The suggestion that there are two species of potato cyst nematode each with pathotypes was supported. Populations from Holland, Bolivia and Venezuela were unusual in having yellow females, shorter larval stylet and being able to reproduce on ex *andigena* hybrids with gene H_1. Gene H_3 from *S. tuberosum* ssp. *andigena* prevented the reproduction of the potato cyst nematode species with white females).

TRUDGILL, D. L.[1] and PARROTT, D. M. (1972). Effects of growing resistant potatoes with gene H_1 from *Solanum tuberosum* spp. *andigena* on populations of *Heterodera rostochiensis* British pathotype A. *Ann. appl. Biol.* **73**, 67–75.

(Pure pathotype A populations of *Heterodera rostochiensis* produce a few females on ex *andigena* hybrids with the H_1 gene for resistance. As the proportion of larvae able to become female on ex *andigena* hybrids was not increased by reproducing the nematodes on such hybrids for 3 years, these females seem not to be genetically different from the rest of the population. The proportion increased rapidly when the initial population contained a few pathotype (species) E nematodes but again no increase in the proportion of pathotype (species) A larvae able to become female on ex *andigena* was detected and pathotype E replaced pathotype A).

WOODFORD, J. A. T.[3] (1973). The climate within a large aphid-proof field cage. *Ent. exp. & appl.* **16**.

(A large field cage, used to confine winged aphids, reduced air movement by over 85% and light intensity by 58%. Daily temperature fluctuations were reduced inside the cage. Cumulative temperatures exceeded those outside because the cage retained heat at night).

[1]Based on work done at Rothamsted Experimental Station.
[2]Based on work done at University of Newcastle-upon-Tyne.
[3]Based on work done at Cambridge University.

WOODFORD, J. A. T.[3] (1973). The flight activity and movements of *Myzus persicae* (Sulzer) and *Brevicoryne brassicae* (L.) in a field cage. *J. appl. Ecol.* **10**, 811–832.

(Large proportions of winged *M. persicae* flown for 5 or 10 h in a flight chamber, took off again after settling on potato, cauliflower or sugar beet. Many alatae, caged on plots of potato and cauliflower, remained mobile and flight-worthy for 4–5 days. Fewer alate *M. persicae* settled on cauliflower than *B. brassicae*; consequently *M. persicae* remained active longer than *B. brassicae*. The significance of subsequent flight activity for plant virus epidemiology is discussed).

[3]Based on work done at Cambridge University.

Scottish Horticultural Research Institute Association

The Association was formed in August 1967, to promote interchange of information between the Institute and the horticultural industry; membership is on an individual or corporate basis. A Bulletin is published at indefinite intervals but usually there are two issues per year and the articles are intended to communicate the results of experimental work, sometimes at an incomplete stage, between research workers amd growers. It also publishes papers presented at symposia organised for the Association.

During the year members of the Association were conducted round many of the fruit and vegetable experiments when meetings were organised on their behalf. Also, a symposium in November attracted an audience of 130 when speakers from the wholesale produce market, advisory and development service, and research service, read papers on the transport, handling and marketing of raspberries and strawberries.

The number of members has remained almost unchanged at about 250 and a wide cross section of the agricultural industry are included. Among the membership there is a preponderance of Scottish growers and farmers but with an increasing interest from south of the border. There is a good representation of the agricultural support industries as typified by chemical, seed and processing firms.

Bulletin No. 6 (June, 1972)

Papers presented at a symposium on 'The efficient use of herbicides' held by the Association on 21 October 1971.

Soil conditions and the efficiency of herbicides *by* D. S. C. Erskine (The Edinburgh School of Agriculture), pp. 2–6.

Spraying machinery and herbicide application *by* H. J. Nation (NIAE, Silsoe), pp. 7–15.

Weed seeds in the soil *by* H. A. Roberts (NVRS, Wellesbourne), pp. 16–19.

The control of couch grass *by* G. W. Cussans (WRO, Yarnton, Oxford), pp. 20–25.

Herbicide management *by* H. M. Lawson, pp. 26–30.

Meteorological Records 1972

D. K. L. MACKERRON AND J. L. MILNE

MYLNEFIELD

Wind

Total wind-run for the year was near average, the unusually high wind runs during January, June and November being offset by below average values for the early spring and autumn months. On 5 December there was a gale from WSW gusting up to 124 km per hour, but little damage was caused at Mylnefield.

Temperature

The first 4 months of the year were milder than usual, particularly February. Mean air temperatures for the year, however, were only marginally above average as both June and September were appreciably cooler than usual.

Rainfall

January and February were particularly wet months, the former receiving its highest rainfall since records began at Mylnefield in 1954. In contrast the period July to November inclusive was exceptionally dry, most notably during September and October when total precipitation was the lowest recorded for these months in the Dundee area since 1923.

Sunshine and solar radiation

Total hours of bright sunshine was down on the 1954-68 average by 64 hours which is approximately a 5% reduction. This was due to some particularly low values during the first half of the year, the January and February figures being the lowest in the Dundee district since 1948, and 1914 respectively.

Total receipt of solar radiation in 1972 was 11% lower than the average for the 3 preceding years.

MYLNEFIELD 1972

Month	Temperature (Centigrade)										Soil Temperature at 30cm depth		Ground frost days	Rainfall		Solar Radiation			Wind Run
	Mean of daily maxima	Deviation from average*	Mean of daily minima	Deviation from average*	Accumulated Temperature Above 6°C	Accumulated Temperature Below 6°C	Highest Max. Temp.	Highest Max. Date	Lowest Min. Temp.	Lowest Min. Date	Mean	Deviation from average*		Millimetres	Deviation from average*	Sunshine Hours	Sunshine Deviation from average*	Mean daily radiation mW h cm^{-2}	Kilometres
January	5.6	+0.5	1.2	+1.7	8	76	10.6	23	−10.5	31	4.5	+2.6	15	107.7	+57.7	31	−27	37	12301
February	6.0	+0.4	2.9	+3.3	3	56	9.1	3	−8.5	1	3.9	+1.7	20	83.3	+38.8	30	−45	61	7257
March	8.3	+0.3	2.1	+0.3	28	48	15.5	23	−0.8	13, 16	5.2	+1.1	16	43.5	−3.0	108	+8	236	9937
April	12.0	+0.5	4.1	+0.8	83	13	19.5	25	1.0	15	7.9	+1.0	12	34.4	−8.3	155	−5	323	10714
May	13.3	−0.6	5.8	+0.2	129	7	16.5	17	1.6	16	9.9	−0.2	7	54.8	+0.7	136	−52	310	10263
June	15.1	−1.9	6.9	−1.6	161	2	19.7	16	2.5	3	12.3	−1.3	2	48.8	−2.5	149	−27	349	9768
July	18.6	+0.5	9.2	−0.6	258	1	25.0	14, 15	5.0	9	14.7	−0.2	2	29.1	−38.5	223	+58	385	7343
August	18.3	+0.6	9.3	−0.4	255	0	22.9	24	3.8	11	14.4	−0.1	0	52.8	−26.2	164	+18	355	6585
September	15.1	−0.8	6.6	−1.9	164	8	22.5	1	−0.2	8	12.8	+0.1	6	6.3	−57.2	143	+26	268	5396
October	13.4	+0.7	6.3	+0.2	135	6	18.1	4	1.4	21	10.1	+0.4	6	10.8	−52.4	86	−7	131	7697
November	8.3	0.0	1.3	−0.9	36	62	16.7	6	−4.5	18	5.2	−0.3	23	27.7	−33.3	67	+7	69	10455
December	6.9	+1.1	1.5	+1.1	15	69	12.1	14	−5.5	9	4.0	+0.8	22	55.6	−18.1	27	−18	30	8487
Year	11.7	+0.1	4.8	+0.2	—	—	—	—	—	—	8.7	+0.4	131	554.8	−142.3	1319	−64	213	106203

*Recorded at Mylnefield 1954-1968

AUCHINCRUIVE 1972

Month	Temperature (Centrigrade)								Soil Temperature at 30 cm depth		Ground frost days	Rainfall		Sunshine	
	Mean of daily maxima	Deviation from average*	Mean of daily minima	Deviation from average*	Highest Max. Temp.	Highest Max. Date	Lowest Min. Temp.	Lowest Min. Date	Mean	Deviation from average*		Millimetres	Deviation from average*	Hours	Deviation from average*
January	5·9	−0·2	1·7	0·0	10·0	11	−8·1	31	5·2	+1·3	15	60·0	−21·5	59	+ 3
February	6·8	+0·4	1·0	+0·6	9·3	23	−2·2	20	4·1	+0·5	24	43·6	−4·7	71	− 7
March	9·1	+0·3	2·5	+0·1	16·9	17	−3·2	12	5·5	+0·6	12	46·6	−7·0	103	− 2
April	11·1	−0·3	3·8	−0·1	12·9	21	−1·1	23	8·2	+0·9	11	131·1	+79·7	160	+ 7
May	13·2	−1·1	6·4	+0·3	16·7	20	1·1	16	10·3	0·0	3	58·1	+2·1	149	−45
June	14·2	−3·0	7·3	−1·8	17·2	17	2·9	9	12·3	−0·8	2	107·3	+42·2	178	− 4
July	18·1	+0·1	10·3	−0·1	26·1	17	6·7	5	14·9	+0·5	0	51·5	−34·5	212	+53
August	16·6	−0·9	9·8	−0·4	20·2	26	4·4	15	14·5	+0·3	0	34·4	−60·8	151	+ 2
September	15·0	−1·0	6·6	−2·5	19·6	2	−0·4	9	12·7	−0·2	1	21·0	−87·0	162	+45
October	13·9	+0·8	5·6	−1·3	20·3	5	−3·4	21	10·7	+0·1	6	37·6	−67·6	125	+42
November	8·3	−0·7	2·7	−0·4	15·7	6	−4·9	18	7·4	−0·4	12	122·4	+42·0	47	−11
December	8·5	+1·5	3·5	+2·0	12·6	17	−1·7	25	6·0	+0·7	10	69·6	−24·4	33	− 6
Year	11·7	−0·4	5·1	−0·3	—	—	—	—	9·3	+0·3	96	788·2	−141·5	1450	+77

*Recorded at Weather Station, Department of Plant Pathology, Auchincruive, 1954–1968.

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