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The Scottish Horticultural Research Institute

24th Annual Report for the year 1977

The Scottish Horticultural Research Institute
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Contents

- 4 Members of Governing Body
- 5 Staff
- 9 General Report
- 25 Index to Projects
- 29 Crops Research
- 49 Plant Breeding
- 68 Mycology
- 90 Virology
- 107 Zoology
- 118 Estate
- 121 Information Services
- 124 Scottish Horticultural Research Institute
Association
- 126 Meteorological Records
- 130 Publications
- 136 ARC Institutes
- 137 Abbreviations
- 138 Map of approach routes

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Deputy Director B. D. Harrison*, B.SC., PH.D.

Crops Research

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J. S. Wiseman, S.D.H.

Assistants Mrs. Janet E. Brinklow

Mrs. Jeanette McD. Brown

D. G. Cathro

D. Crabb

Jane E. Kettles

G. C. Nicol

R. N. Wilson

Mrs. Gladys Wright

Plant Breeding

Acting

Head of Section D. L. Jennings, B.SC., PH.D.

M. M. Anderson, N.D.H., S.D.H., D.H.E.

Eleanor Carmichael

A. Dale, B.SC., PH.D.

J. R. T. Hodgkin, B.SC., PH.D.

A. J. Redfern, B.TECH.

P. Smith, B.SC.

Barbara M. M. Tulloch, S.D.H.

A. B. Wills, B.SC., M.S., PH.D.

Mrs. Eveline M. Wiseman

Assistants J. N. Dick

Mrs. Norma Dow

T. P. Reid

Judith Thomson

West of Scotland Unit (Auchincruive)

Officer-in-Charge H. J. Gooding, B.SC., PH.D., F.L.S.

D. MacIntyre, B.SC., M.SC.

R. J. McNicol, B.SC.

Assistant T. J. Edwards

Attendant Mrs. Sarah Borland
Secretary Janet B. Henry
Estate J. Andrews
H. McNeillie
C. A.Reid

Mycology

Head of Section R. A. Fox*, B.SC., B.AGR., M.I.BIOL.
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.
Diana M. Kennedy, B.SC.
R. Lowe
G. D. Lyon, B.SC., M.SC., PH.D., D.I.C.
Isabel G. Montgomerie, B.SC., PH.D.
M. C. M. Pérombelon, B.SC., M.SC., P.H.D.
D. A. Perry, B.SC., PH.D.
B. Williamson, B.SC., M.SC., PH.D.
H. M. Wilson

Assistants Mrs Alison M. Campbell
Mrs Norma M. Colliar
Frances Devaney
Mrs Lisbeth J. Hyman
Mrs Elizabeth J. Lindsay
Naomi A. Nyananyo
Alison Savege

Attendant Mrs Joan Jenkins

Virology

Head of Section B. D. Harrison*, B.SC., PH.D.
H. Barker, B.SC.
J. Chambers, B.SC.
A. T. Jones, B.SC., PH.D.
M. A. Mayo, B.SC., PH.D., M.I.BIOL.
W. P. Mowat, B.SC., DIP.AGR.SCI.
A. F. Murant, B.SC., PH.D.
J. H. Raschké
I. M. Roberts, DIP.RMS.
D. J. Robinson, M.A., PH.D.
Mrs Margaret Taylor, B.SC.

Assistants Margot E. Anderson
Erica M. Bell
Linda C. Cable
Mrs Eleanor M. W. Russell

Attendant Mrs Rena Reid

Zoology

Head of Section D. L. Trudgill*, B.SC., PH.D.
T. J. W. Alphey, B.SC., PH.D.
B. Boag, B.SC., PH.D.
D. J. F. Brown B.A.

Zoology—*continued*

S. C. Gordon

W. M. Robertson

J. A. T. Woodford*, M.A., PH.D.

Assistants Mrs Sylvia R. Dick
Mrs Sandra A. Husband
Mrs Sheena S. Lamond
Mrs Irene E. Raschké

Estate

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Experiments Officer G. Wood, B.SC., PH.D

Supervisors R. W. Reid

R. D. Taylor

A. Bruce

C. C. Carrie

W. C. W. Jolly

A. D. Lindsay

A. W. Mills

R. Ogg

D. S. Petrie

A. Pirie

D. G. Pugh

J. Small

E. L. Allsworth

D. C. Cameron

E. A. Davidson

E. A. M. Gardiner

J. P. T. Grant

W. W. Killoh

P. T. Logie

L. A. McNicoll

A. D. MacDonald

N. McInroy

J. Mason

Mandy Morris

B. D. Robertson

F. Robertson

D. R. Simpson

A. S. Spink

G. Wilson

Farm Workshop

W. R. S. Batchelor

G. W. Pollock

Maintenance

Head of Section J. H. Couttie

J. R. Caithness

A. Davidson

A. Low

R. MacDonald

G. Merchant

D. J. G. Redford

L. A. Swan

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<i>Stores</i>	Mrs Anne L. Bertie J. F. McLean

* Honorary Lecturer in the University of Dundee.

† Honorary Senior Lecturer in the University of St. Andrews.

General Report

C. E. TAYLOR

As in previous years, this report presents a summarised statement of the research work that has been undertaken at the Institute during the year. The framework of the research programme remains unchanged and is broadly in accord with the recommendations of the Joint Consultative Organisation (JCO) and the requirements identified within the Research Packages approved and financed by the Department of Agriculture and Fisheries for Scotland. However, unexpected problems that have arisen in crop situations, the variable and indeterminate rate of scientific progress, or changes in outlook in the agricultural industry, have individually or together resulted in some modifications in the research programme—an intensification of research input in particular areas and a diminution in others.

The widespread and devastating occurrence of the raspberry cane midge in Scotland in recent years is an example of the unexpected crop problem. As indicated in the report of the Zoology Section, entomological monitoring of the raspberry crop had given some indication as early as 1972 of the potential hazard of the pest in Scotland, and biological investigations started then ensured that adequate and effective control measures are now available. Another pest of raspberry that has been revealed by critical experimentation is the nematode *Pratylenchus penetrans*, which under certain circumstances can cause considerable decreases in the growth of canes. Chemical treatment of the soil before planting and the use of uninfested planting stocks avoid the consequences of this pest.

Crown gall is a widespread bacterial disease which is a problem in many parts of the world. In Scotland, it was at one time not uncommon when the raspberry acreage was dominated by the cultivar Malling Promise and its occurrence was reported in most years. However, with the replacement of Malling Promise by cv. Malling Jewel, apparently less susceptible or less liable to symptom expression, the problem largely disappeared. Recently however, it has reappeared notably among some of the more vigorous new cultivars. In the Americas it has been recorded as affecting especially fruit quality, and this year in Scotland we have had reports of unusual outbreaks affecting also yield. In general in cane fruit it is more a problem of certification in that it renders unsaleable otherwise satisfactory planting materials.

Some of our research resources have been diverted to an investigation of biological and chemical control of the disease.

Cane vigour is generally considered to be a useful attribute in raspberry cultivars but has become something of a problem in recent years with the introduction of very vigorous cultivars such as Glen Clova. Excessive growth of young cane causes problems in summer by restricting access in the alleyways and hiding the fruit during harvest, and in winter by increasing labour demand for cane handling and tipping operations; very tall canes are also easily damaged by wind or the passage of pickers and tractors. Experimentation in the Crops Research Section has resulted in the development of a chemical application technique which controls cane vigour, thus avoiding the problems and diverting the excess vigour into fruit production. This treatment allows some cultivars, such as Glen Clova, to be grown to their full potential; it is also incidentally beneficial in depriving the cane midge of its egg laying sites at a critical time in its life cycle.

Plant breeding has of necessity to be based on long term objectives. Black currants have never been an important commercial crop in Scotland mainly because of the yield losses due to frost or low temperatures at flowering time or to uneven ripening of fruit on the strig ('running off'); problems that can equally apply in England. The breeding programme initiated some years ago with the primary objective of overcoming these problems has so far produced two named cultivars, Ben Lomond and Ben Nevis (Ann. Rpt 1974), which have yielded well in 1977 when other cultivars succumbed to the particularly severe spring frosts. Other improved cultivars will follow these and should provide the basis for stable black currant production to meet home demands as well as the considerable potential in markets overseas. The strawberry and raspberry breeding programmes continue to meet the long term objectives of increased yield and improved quality, and in recent years have directed attention to the requirements for mechanical harvesting of the crops.

Our interest in field beans stems from its attraction as a crop with high nutritive value in both energy and protein. However, yields are generally inconsistent and unreliable and our investigations have been directed towards identifying and overcoming this major disadvantage to crop production. Although present levels of production cannot compete economically as a source of vegetable protein with imported soya bean, it has been shown that relatively high yields can be obtained in Scotland, and whilst there remain some questions about yield variability there seem prospects of re-establishing field beans as a major crop, particularly with the introduction of new cultivars from the plant breeding programmes. Our research interests in field beans are identified in this report, but a wider view was presented at a symposium on the 'Production, Processing and Utilisation of the Field Bean (*Vicia faba* L.)' held at the Institute in March, the proceedings of which were subsequently published in the SHRI Association Bulletin No. 15.

Whilst research on field beans may be considered to be an attempt to promote change, that on the production of virus tested stocks of narcissus is firmly identified with an expanding sector of the horticultural industry in Scotland. Exports of narcissus bulbs have continued to increase, but despite the high health status achieved through the certification scheme administered by the Department of Agriculture and Fisheries for Scotland, research has shown that many plants without obvious symptoms may be infected with one or more viruses. A scheme for the introduction of narcissus clones propagated from virus free plants was therefore started several years ago and has now reached a stage where the first stocks of bulbs will be handed over to the Scottish Nuclear Stocks Association (Flower Bulbs) Ltd., formed in 1976 expressly for the purpose of handling this material. Each year quantities of virus-tested bulbs of selected narcissus cultivars will be passed to the SNSA (FB) for further propagation in the field before being released for commercial production.

Governing Body

Professor J. A. Macdonald, University of St. Andrews, and Professor P. E. W. Weatherley, University of Aberdeen, retired from the Governing Body. Both have been associated with the Institute for many years and they are warmly thanked for their services. The Secretary of State has appointed Professor P. G. Jarvis, Department of Forestry and Natural Resources, University of Edinburgh, and Professor D. H. N. Spence, Department of Botany, University of St. Andrews, to be members of the Governing Body to serve with other Governing Body members who have been re-appointed for a period of 3 years from 1 April, 1977. Mr A. Gordon Porter was appointed as Chairman of the Governing Body when this office was relinquished by Professor N. F. Robertson. Professor Robertson is thanked for his generous and expert counselling as Chairman and for his continuing interest in the Institute by remaining as a member of the Governing Body.

Appointments

Miss Margaret Blessing was appointed in May as Scientific Officer in the Virology Section.

During the year the following Assistant Scientific Officers were appointed:

T. J. Edwards	West of Scotland Unit
Mrs Lisbeth Hyman	Mycology Section
Naomi Nyananyo	Mycology Section
Alison Savege	Mycology Section
Jane E. Kettles	Crops Research Section
Mrs Gladys Wright	Crops Research Section

Mrs Joan Jenkins was appointed as Laboratory Attendant in the Mycology Section in August, P. Logie joined the Estate Section in March as an Apprentice Experimental Worker and J. C. Goddard joined the West of Scotland Unit as an Experimental Worker Grade I. Miss Pamela T. Reid joined the Administration Section at Mylnefield in November as a Shorthand Typist.

Resignations

Mrs Aileen M. Hutcheson	SO, Virology Section
Sheila M. Royle	SO, Crops Research Section
Ann C. Warne	SO, Virology Section
Evelyn M. Ballantine	ASO, Mycology Section
Elizabeth Lowe	ASO, Crops Research Section
Mrs Moira E. Mackenzie	ASO, Mycology Section
Mrs Marjorie Morrison	ASO, West of Scotland Unit
Kathleen R. Myles	ASO, Crops Research Section
Helen Moncrieff	Shorthand Typist, Administration
A. Ryce	Retiral, Maintenance Section
W. Culloch	Apprentice, Estate Section

Promotions

T. W. Hegarty	}	SSO to PSO
A. T. Jones		
M. A. Mayo		
R. Thompson		
W. M. Robertson		

Awards

D. J. F. Brown	B.A., Open University
A. El B. Ibrahim	M.Sc. University of Dundee
L. F. Salazar	Ph.D., University of Dundee
R. D. Taylor	Silver Jubilee Medal

Retirements

Dr C. North retired on 30 September. He was appointed in 1953 as Experimental Officer in the Horticultural Botany Department and following re-organisation within the Institute took charge of the Vegetable Crops Section. In 1966 he was appointed Head of the newly formed Plant Breeding Section and in 1970 took on the additional duties of Deputy Director.

Besides general supervision of the breeding of soft fruit and vegetables, Dr North was personally involved in lily breeding in which he achieved notable success and international recognition.

Mr A. Ryce retired in February after serving for 8 years in the Maintenance Section.

Research Students

R. M. Brook continued an ARC Research Studentship studying factors controlling yield and yield components in field beans.

C. J. Wright completed the final year of his ARC Research Studentship, studying the nature and effects of the competition which exists within the raspberry plant between its vegetative cane and its fruiting cane.

A. El B. Ibrahim returned to the Sudan after completion of his M.Sc. studies on seed physiology. This project was financed by a British Government Technical Assistance Training Award.

C. Hoogenboom, a graduate of the Agricultural University at Wageningen, is spending five months from September studying factors affecting early initiation and the location of flowering in field beans.

(Crops Research Section)

D. R. Ellerton was appointed to an ARC Research Studentship to study problems of establishment of low vigour seeds with particular reference to the effects of the soil microflora.

T. M. O'Neil was appointed to an SRC CASE Research Studentship (jointly with the University of Stirling) to study host-pathogen interactions in smoulder of narcissus.

(Mycology Section)

F. Bem and Lesley Torrance continued their studies on viruses of umbelliferous plants and grasses, respectively. L. F. Salazar completed his studies on potato viruses and returned to the International Potato Center, Peru in July. R. L. S. Forster, who is supported by the New Zealand National Research Advisory Council, arrived in April to work on genetical variants of nepo-viruses.

(Virology Section)

C. S. Aveyard continued studies on the control of potato aphids in relation to spread of virus.

(Zoology Section)

Sandwich Course Students

R. M. Shields (University of Bath) assisted from April to September with research on the fractionation of virus-infected leaf tissue.

(Virology Section)

S. Mahechani (Dundee College of Technology) from April to September assisted with research assessing the interaction between nematode damage and uptake of nutrients.

(Zoology Section)

Visiting Workers

Miss P. Haigh of Asmer Seeds Ltd., Miss J. Palmer of Elsoms Seeds Ltd., and Miss A. Balver of Beemsterboer Ltd., Holland, received training in sib detection in *Brassica* hybrids by isoenzyme electrophoresis.

Miss M. Spaargaren and Mr E. de Kuyper, plant breeding students of Wageningen University, Holland spent 6 months and 3 months respectively working on plant breeding problems in *Brassica* and *Rubus*.

(Plant Breeding Section)

A. S. Ghanekar of the Bhabha Atomic Research Centre, India and holder of an International Atomic Energy Agency Training Fellowship, commenced work in July on host-pathogen interactions in potato softrot, especially the role of plant lectins.

B. Løschenkohl of the Royal Veterinary and Agricultural University, Denmark studied methods used in investigations on potato gangrene during November.

(Mycology Section)

Dr E. L. Halk arrived in August from the University of Wisconsin, USA, to spend a post-doctoral year working on carrot mottle virus.

(Virology Section)

Sabbatical Leave

A. T. Jones took up a Senior Fellowship of the New Zealand National Research Advisory Council in April and is working for a year on plant virus diseases at the Department of Scientific and Industrial Research, Plant Diseases Division, Auckland.

W. P. Mowat departed in September to spend 6 months working by invitation on viruses of ornamentals at the Victorian Plant Research Institute, Australia.

Visits Abroad

Dr T. J. W. Alphey attended the European Science Foundation/European Science Research Council Working Group on European Co-operation in Taxonomy, Systematics and Biological Recording (Zoology Section) held in Zurich 24-25 June to discuss the formation of a European Nematode Survey.

B. Boag attended the 3rd International Symposium of the European Invertebrate Survey held in Paris on 24-27 May.

H. J. Gooding attended a Eucarpia Congress in Madrid from 23-27 May on the subject 'Interspecific Hybridization'.

B. D. Harrison spent 2 weeks in Kenya in May as consultant to the Ministry of Overseas Development Crop Virology Project based at the East

African Agriculture and Forestry Research Organization, Muguga. He then paid brief invited visits to the International Institute for Tropical Agriculture, Ibadan, Nigeria, and the ORSTOM laboratory at Adiopodoume, Ivory Coast, to discuss research on plant virus diseases. In October, he spent a week in The Netherlands visiting centres of plant virus research at Wageningen and Leiden, aided by a DAFS travel grant.

D. L. Jennings visited the University of Arkansas, USA in November, to discuss blackberry breeding and then went by invitation to a Plant Protection Workshop at Centro Internacional de Agricultura Tropical in Cali, Colombia. While in Colombia he collected species of blackberry in the Bogota area for use in breeding.

M. A. Mayo spent 17-24 August at the Institut de Biologie Moleculaire et Cellulaire, Strasbourg, for discussions and collaborative experiments on the translation of nepovirus RNA. He received a DAFS travel grant.

I. G. Montgomerie visited the Institut für Obstkrankheiten at Dossenheim über Heidelberg, Federal Republic of Germany, from 27-29 September.

D. A. Perry attended the 17th International Seed Testing Congress held in Madrid, Spain from 6-14 May.

C. E. Taylor attended two meetings of the Consiglio Scientifico del Laboratorio di Nematologia agraria, Bari, Italy, on 15-18 March and 29 June-1 July. Also, he attended the EPPO Meeting in Paris on 21-24 June, meetings of the American Phytopathological Society and the Society of Nematologists at East Lansing, Michigan, USA, and an International Symposium on *Meloidogyne* Nematodes at Bari, Italy.

P. D. Waister and D. L. Jennings visited centres engaged in soft fruit research in the Moscow/Leningrad area and in Siberia from 27 July-8 August, at the invitation of the Soviet Ministry of Agriculture.

Courses Attended

T. J. W. Alphey, B. Boag, D. J. F. Brown and W. Robertson attended the Association of Applied Biologists Workshop for Nematology Techniques held at Cambridge University 6-8 September.

A. Dale attended an introductory course on the use of the 2980 computer at ERCC Edinburgh in November.

J. M. Duncan, D. M. Kennedy and I. G. Montgomerie attended the Phytophthora Workshop held at the University College of North Wales, Bangor from 12-15 September.

S. C. Gordon attended the 9th Course in Acarology, University of Nottingham, School of Agriculture, Sutton Bonnington 11-22 July.

D. J. Robinson attended a middle management basic course at the Civil Service College, Sunningdale, from 12-13 May.

Pauline B. Topham and R. J. Clark attended an ERCC course on the ICL2980 VME/B operating system, at Edinburgh 21-23 November.

J. A. T. Woodford attended the M.A.F.F. Agricultural Development and Advisory Services 'Open' Conference of Advisory Entomologists, Summer Training Visit on Fruit & Hops, Wye, Kent 12-14 July.

Three members of Auchincruive estate staff attended courses on electric welding and tractor maintenance arranged by the ATB.

Conferences at which papers were given

- | | | |
|-------------|---|---|
| 5 January | Society for General Microbiology Virus Group, Warwick.
D. J. Robinson | Inactivation of tobacco rattle virus by EDTA, and the role of metal ions in the stability of the virus. |
| 7 January | Society for General Microbiology Microbial Pathogenicity Group/Virus Group, London.
A. F. Murant | Transmission of plant viruses through seed and pollen. |
| 3 February | Association of Applied Biologists, London.
D. L. Jennings | Selecting for resistance to the raspberry beetle. |
| 21-22 March | Genetics Society, Hull.
J. R. T. Hodgkin | The role of pollen and stigma in determining the level of self-compatibility in Brussels sprouts. |
| 23-24 March | Symposium on Problems of Pest and Disease Control in Northern Britain, Dundee.
T. J. W. Alphey | Control of spraing in potatoes by application of oxamyl. |
| | R. A. Fox | Some effects of time of haulm destruction and harvest on the incidence of potato gangrene. |
| | D. T. Mason | The effectiveness of pre-harvest fungicide sprays in reducing post-harvest spoilage of soft fruit. |
| | D. A. Perry | Effect of seed vigour on barley emergence. |
| | D. A. Perry | A review of vegetable diseases. |
| | D. L. Trudgill | Nematodes; a hidden pest of raspberries. |

- B. Williamson The importance of raspberry cane diseases and their control.
- J. A. T. Woodford The biology and control of raspberry cane midge in Scotland.
- J. A. T. Woodford The potato aphid spray warning scheme in Scotland.
- 24 March Symposium on Negative Staining: Viruses, Macromolecules and Membranes, Fairlane Conference Centre, Hornchurch.
I. M. Roberts Negative staining in electron microscope serology.
- 31 March Society for General Microbiology Virus Group, London.
B. D. Harrison Variation in the nepoviruses and tobnaviruses.
M. A. Mayo Inoculation of tobacco protoplasts with tobacco rattle virus: some physical properties of the inoculum.
- 5 April United Kingdom and Ireland Agricultural Students Association 15th Annual Conference, Leeds.
A. F. Murrant Plant viruses and their transmission.
- 20 April Association of Applied Biologists, Brighton.
W. M. Robertson The oesophageal nerve system in *Longidorus leptocephalus*.
- 20 April Pathology Section Meeting, EAPR, Braunschweig.
R. A. Fox The interactions of heat treatment, the tuber plane microflora and the development of potato gangrene.
- 27 April U.K. Agricultural Supply Trade Association Seeds Symposium, London.
D. A. Perry Seed vigour—present position and future prospects.
- 12 May International Seed Testing Congress, Madrid.
D. A. Perry Report of the Vigour Test Committee, 1974-1977.
- 24-27 May European Invertebrate Survey, 3rd International Symposium, Paris, France.
B. Boag The manipulation of survey data for ecological studies.

	B. Boag	The European plant parasitic nematode survey.
	B. Boag	An appreciation of some problems associated with nematological surveys.
6-10 June	European Association for Potato Research, Virology Section, Bled, Jugoslavia.	
	L. F. Salazar	Potato black ringspot virus, a nepovirus from South America.
	L. F. Salazar	Potato virus T, a seed borne virus.
21-23 June	European and Mediterranean Protection Organisation Meeting, Paris, France. 'Forecasting on Crop Protection'.	
	C. E. Taylor	Computer mapping and analysis of nematode distribution.
22 June	Federation of British Plant Pathologists Virology Group, East Mallong.	
	A. F. Murrant	Antibody sensitized latex for tests with plant viruses.
	B. D. Harrison	Electron microscope serological tests at SHRI.
18-22 July	ISHS symposium on the timing of field vegetable production, Wellesbourne.	
	T. W. Hegarty	Physiology of seedling emergence.
	Sheila M. Royle	Soil impedance and its effects on calabrese emergence.
15-31 August	Meeting of American Phytopathological Society, East Lansing, Michigan, USA. Symposium on nematode transmission of viruses.	
	C. E. Taylor	Virus vector relationships and mechanics of transmission by nematodes.
16-19 August	16th Annual Meeting of the Society of Nematologists, East Lansing, Michigan, USA.	
	Talks given by C. E. Taylor for Zoology Section were:—	
	W. M. Robertson	Possible receptor regions within the oesophagus of <i>Longidorus leptcephalus</i> .
	D. L. Trudgill & D. J. F. Brown	A comparison of the efficiency with which <i>Longidorus macrosoma</i> transmits two strains of raspberry ringspot virus.

- 8-9 September Society for General Microbiology Virus Group, Norwich.
 B. D. Harrison Mixed infections of plant viruses and cross-protection.
 H. Barker Interaction of strains of raspberry ringspot virus in protoplasts.
 M. A. Mayo Satellitism in plant viruses.
 A. F. Murrant Vector transmission of plant virus complexes.
- 26-30 September ISHS symposium on Seed problems in horticulture: The search for practical solutions, University of Nottingham School of Agriculture.
 T. W. Hegarty Seedbed conditions and seedling establishment.
 D. A. Perry Problems of the development and application of vigour tests to vegetable seeds.
 A. B. Wills and C. North Problems of hybrid seed production.
- 14-31 October Symposium on *Meloidogyne* nematodes, Bari, Italy.
 C. E. Taylor *Meloidogyne* inter-relationships with micro organisms.
- 9 November Scottish Symposium on Electron Microscope Techniques, Aberdeen.
 I. M. Roberts Electron microscopy—the occupational hazards.
- 14 November Plant Protection Workshop, CIAT, Colombia.
 D. L. Jennings The inheritance of linked resistances to African cassava mosaic and bacterial blight diseases.
- 23 November PMB Meeting, Aberdeen.
 C. E. Taylor Aphids in perspective.
- 21-24 November 1977 British Crop Protection Conference—Pests and Diseases, Brighton.
 J. A. T. Woodford The potato aphid spray warning scheme in Scotland, 1975-1977.
- 13-15 December NSCA course on vegetable production on the farm, Craibstone, Aberdeen.
 T. W. Hegarty The seed and the soil.
 H. M. Lawson Weed control
- 14-16 December FBPP/AAB Conference on Plant Disease Epidemiology and the Dispersal of Plant Parasites, London.
 T. J. W. Alphey Chemical control of virus-vector nematodes.

B. D. Harrison	Molecular aspects of variation and ecology of nematode-borne viruses.
A. F. Murrant	Recent studies on association of plant viruses with aphid vectors.
A. F. Murrant	Nematode-borne viruses: <i>dramatis personae</i> .
C. E. Taylor	The distribution of nematode virus-vectors in Great Britain.
D. L. Trudgill	Frequency of transmission of some nematode-borne viruses.
J. A. T. Woodford	The effect of persistent granular aphicides and foliar sprays on potato aphids and potato leaf roll.

Conferences Organised

- C. E. Taylor Joint organiser with Professor Lamberti of an International Symposium on root-knot nematodes, *Meloidogyne* species, held at Bari, Italy, from 14 to 31 October.
- R. A. Fox Symposium on Problems of Pest and Disease Control in Northern Britain, Dundee 23-24 March. This Symposium was part of a series of Symposia organised with the British Crop Protection Council on subjects of special interest which are considered at the annual Brighton Conferences. The convening committee was chaired by J. R. Cutler, DAFS Agricultural Scientific Services, and included representatives from the Scottish Colleges of Agriculture, the Northern Ireland Department of Agriculture, agro-chemical companies, and this Institute. The objective was to bring together farmers, users of agricultural chemicals, advisory, research, and government organisations to discuss problems in Northern Britain—Northern England, Northern Ireland, and Scotland.

The Symposium was divided into five Sessions; Cereals and Grass (convener M. J. Richardson), Potatoes (A. E. W. Boyd), Soft Fruit (D. L. Trudgill), Agricultural Vegetables (M. A. Miller), and Pesticides (C. M. Graham). These were run consecutively in a very full 2-day programme held in

the University of Dundee and attended by over 200 registrants. R. A. Fox was responsible for administration and for organising, editing and publishing the Proceedings.

- R. A. Fox Pathology Section Meeting, European Association for Potato Research, Braunschweig, 18-22 April. This meeting was held at the Biologischen Bundesanstalt für Land- und Forstwirtschaft with Dr. Bärbel Schöber acting as local Secretary. It was attended by over 40 participants from 13 countries. A total of 22 papers were read and visits made to the Institutes for Plant Protection and Plant Virus Diseases as well as to commercial organisations concerned with potato production.
- R. Thompson A meeting at SHRI on 'Production, processing and utilisation of the field bean, *Vicia faba*' was held at SHRI on 9 March. It was attended by 66 people from the ARS, advisory services, universities, the seed trade and the animal feed compound industry.

Editorial Duties

- C. E. Taylor Editor of *Nematologia Mediterranea*.
Associate Editor of *Journal of Horticultural Science*.
Member of the Board of Editors of *Horticultural Research*.
- R. A. Fox Member of Board of Editors of *Potato Research*
- H. J. Gooding Member of the Board of Editors of *Horticultural Research*.
- B. D. Harrison Editor of *Journal of General Virology*.
Editor of *Commonwealth Mycological Institute/ Association of Applied Biologists Descriptions of Plant Viruses*.
- M. A. Mayo Member of Editorial Board of *Intervirology*.
Member of Editorial Board of *Journal of General Virology*.
- A. F. Murrant Member of Board of Editors of *Annals of Applied Biology*.
Editor of *Commonwealth Mycological Institute/ Association of Applied Biologists Descriptions of Plant Viruses*.
- Pauline B. Topham Assistant Editor of *The Lichenologist*.
Editor of *Horticultural Research*.

P. D. Waister Associate Editor of *Journal of Horticultural Science*.

Service on Committees

- C. E. Taylor Journal of Horticultural Science Publications Committee.
University of Strathclyde/West of Scotland Degree Advisory Board.
West of Scotland Agricultural College Glasshouse Advisory Committee.
ARC Management Advisory Committee.
ARS Whitley Council.
Joint ARC/IPCS Working Party on Promotion Procedure.
NFT Advisory Committee.
SNSA—Adviser to Committee.
SNSA (Flower Bulbs)—Adviser to Committee.
NSDO Advisory Committee.
Member of Scientific Council of the Laboratorio di Nematologia Agraria, University of Bari, Italy.
SHRI/Scottish Colleges Liaison Group.
ACAS Advisory Committee.
HEA Scottish Branch.
- M. M. Anderson NFT Blackcurrant Sub-Committee.
- B. Boag European Invertebrate Survey—
Nematology representative.
- R. J. A. Exley Tayside and Fife Branch Committee of the B.A.
- R. A. Fox Chairman, Pathology Section, European Association for Potato Research (EAPR).
Chairman, EAPR Committee on Methods of Disease Assessment.
- H. J. Gooding NFT Strawberry Sub-Committee.
Fruit Working Group Committee.
City and Guilds of London Institute Advisory Panel on Tropical Agriculture.
NFT Scottish Sub-Committee.
- B. D. Harrison British National Committee for Biology,
Member of Microbiology Sub-Committee.
International Society for Plant Pathology,
Member of Council.
JCO, Member of Plant Science Committee.
Section of Virology, International Association of Microbiological Societies, Member of Advisory Council.

- D. L. Jennings NFT Raspberry Sub-Committee.
 NFT Scottish Sub-Committee.
 SNSA Adviser to Committee.
- A. T. Jones Association of Applied Biologists, Member of
 Council.
 Virology Group of Federation of British Plant
 Pathologists, Member of Committee.
- H. M. Lawson ISHS Working Group on Weed Control in
 Vegetables.
 JCO, Technical Secretary of Field Vegetables
 Committee.
 AAB Weeds Group.
- D. MacIntyre WSAC Safety Committee.
- W. P. Mowat Scottish Bulb Technical Committee.
- A. F. Murant Society for General Microbiology, Virus Group
 Committee.
 International Society for Horticultural Science,
 Chairman of Working Group on Small Fruit
 Viruses.
- C. North Eucarpia Member of Board of Directors.
 Eucarpia Chairman of Vegetable Section.
 Dundee University Botanic Garden Committee.
- D. A. Perry Chairman, Vigour Test Committee, International
 Seed Testing Association.
- R. Thompson NIAB Vegetable Trials Advisory Committee.
 SHRI/Scottish Colleges Liaison Group.
- Pauline B. Topham Convener ERCC PLU 2980/370 Service Committee.
- P. D. Waister JCO, Member of Fruit Committee.
 NFT Scottish Sub-Committee
 Dundee University Botanic Garden Committee.
 Tayside and Fife Branch Committee of the B.A.

Exhibitions

- 17-20 May Chelsea Show, London. New lily cultivars bred at
 SHRI.
- 4-7 July Royal Agricultural Show, Stoneleigh. Isoenzyme tests
 and glossy foliage markers for the detection of sibs
 in *Brassica* hybrids.

- 16-19 August 16th Annual Meeting of the Society of Nematologists, East Lansing, Michigan, USA. D. J. F. Brown, P. B. Topham and C. E. Taylor displayed an exhibit showing the application of computerised data processing systems to nematological surveys.
- 23-25 August Ayr Flower Show.
An exhibit was staged showing the four newly named cultivars of strawberries bred at the West of Scotland Unit, together with specimens of meristem cultured strawberries.
- 13-15 September *Phytophthora* Workshop organised by FBPP at University College of North Wales, Bangor.
D. MacIntyre contributed an exhibit of screening techniques for *Phytophthora cactorum* on strawberries.

Radio and Television

C. E. Taylor took part in a discussion on mechanical harvesting of raspberries in the BBC Radio Scotland programme 'Farming Week' on 16 August.

C. E. Taylor took part in the BBC TV Landward programme on soft fruit production in Scotland on 20 August.

D. L. Jennings discussed the 'Tayberry' on BBC Radio Scotland on 19 August and on Grampian Television on 23 August.

Index to Projects

<i>Crops Research</i>	<i>Page</i>
01001 Effects of weather conditions on growth, yield and quality of soft fruit crops	29
01004 Germination and establishment of vegetable seeds in relation to moisture and temperature	32
01008 Physiological disorders of soft fruit	45
01012 Ecology of new crops for Scotland	46
01014 Physiological and cultural factors affecting the mechanical harvesting of soft fruits	43
01018 Control of growth, yield and quality of raspberries by cultural methods and choice of genotype	41
01019 Control of growth, yield and quality of strawberries by cultural methods and choice of genotype	45
01021 Weed ecology and control in soft fruit	35
01023 Weed ecology and control in flower bulbs	35
01024 Weed ecology and control in vegetables	35
01029 Weed control in crop rotations	37
01030 Control of growth, yield and quality of vegetable crops by cultural methods and choice of genotype	37
01037 Control of growth, yield and quality of flower bulb crops by cultural methods	40
01040 Post harvest handling of soft fruit	46
01042 Statistical studies in plant variation	46
01044 Statistics (Service)	47
01045 Use of computing facilities	47
01046 Agro-meteorological recording (service)	126
01049 Effects of weather conditions on growth, yield and quality of vegetable crops	30
01050 Cultural techniques for control of growth, yield and quality of protein and other seed crops used for food manufacture	39
	25

01051	Effects of soil structure on germination and emergence of vegetable seeds	33
01052	Effects of seed production conditions on germination and establishment of vegetables	35

Plant Breeding

Page

03001	Strawberry: breeding and associated genetic studies	49
03003	Strawberry: breeding systems	51
03006	Raspberry: breeding and associated genetic studies	51
03008	Breeding early, erect blackberries and other hybrid <i>Rubus</i> berries	54
03009	Breeding black currant for northern regions of the UK	56
03010	Brassicas: genetics of S-allele incompatibility system in <i>Brassica oleracea</i>	58
03011	Brussels sprout: breeding hybrid cultivars	58
03012	Cabbage: breeding hybrid cultivars	60
03013	Brassicas: isoenzyme analysis in <i>Brassica oleracea</i>	60
03015	Brassicas: genetics and cytology of <i>Brassica oleracea</i>	61
03019	Calabrese breeding	61

Mycology

02001	Chemical and cultural control and economic importance of diseases of cane and bush fruits	86
02003	Shoot disorders of cane and bush fruits	81
02004	Chemical and cultural control and economic importance of strawberry red core	87
02005	Analysis of and screening for resistance to diseases of soft fruit	85
02007	Biology of diseases of ornamental bulbs.	86
02010	Seed quality-soil interactions and the effects on seedling emergence, growth and crop yield	73
02012	Seed quality, causes of its variation and its effect on yield	78
02013	Biology of root diseases in field pea and bean	71
02015	Disorders of vegetables	77
02016	Chemical and cultural control of potato gangrene	88
02017	Biology of potato gangrene	68

02018	Diseases of potato tubers	76
02019	Gangrene, blackleg and soft rot and contamination of VTSC seed potato stocks	84
02021	Immunofluorescent and fluorescent techniques in histology	89
02022	Harvest disorders of soft fruit	83
02024	Autecology of the strawberry red core fungus (<i>Phytophthora fragariae</i>)	70
02025	Rhizosphere and allied phenomena affecting plant health	75
02026	The nature and implication of quiescent fungal and bacterial infections	75
02027	Studies of plant pathogens	79
52029	Phytopathological methods	89
<i>Virology</i>		<i>Page</i>
04001	Potato viruses, especially soil-borne viruses	101
04002	Viruses with nematode vectors and/or multipartite genomes	90,93
04003	Viruses infecting raspberry	98
04004	Production of virus-tested raspberry stocks	98
04007	Viruses affecting umbelliferous crop plants	99
04010	Viruses infecting bulbous ornamentals	96
04011	Production of virus-tested bulb stocks	97
04014	Identification of viruses in relation to diseases of other crop plants	103,105
04020	Viruses of grasses	102
54015	Ultrastructure of virus-infected plants and virus-carrying vectors	106
<i>Zoology</i>		
05001	Ecology and control of pests (other than aphids) of horticultural crops in Scotland	113
05002	Biology and ecology of trichodorid species and their role as virus vectors	108
05003	Chemical control of ectoparasitic nematodes with special reference to virus vector nematodes	110
		27

05004	Feeding behaviour of <i>Longidorus</i> and <i>Xiphinema</i> spp. in relation to virus transmission	110
05005	Ultrastructure of nematode vectors of plant viruses with reference to their feeding apparatus	112
05007	Ecology of <i>Longidorus</i> and <i>Xiphinema</i> spp. in relation to their role as plant pathogens	109
05008	The ecology of aphids infesting raspberries and other crops	116
05010	Assessment of the damage caused by potato cyst and other plant parasitic nematodes in Scotland.	112
05011	Migratory plant parasitic nematodes associated with crops in Scotland	107
05012	Ecology and control of <i>Pratylenchus</i> spp. associated with soft fruit	112
05013	Control of aphids and virus diseases of potato, raspberry and ornamentals	116

CROPS RESEARCH

P. D. WAISTER

In recent years there has been considerable debate about the extent to which crop yields are approaching what has been called potential yield or maximum yield. For many crops there remains doubt about the level of this potential yield, and also about the level of yield now attainable using our existing knowledge of crop requirements.

In experiments commenced in 1975, we have tried to provide non-limiting conditions, except for light, temperature and carbon dioxide, for several crops and have recorded what might be called 'measured maximum yield' (to contrast it with the theoretical maximum). An important feature of the method is the attempt to remove as many as possible of the soil constraints, known and unknown, by growing the experimental crops in an artificial medium.

Comparison of the growth and yields of the maximum yield plots with those obtained on adjoining control plots has produced some surprises, and the technique looks like becoming a useful way of guiding agronomic research in potentially rewarding directions. The contrast between responses of species is interesting. Field beans produced much higher total dry matter, but failed to show a corresponding increase in grain weight. Yield component analysis pointed to a need for fuller investigation of the factors affecting percentage pod set. The large yield increases for calabrese and tulips focus attention on soil factors, and suggest that even on the Institute's very good arable soils, and under conditions of careful management, there are significant soil problems which are not yet adequately understood.

01001 *Effects of weather conditions on growth, yield and quality of soft fruit crops*

Crop response to shelter

Final yields were taken from the strawberry experiment planted in 1974. The mean yield of the sheltered plots exceeded that of the control by 19% and, as in previous years, truss numbers appeared to be the yield component most affected. Samples of crowns were taken in November and preserved in alcohol for microscopic examination of possible differences in truss initiation per crown.

There have been very considerable year-to-year differences in the extent of response to shelter, presumably linked with differences in wind patterns. As yet it has not been possible to identify any characteristics of timing and strength of winds which would explain the observed fluctuations in growth and yield in the exposed plots.

Irrigation and water use

There was no significant yield response to irrigation of strawberries in plots watered to maintain low deficits throughout the season or irrigated once at pink fruit stage. The experiment was terminated in November, at which time root distribution and soil profiles were examined. Roots were abundant throughout the topsoil down to a depth of 40 cm, and significant numbers were present down to 70 cm in the underlying coarse sandy till.

The available water content of the top soil has been estimated to be 91 mm and that of the sub-soil to a depth of 80 cm to be 70 mm. Measurements of soil water made by neutron moderation showed that, throughout the season, water was lost from all soil depths examined. The level in the soil from which the greater part of the water was drawn became deeper as the season progressed, so that during April and May, over 30% of water uptake was from the top 25 cm of the soil, while in July and in August only 15% was taken from the same zone.

For only the second time since experiments began in 1973, yields of raspberries were greater (by 28%) on irrigated plots, and again for the same reason, namely a carry-over of response from enhanced vegetative growth in the previous year. There were 25% more canes on the irrigated plots. No response to irrigation was obtained at a new site, on a soil of low water-holding capacity, in observations conducted jointly with the ESCA. This was the first year of irrigation, and effects on yield produced via enhanced growth of young cane will not be measurable until the 1978 season.

(D. K. L. MacKerron)

01049 *Effects of weather conditions on growth, yield and quality of vegetable crops*

Low temperature

The second generation of the frost chamber described in the 1972 Annual Report was designed to use liquid nitrogen as a cooling medium. However, increasing operating costs have necessitated the use of an alternative, cheaper coolant. In the new system industrial alcohol is pumped around a finned heat exchanger inside the test chamber, the pump being switched directly by the temperature controller. This alcohol is cooled outside the chamber by a dry ice/alcohol bath.

Initial tests proved favourable, temperature control being better than with liquid nitrogen because of the smaller differential between the coolant and plant temperatures. The chamber has been used during the winter of 1977/8 for testing the hardiness of autumn-sown onions.

Hardiness of WPBS grass selections

The SHRI frost chamber was used to test the hardiness of selections of *Lolium perenne* and *Lolium multiflorum*, from the WPBS. The spaced plants were grown at Aberystwyth in wooden boxes and transported to Dundee at the end of May.

The first artificial frost was applied at the end of November. A grass minimum of -20°C was maintained for $9\frac{1}{2}$ hours, with a cooling rate of $6^{\circ}\text{C}/\text{hour}$.

The second treatment was of a grass minimum between -15 and -20°C for 20 hours, with a cooling rate of $3^{\circ}\text{C}/\text{hour}$, and was applied in mid-December. Records of plant survival have been passed to WPBS.

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

Light interception in canopies of pea

Pea cultivars of 'leafy' and 'tendrill' types were sown to provide contrasting canopies. Cv. Filby (tendrill) was chosen because it is truly leafless, and cv. Vedette because it is leafy, and like Filby is round-seeded. The plots of Vedette were provided with wire mesh supports to avoid complications due to lodging.

Light profiles were measured at intervals, and three harvests were made, the last one at pod maturity.

The plant density achieved ($60/\text{m}^2$) was less than intended, but should not invalidate broad comparisons of plant form and light interception.

Indices of projected area were calculated separately for leaves, tendrils, stems, and pods. The total area index so derived was less for Filby than for Vedette, 1.7 compared to 3.1, respectively. Yields of air dried peas did not differ significantly at 610 and $660 \text{ g}/\text{m}^2$ respectively.

A preliminary examination of the photosynthetic performance showed that the tendrils of Filby were highly active on an area basis.

(D. K. L. MacKerron)

Continuous sowing experiment

Calabrese and carrot seeds were sown on five occasions between 10 March and 1 June. The seeds were left untreated or were dusted with captan fungicide and, after sowing, the plots were either left exposed to natural rainfall or were covered with clear, corrugated plastic screens. In most cases captan treatment only marginally improved emergence of both crops, but at the final sowing of carrots it caused a decrease in emergence of 19% for reasons as yet unexplained. Plot covers resulted in higher emergence of both crops at the third sowing in comparison with exposed plots in which rainfall caused deterioration of the soil surface.

Fine-mesh bags containing untreated or fungicide-treated seeds were 'sown' for comparison in drills at the same time as the 'free' seeds but were removed from the soil at intervals to check on the levels of seed germination and the viability of those seeds not yet germinated. Analysis of these data, together with emergence figures from the 'free' seeds, permits separate evaluation of losses in the pre- and post-germination phases.

The results strongly suggest that in calabrese the main cause of poor emergence is the failure of seedlings to reach the soil surface rather than the failure of seeds to germinate. In carrot the situation is less clear but there is still a strong suggestion that emergence failure is at least as important as germination failure.

Water uptake in calabrese seeds

Seeds of calabrese were held in -7.5 bar polyethylene glycol (PEG) 6000 solution which permitted approximately 60% germination after 28 days. In the lag phase of water uptake after initial imbibition the majority of non-germinating seeds showed a slow and significant increase in fresh weight with time. By using separate seed samples it appeared that seed dry weight decreased very slightly during this period, so that the increases in fresh weight indicated an increase in the water content of the seeds. The mean moisture content of the germinated seeds in the lag phase just before germination was 54% (of initial seed weight) with a range of from 44 to 66%, whereas in the non-germinated seeds after 28 days it was 62% (significantly greater than 54%) with a range of 50 to 83%. Thus hydration thresholds permitting germination in water-stressed seeds vary considerably within a population, and those seeds most sensitive to moisture stress fail to germinate despite their higher water content. (T. W. Hegarty, H. A. Ross)

Germination release in 'primed' calabrese seeds

Calabrese seeds were 'primed' by placing them in -10 bar PEG 6000 solution for 10 days. They were then transferred to water for up to 16 h. Germination started between 1 and 2 h after transfer, a rate of germination far more

rapid than in 'unprimed' seeds. Germination levels were 5, 44, 80 and 94% after 2, 4, 8 and 16 h respectively. Germination was rapidly inhibited again on transfer back to PEG solutions of from -8 to -12 bars, though less so at higher solute potentials, the additional germination in PEG solutions meant over all water-duration treatments being 31, 20, 9, 7 and 5% in -8, -9, -10, -11 or -12 bar solution respectively. The radicles of seeds that germinated in water continued to grow after transfer to PEG solutions, as did the radicles of seeds that germinated after transfer to PEG solutions, and the rate of radicle growth was dependent upon the solute potential. Thus germination itself was inhibited at solute potentials that permitted both seed development prior to germination and radicle growth after germination, and the initiation of cell elongation is implicated as the moisture sensitive block in the germination process.

(T. W. Hegarty, H. A. Ross)

Incorporation of fertiliser into the seedbed

Iron shot (2 mm grade), used to simulate granular fertiliser, was applied to a reasonably level soil surface and was worked into the soil using one or two passes of either a rotovator or a power harrow (Lely Roterra) set for 'shallow' or 'deep' working. Soil samples were taken at 10 mm depth intervals from a 300 mm square area within each plot to a depth of 100 mm and the shot was retrieved from each sample with a magnet. At the 'shallow' setting the rotovator was working to a depth of 80 mm and the power harrow 65 mm, but at the 'deep' setting both were working to a depth of 100 mm. Incorporation of the shot by the rotovator was very uniform, with on average 32% of the total recovered found in the top 30 mm (the seed zone) irrespective of number of passes or depth. With the power harrow at the shallow setting, 77% of the total recovered was found in the top 30 mm, but at the deep setting there was 66% after one pass and this was reduced to 46% after two passes. It appears that with a power harrow of this type, a single pass or working to a depth of only 60-70 mm is not sufficient to give even incorporation of fertiliser and this could lead to germination or seedling emergence problems in dry soil conditions.

(T. W. Hegarty)

01051 *Effects of soil structure on germination and emergence of vegetable seeds*

Soil impedance and field emergence of vegetables

In a continuation of last year's experiment with calabrese (Ann. Rept 1976, p. 28) seeds of calabrese, carrot, onion and sugar beet were sown by hand on four occasions and plots were left uncompacted or compacted at 2.8 or 8.0 N/cm².

Five millimetres of water were then applied to half of the plots to induce surface crusting and the plots were then protected from natural rainfall with clear corrugated plastic screens. Soil impedance measurements were made at the time of first emergence of each crop on the non-watered, uncompacted plots using a force-transducer downward-acting penetrometer with a 2 mm diameter flat-ended probe. Emergence in the non-watered, uncompacted 'control' plots did not vary significantly between the first three sowings, the mean emergence levels for calabrese, carrot, onion and sugar beet being 88, 80, 83 and 86% respectively. At these three sowings the effect of the watering treatment was to reduce mean emergence from 84 to 64% with no compaction, from 81 to 48% with light compaction, and from 68 to 23% with heavy compaction. The interaction with the individual crops was relatively small. Rate of emergence was also reduced by the water treatment and by compaction. At the fourth sowing emergence was apparently affected by lack of soil moisture, with compaction increasing emergence in the un-watered plots and water increasing emergence in the non-compacted plots. Correlation coefficients for the relationships between percentage emergence and integral impedance at the first three sowings were 0.82, 0.90, 0.90 and 0.93 for calabrese, carrot, onion and sugar beet respectively. There was some indication of an interaction between soil temperature and seedling emergence under high impedance, especially in the case of calabrese.

(S. M. Royle, T. W. Hegarty)

Interaction between soil temperature and soil compaction on calabrese emergence

Seeds of calabrese were sown 20 mm deep in pots containing soil that was subsequently compacted with a static force of 0.6, 2.7 or 4.8 N/cm², and pots were then held with minimum moisture loss at 20, 13 or 6°C until emergence was completed. Mean emergence at 20 and 13°C was 91%, with no effect of compaction, but at 6°C emergence was reduced to 78% at 0.6 and 2.7 N/cm² and to 33% at 4.8 N cm².

Retrieval of non-emerged seedlings from the soil showed that germination was at least 92% at 20 and 13°C, and at least 84% at 6°C, with no effect of compaction. Thus low temperature (6°C) reduced either germination or seedling survival in the soil by approximately 10% and, at the high level of compaction only, reduced seedling emergence by a further 50%.

(T. W. Hegarty)

01052 *Effects of seed production conditions on germination
and establishment of vegetables*

Seed vigour in field bean

Seeds of three stocks of field bean cv. Maris Bead showing high (H), medium (M) and low (L) levels of seed vigour (seed leachate conductivity) were sown in mid-March by hand in dibbed holes of four depths (25, 50, 75, 100 mm). After 10 weeks, shoot fresh weight and leaf area were 30% higher in H and M compared to L, but there was no significant effect of sowing depth. Plant stand at harvest in the first week of September was also not affected by sowing depth but H and M, at 79/m², were greater than L at 66/m². Yield was unaffected by either seed stock or sowing depth and averaged 6.1 tonnes/h at 15% m.c. There is thus no evidence that seed vigour affects yield through an effect on plant growth. The most likely effect of seed vigour on yield is through the possible reduction in plant stand below the optimum for maximum yield (Ann. Rept 1975, p. 26).

(T. W. Hegarty)

Seed vigour in brassicas

Seeds of five lots of open-pollinated Brussels sprouts were size-graded on round-hole sieves. In the laboratory at 20°C the middle grades germinated better than either the larger or smaller but the coefficient of rate of germination did not differ between grades. In the field, differences in germination and emergence levels and in germination rate between seed lots were more important than between seed grades and were not associated with differences in seed weight.

Seeds of four lots of F₁ hybrid Brussels sprout and four lots of kale were sown in compost and grown in growth cabinets. The four sprout seed lots had similar seed vigour levels whereas the four kale lots had different seed vigour levels. Small but significant differences in relative growth rate (seedling vigour) were found within the sprout and kale seed stocks. There was no association between the levels of seed and seedling vigour.

(A. E. B. Ibrahim, T. W. Hegarty, J. R. T. Hodgkin)

WEED INVESTIGATIONS

01021-01024 *Weed ecology and control in soft fruit, vegetables
and flower bulbs*

Weed competition

Earlier experiments on weed competition during the establishment year of spring-planted strawberries dealt with crops grown as spaced plants. Recent studies on plants with runners trained into matted rows during the first summer have shown much more drastic effects of weed presence on growth and yield of cv. Cambridge Favourite. Spring-germinating weeds were allowed to remain until early July, early August or until November 1976

and then removed. The plots were kept weed-free thereafter and during the following year. Yields of fruit on these plots in 1977 were 49, 18 and 13% respectively of yields on plots kept weed-free throughout. Much of the crop loss was attributed to suppression by weeds of the runner production necessary for the matted row.

The removal of all crop leaves and stolons together with weeds in July 1976—to simulate the maximum severity of crop injury if weeds were removed by forage harvester—reduced crop yield in 1977 by more than 40% compared with removal of the weeds alone. However, similar treatment in early August caused no additional crop loss. Both sets of plants made considerable recovery growth after defoliation and a less drastic treatment might prove more acceptable than the continued presence of weeds.

Herbicide evaluation

Further examination of the residual pre-emergence herbicides cyanazine, trietazine/simazine and terbutryne/terbuthylazine, applied at rates recommended for use in the pea crop produced no evidence of greater phytotoxicity to field beans, cv. Herz Freya than occurred with simazine. All three newer herbicides gave better control than simazine of *Polygonum aviculare*, but a chlorthal-dimethyl/methazole mixture gave no better overall results on weeds, mainly due to a failure to control *Fumaria officinalis*.

In 1977, post-emergence application of dinoseb acetate when the field bean crop was 5 or 15 cm high caused slight foliage scorch, which was soon outgrown. Treatment with bentazone when the crop was 15 cm high checked crop growth, reduced the size of subsequent leaves, delayed ripening and reduced yield. Neither herbicide gave satisfactory control of *P. aviculare*, and bentazone also failed to eliminate *F. officinalis*.

While the results of the past 2 years indicate that a number of useful alternatives to simazine for residual weed control in the field bean crop are available, a safer and more effective post-emergence herbicide than dinoseb acetate has still to be found.

A trietazine/simazine mixture was again no safer than simazine alone on maiden strawberries cv. Cambridge Favourite when applied as an immediate post-planting treatment in April. Propachlor, pendimethalin and ethofumesate had little phytotoxic effect on the crop even at three times the suggested rate.

These three herbicides appear suitable for inclusion in programmes of weed control designed to prevent weed development during the critical establishment year of the strawberry crop.

Potato seedlings

These continued to emerge in the glasshouse in trays of soil taken from field plots which were last cropped with potatoes in 1971. The latest series of soil samples was extracted in March 1977. Outdoors, potato seedlings emerged in considerable numbers in a field bean crop sown in early spring 1977. Here also, the last potato crop was grown in 1971, when several cultivars produced large numbers of fruits. The growth of tagged seedlings was monitored until the bean crop was harvested in mid September. Some died, but a substantial number developed sufficiently to produce small tubers. The ability of these tubers to survive the winter and produce volunteer plants is being investigated.

Detailed examination of the survival and germination pattern of seeds from berries planted outdoors in autumn is now being made.

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

VEGETABLES, FIELD CROPS AND FLOWER BULBS

01030 Control of growth, yield and quality of vegetable crops
by cultural methods and choice of genotype

Calabrese: measured maximum yield

Calabrese yields have fluctuated markedly at the SHRI, and more especially on farms, in the past 4 or 5 years. Last year irrigation was shown to have marked effects on plant development and yield, but it was not clear whether the growth obtained in the irrigated crop was approaching the best that could be expected in our climate. A crop has therefore been grown in a 'non-limiting' plot (as described for field beans) and compared with one grown in our normal way. Despite the various experiments done over several years on the effects of density on yield, variation between experiments has been such as to make it difficult to identify a single population that will produce consistently high yields under a range of cultural conditions. The opportunity was taken therefore to identify the response of calabrese yield to changes in plant density when grown with minimum constraint on controllable resources.

Yields for the maximum yield crop (MM) increased from about 10 t/ha at 3.6 plants/m² up to about 19 t/ha at 23 plants/m², remaining at this level for up to 48 plants/m². These compared for the control plot with yields of about 7 t/ha at 3.6 plants/m² rising to about 11 t/ha at 16 plants/m², with no significant change when density was increased further up to 48 plants/m².

It is clear that as plant density was increased, and with it competition for resources, so the difference in yield between the control and the MM yields increased. These differences were reflected in individual spear diameter and

show the extent to which density needs to be adjusted according to growing conditions when particular head sizes are required. For example, whereas a spear diameter of 7.2 cm was produced by plants grown at a density of 16 plants/m² under normal growing conditions, 33 plants/m² were required to give this head size from the MM crop. In addition to the improved yields from the MM crop, the amount of leaf which had to be trimmed from the spear stem was halved.

Dried peas

A number of high-protein genotypes provided by USDA have been multiplied sufficiently to start yield assessment experiments next year and for preliminary feeding trials by the Rowett Research Institute (RRI). Samples were analysed by RRI this year for total protein and amino acid contents. The highest levels of total protein found exceeded 30% of the dry matter.

Vining peas

Last years' sowing date experiment was repeated. The second early cv. Scout was sown on six occasions between 22 March and 16 June to determine which sowing dates were likely to restrict yield of this high yielding cultivar, and so determine its suitability for a production programme covering the whole of the pea season (usually mid July to end of August).

Yields were determined at T100 and T120, and the dry pea yield was recorded at maturity. At all three stages of maturity yield tended to decline as sowing date was delayed after 22 March. At T100, yields for the six sowing dates in chronological order were 10.1, 8.9, 9.5, 8.1, 7.0 and 5.9 t/ha. Corresponding values at T120 were 12.6, 10.3, 10.4, 9.0, 7.8 and 6.2 t/ha and for the dried peas at maturity 4.9, 4.6, 5.2, 3.9, 2.8 and 2.3 t/ha at 15% moisture content. The cv. Puget is widely used in the later part of the pea season, and one sowing was included in this experiment to reach T100 about mid August. Its yield was 7.6, 9.5 and 4.4 t/ha at T100, T120 and when dry respectively.

The first sowing of Scout reached T100 about 21 July and the final sowing on 31 August, with Puget reaching this value on about 12 August.

Peas are not at present required by Scottish processors after mid August, and these results indicate that, if yield were the only criterion, the mid season Scout may be used in place of the late Puget to crop at the end of the season without significant yield penalty.

Clearly, disregarding the influence of quality on the choice of cultivars, cv. Scout can be used to give high yields throughout the normal pea season, and comparable to those of cv. Puget maturing at its normal time. Nevertheless the best yields from cv. Scout can be expected from the earliest sowings.

(R. Thompson, H. Taylor)

Field bean—measured maximum yield

Following the marked effects on growth observed last year, the development of cv. Herz Freya when grown in a maximum yield plot (MM) has been compared in detail with a crop grown alongside in the conventional way. Again, the 'non-limiting' treatment included potting compost to a depth of about 22 cm, irrigation, and additional nutrients in solution in mid July.

Although a larger leaf area was quickly developed in the MM crop than in the control, flowering occurred earlier in the latter. Leaf area for the MM plot was on average about double that of the control, and senescence of leaves was complete in both about 8 September. Maximum leaf area indices of about 8 and 5.2 for the MM and the control respectively were reached on about 18 July and 6 July. For both crops total plant dry weight reached maximum about 18 August, but the MM value was 28% greater than that for the control. Even though these marked differences in growth were recorded, the MM crop produced only 12% greater weight of beans than the control. The plant density was 9% less, and the weight of beans per plant about 23% more for the MM crop than for the control. Compared with the control, plants from the MM crop produced about 11% more pod bearing nodes, similar numbers of pods/node and of beans/pod, and a 5% greater average bean weight.

The better growth of beans last year in a maximum yield plot could have resulted from a number of the factors introduced to enhance growth.

This year the influence of irrigation or of nitrogen applied on several different occasions was examined. The crop was watered at a predetermined soil moisture tension (27 centibars) and 188 kg/ha N (ammonium nitrate) was applied in solution at each of several different stages of growth.

Irrigation, with or without nitrogen, had no significant effect on yield, which averaged 6.2 t/ha overall. As with the maximum yield experiment, however, there were large differences in total plant weights, with irrigated plots producing over double the fresh weight of plants from the control (20 compared with 44 t/ha).

It is clear from both experiments that the potential for dry matter production in field bean is no guide to yield potential. Partition of assimilates in favour of the reproductive rather than the vegetative phase of development is required to exploit the capacity of the crop to produce dry matter.

Winter and spring sowing of field bean

In this, the final year of the experiment comparing spring and autumn sowing of both spring and winter cultivars, the degree of winter kill has been

significant for the first time. Even then only the spring cultivars Maxime and Minor of the seven spring and four winter ones were substantially affected, being reduced in numbers to 8% and 13% of the average density of 53 plants/m² for the autumn sowing. Average density of the spring sowing was 68 plants/m². Omitting cv. Maxime and Minor (which when spring-sown gave satisfactory yields) autumn sowing and spring sowing of spring cultivars again gave similar yields (3.5 and 3.0 t/ha respectively). Winter cultivars, however, when sown in the autumn gave higher yields (4.0 t/ha) than when sown in spring (2.8 t/ha). For both spring and autumn cultivars average bean weight and number of pod-bearing nodes were favoured by autumn sowing and numbers of pods/pod-bearing node by spring sowing. The difference in yield between spring and autumn sowing of the winter cultivars was largely accounted for by a 21% higher value for mean bean weight and a 43% increase in number of pod-bearing nodes for the autumn sowing. These large differences were slightly balanced by 16% fewer pods/pod-bearing node for the autumn compared with the spring sowing.

(R. Thompson, H. Taylor)

Aspects of the partition of assimilates in the field bean (*Vicia faba* L.) were studied in a field crop in 1977. Growth analysis throughout the season showed that at the time of maximum rate of seed growth, in August, the seeds were accumulating 20.1 g dry matter/m²/day while concurrently leaf area index decreased from 2.2 to 1.1. It seems unlikely that such a low leaf index could produce carbohydrates at the rate required at the time of maximum rate of seed filling. The drop in dry matter in leaves, pods and particularly stems at this time, strongly suggests that these are significant sources of materials for seed filling. Stem storage was investigated by ¹⁴C feeding and subsequent autoradiography. Plants fed before anthesis subsequently showed ¹⁴C assimilates in the pods and seeds when harvested at maturity.

Stem dry weight did not decrease in the characteristic fashion if all flowers were removed to prevent any pods setting, but instead stem dry weight increased throughout the period when pod filling would normally occur. Nodule N₂-fixing activity was measured using the acetylene reduction method. Nodules on deblossomed plants did not show the characteristic decline in activity usually encountered in the pod setting period, but activity continued to increase as the season progressed, thus suggesting an adequate supply of carbohydrate for *Rhizobium*.

(R. M. Brook, R. Thompson)

01037 Control of growth, yield and quality of flower bulb crops by cultural methods

Tulip: measured maximum yield

Last year bulbs of cv. Apeldoorn produced appreciably higher yields when

grown in a 'non-limiting' plot compared with conventional culture. This year a start has been made to establish the part played by irrigation in this enhanced growth. Bulbs grown under non-limiting conditions gave 43 t/ha of daughter bulbs, compared with 34 and 26 t/ha from the irrigated and non-irrigated controls respectively. Relative growth rates corresponding to these yields were 0.0293, 0.0273 and 0.0231 g. g. day recorded during the time about peak leaf area, the indices for which were 2.5, 2.0 and 1.6 respectively. Although irrigation accounted for some improvement in yield, considerable potential remains to be explained and is most likely due either to nutritional or soil physical effects.

Tulip forcing

A final experiment has been completed in the series seeking relationships between forcing performance and morphological development or carbohydrate levels in the mother bulb. No reliable general relationships were found which would hold true over 3 years of forcing experiments involving the cv. Apeldoorn, at up to three preconditioning temperatures (5°C, 9°C and 13°C). Nevertheless total soluble sugars was as good an indicator of stem length at harvest as was either duration of preconditioning or shoot length at the time of housing. The period from housing to flowering was not well related to changes in any carbohydrate but bore a strong relationship to duration of preconditioning.

(R. Thompson, H. Taylor)

FRUIT CROPS

01018 Control of growth, yield and quality of raspberries by cultural method and choice of genotype

National Fruit Trial 1975

Vigour control was introduced in 1977 as a treatment in two out of the four replicates of this trial. Dinoseb-in-oil was applied when the first flush of young canes of each cultivar or selection reached 15 cm high. The dates of application ranged from 29 April (Glen Clova and 23/69) to 18 May (2476/123). The majority of cultivars showed no increase in yield of fruiting canes on treated plots; detailed analysis of fruit yield and cane production in 1977 may indicate reasons for this apparent lack of response to the removal of competition from young canes. Ignoring any effects of vigour control, yields of fruit were considerably higher than in 1976, the first fruiting year, for all cultivars and selections except M32. Malling Admiral, Leo, M32 and most of the seedlings, produced yields similar to that of Glen Clova (17 t/ha). The outstanding exception was the late selection 2476/123 (24 t/ha), while 2488/36 (9 t/ha) and Malling Jewel (10 t/ha) gave the lowest yields.

(M. R. Cormack, H. M. Lawson)

Control of cane vigour

Much of the research on vigour control has concentrated on Glen Clova, the cultivar in which the problem first became evident on a commercial scale. Preliminary information on other cultivars has been obtained by treating part of the 1971-planted National Fruit Trial with dinoseb-in-oil in early May 1976 and again in May 1977. The cultivars varied considerably in vigour and their young canes were at different heights when treatment was applied all at the same date. The results, therefore, represent the reactions under one particular set of conditions. Nevertheless, several cultivars showed interesting responses.

M32, M30, 1318/27, Norfolk Giant and Malling Jewel produced yield increases in excess of 35% from existing fruiting canes in 1976 on treated as compared with untreated plots. However, there was a severe reduction in the amount of young cane available for fruiting in 1977 on treated plots of several cultivars, notably Malling Delight, 1318/27, Glen Isla, M32, Malling Jewel and Malling Promise. In contrast, cane numbers tied in for fruiting on treated plots of Malling Orion, Malling Admiral and Norfolk Giant were considerably in excess of those on untreated plots. Sprawling young canes on untreated plots of these three cultivars were substantially damaged by pickers in 1976, whereas the younger canes on treated plots caused less obstruction and suffered less injury. These were the only cultivars giving significantly increased yields per plot in 1977 in treated as against untreated rows, although most cultivars showed an increase in yield per fruiting cane.

Over the 2 year period, yields of Leo, M30, M32, Malling Orion and Malling Promise were increased by 20 - 30% as a result of vigour control. Yields of Malling Admiral and Norfolk Giant were increased by 48% and 65% respectively.

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

Biennial cropping

The experiment on the responses of six cultivars moved into its second cropping year, in which yields of a fully-biennial system could be compared with a part-biennial. The fully biennial system measures the combined effects of unrestricted growth of cane in its vegetative year and in its fruiting year, while the part-biennial system measures the response to removal of competition in 1977 only. In all six cultivars, the increase in yield compared with annual cropping was 29% in the part-biennial phase, and 72% in the fully biennial. Malling Jewel showed the least response in the biennial phase, with an increase of 43%, while Malling Admiral showed the greatest at 130%.

In a second experiment with Glen Clova, nitrogen was applied at three levels in the vegetative (first) year, followed by three levels in the second (fruiting) year in all combinations with the first year treatment. Fruit yields in 1977 showed no significant response to level and timing of nitrogen treat-

ments. In this, and in a third experiment, involving comparison of hedge-rows and stools, there was some evidence that a large yield response in the biennial fruiting year may only be obtained if high cane numbers are produced in the vegetative year, and retained for fruiting.

Measurements were made of dry matter accumulation and mineral uptake in vegetative and fruiting canes in the annual system. This terminates a 3 year study on reasons for within-plant competition, the results of which are being prepared for a Ph.D. dissertation by C. J. Wright.

(M. R. Cormack, C. J. Wright, P.D. Waister)

01014 *Physiological and cultural factors affecting the mechanical harvesting of soft fruits*

Raspberry

Plots harvested by machine in 1976 were hand-harvested in 1977 to assess yield loss attributable to machine damage to young cane, as part of a co-operative project with SIAE. The results confirmed previous findings that loss is appreciable, and indicated two main sources. Up to 25% of potential fruiting canes may be destroyed during the harvest operation. Further substantial losses of yield came after tying in, as a result of the death of some canes and death of part of others.

Adjustment of stroke and frequency of vibration of fingers on a drum harvester failed to reduce significantly the yield depression in the following year. There was no significant difference in yield reduction following harvesting by two different machines in 1976.

Plots of four cultivars were harvested by machine throughout the season in 1977 and their yields compared with those from a parallel series of hand-harvested plots. A higher percentage of fruit was recovered from cv. Glen Isla and selection 20/54 than from either cv. Malling Orion or the American cv. Meeker. This result could not have been forecast from the screening plots in which 30-plant rows of more than 20 cultivars and seedlings were machined harvested, and hand-picked immediately after each pass of the machine. Though this method gives a useful assessment of the ease with which fruit may be removed, it does not adequately measure the effects of lateral damage, removal of green fruit, and 'holding ability' of ripe fruit. These are clearly important characteristics in evaluating suitability for machine harvesting.

Control of cane vigour by treatment with dinoseb-in-oil did not significantly improve ease of removal of ripe fruit in 13 cultivars and selections tested.

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

Fruit retention strength has previously been measured by a Correx tension gauge or by an Instron Tensile Testing machine. In both instruments the proximal end of the berry is supported on a wire C-ring and the load is applied to the pedicel. This way of removing berries may not adequately simulate the way in which the berry/plug interface is stressed when a lateral is shaken by a machine harvester. Removal by centrifugal force may more closely approximate to the action of a harvester. The centrifugal force required for fruit removal was measured by attaching berries one at a time to the periphery of a disc which could be rotated at increasing speed until the berry separated from its plug. From the diameter of the disc, its speed at the time of abscission, and berry weight, it was possible to calculate the relative centrifugal force and the fruit retention strength. The retention strength measurements for berries at different stages of ripeness were similar to those obtained previously using either the Correx or the Instron instruments. Instrumentation for these tests was kindly provided by the Department of Mechanical Engineering, University of Dundee.

(D. T. Mason)

A Fortran program was written to simulate the use of a harvesting machine on a crop of raspberries throughout the season. The inputs are the amounts of fruit ripening on successive days, the effect of the machine on fruits of different ages, various characteristics of the fruit *e.g.* its rate of loss on ageing, the weight, titratable acidity and soluble solids content of berries at different ages, together with the number of harvests and intervals between them. Summaries of the amount of fruit removed, the percentage in different age categories and its average characteristics are printed for each harvest and at the end of each series. Modelling programs available such as GPSS did not adapt readily to the simple but specialised requirements which were more akin to stock-keeping. The first series of results using inputs derived from field experience has focused attention on the importance of delaying the entry of the machine into a crop, and on the value of the holding characteristics of the fruit on the plant.

Data to test the accuracy of the model and of its inputs were collected in 1977. The machine was operated on plots of Glen Isla and Malling Jewel and, in addition to data recorded at the time, the percentage removal of fruits of certain ages is being measured on deep frozen samples; fruiting curves were established on separate plots. It will now be possible to compare values predicted by the model with those obtained in the field.

(D. T. Mason, P. B. Topham)

01019 Control of growth, yield and quality of strawberries by cultural methods and choice of genotype

National Fruit Trial 1975

The cultivars Tantallon, Troubadour and Saladin gave a positive and significant response in 1977 to defoliation after the 1976 harvest. In particular the yield of Saladin at 33 t/ha from defoliated plots was more than 90% greater than from intact plots, and higher than any other cultivar. Negative responses were obtained from ES208, cv. Jurica and cv. Cambridge Favourite.

Intact Cambridge Favourite yielded well at 24 t/ha being outcropped only by defoliated Saladin, defoliated Tantallon, and intact Jurica. Saladin and cv. Hapil again produced the largest berries and this characteristic, together with a very large increase in number of trusses per crown on defoliated plots, contributed to Saladin's achieving the highest yield in the trial for the second year running.

Crop Management

Preliminary investigations into defoliation in the first growing season of spring-planted strawberries grown as spaced plants suggest that berry size can be increased by defoliation although this may be at the expense of crown numbers per plant.

(M. R. Cormack, H. M. Lawson)

Runner production

The rate of runner production from strawberry mother plants at Invergowrie is being compared with that of similar plants growing under the warmer conditions of Auchincruive. Mother plants were grown in U.C. compost in raised beds to eliminate soil differences, and water was not allowed to become a limiting factor. Runners will be lifted in spring 1978, graded for size and planted at Invergowrie to assess their cropping potential (in co-operation with the West of Scotland Agricultural College, P. J. Dudney).

(D. T. Mason)

01008 Physiological disorders of soft fruit

Strawberry pith necrosis and crown death

Field experiments following the 1968-69 survey of pith necrosis and crown death have not increased our understanding of this problem. The effects of potassium sulphate and gypsum are being tested on two sites in Angus and two in Perthshire, in co-operation with the East of Scotland College of Agriculture.

01040 Post-harvest handling of soft fruit

The results of post-harvest studies on raspberries carried out jointly with FRI, suggests that a considerable proportion of the storage rots arise from sources other than the latent infections initiated at flowering time. This project has now been terminated, but the Mycology Section has commenced some detailed studies on the timing and nature of infection.

(D. T. Mason)

01012 Ecology of new crops for Scotland

Blackberry

Biennially cropped plots of Ashton Cross yielded only 14% more than those cropped annually. Yields of both treatments exceeded 13 t/ha. In the cultivar observation plots, Ashton Cross, Bedford Giant and Tayberry all yielded at the rate of more than 10 t/ha. The North American cultivar Chehalem regularly produces high quality fruit but has lacked vigour in previous plantings. Growth has been good in a new series of plots well sheltered from wind, and yield in the first fruiting year has been at the same level as that of Ashton Cross.

Vaccinium species

Highbush blueberries planted in 1969 again produced high yields, the best cultivar (Bluecrop) giving 13 t/ha. Despite dry conditions early in the season, the crop did not respond to irrigation in 1977, and there was no beneficial carryover effect from the irrigation in 1976. Stem canker caused by *Godronia cassandrae* was a significant problem during the early years of the plantation but appears to be less damaging to established bushes.

Mentha species

Hay samples from plots of *M. piperita* and *M. rotundifolia* were distilled at Dundee College of Technology, and the oil submitted for commercial analysis. *M. rotundifolia* oil was not considered a useful substitute for imported spearmint oil, but that from *M. piperita* was ranked equal with the better American peppermint oils. Potential yield levels for the crop will now be examined.

(M. R. Cormack)

01042 Statistical studies in plant variation

Preliminary investigation of a uniformity trial of strawberry involving over 6000 plants has shown that for two variates in the first year, crown number and truss number, there were only slight correlations between neighbouring plants; as would be expected there were no indications of competition at this early stage.

(P. B. Topham, H. J. Gooding)

01044 *Statistics (Service)*

Usage of the GLIM package to analyse discrete data, counts and dilution series increased, and a computer routine was written to complement the output by calculating standard errors for linear functions of parameters.

Possible block/treatment interactions in disease control experiments were explored by various techniques including some derived from analysis of genotype/environment interactions, and from the examination of residuals.

The relationships between yield components in strawberry measured from samples prior to harvest and the achieved yield were investigated to see if there was any evidence of sampling bias. It was concluded that, although sampling was unbiased, factors which had not been quantified were involved in reducing the actual yield from that to be anticipated on the basis of the yield components.

Advice was given on the application of multivariate techniques to topics which included an examination of fruit quality in blackcurrant genotypes using chemical and morphological characteristics, the segregation of joint resistance to Cassava Mosaic Disease and Cassava Bacterial Blight by analysis of resistance scores recorded on the same cassava progenies at different dates, and morphological variation in fruiting-lateral characteristics of red raspberry cultivars in relation to position on the cane.

J. B. Cowan repeated his internal course in elementary statistics. Two groups, about 30 people altogether, attended a series of eight lectures; participants reported an increase in comprehension and consultants a welcome increase in people seeking advice, especially in the early stages of experiment planning.

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

01045 *Use of computing facilities*

At the beginning of June a PDP 11/10 remote job entry terminal was installed. The computer terminal consists of a processor with 16K store, a card reader (300 cards per minute) a line printer (300/600 lines per minute) and a console. The terminal can be linked via the ERCC communications network to both the Edinburgh main frame computers and to the Northumbrian Universities computers at the same time. It can send and receive data simultaneously.

Despite a card reader fault which disrupted service during early December, the average time taken to complete a job dropped from 7.6 days to 3.9 over a comparable period. Users are generally very pleased with the improvement and much more inclined to investigate small but important bodies of data

more thoroughly. The number of jobs rose by 4%, to 960; 84% of these were batch jobs, using established program packages at NUMAC, and involving the analysis of 9600 variates. Many of these variates are analysed in order to check the data for errors, rather than for their intrinsic interest, and attention is being paid to the steps in this process in the case of agronomic experiments involving repeated harvests to see whether economies can be made without reducing efficiency.

The Wang programmable desk calculator continued to be much used; it was in operation for 404 hours. The first balance with teletype interface arrived at the end of the year.

	1976		1977	
	Jobs	%	Jobs	%
Crops Research	620	67.0	582	60.4
Plant Breeding	145	15.7	200	20.2
Mycology	80	8.6	130	14.4
Zoology	69	7.5	31	3.1
Virology	11	1.1	17	1.9
	<hr/>		<hr/>	
	925		960	

Information retrieval

The various projects have been beset by computing difficulties mainly due to transfer to the ICL2980. Since the files involved are too large for EMAS, we have been forced to use the 2980, and despite much assistance, the combined problems of an unfamiliar operating system, rudimentary communications and data transfer have made progress almost impossible. Such little experience as we have been able to acquire of FAMULUS suggests that the package itself is very suitable for our needs. A considerable number of enquiries about BOTBIB, the *Botrytis* bibliography, have been satisfied using TRIAL.

(R. J. Clark, P. B. Topham)

PLANT BREEDING

D. L. JENNINGS

A beneficial result of the severe spring frosts which devastated the English blackcurrant crop in 1977 was that they highlighted important differences in spring frost susceptibility between such standard black currant cultivars as Baldwin and Green's Black and the new cultivars Ben Lomond and Ben Nevis which were bred at SHRI. This was shown both at the NFT, Brogdale and at Luddington Experimental Station. These trials also showed the advantages of frost avoidance by selections which began flowering up to 25 days later than Baldwin and yet ripened at the same time. Growers are consequently showing considerable interest in our black currant programme and we have responded by propagating a number of promising selections for early trial.

Following the retiral of C. North the section's work on bulbous ornamentals is being phased out. The resultant reorganisation of staff has strengthened certain aspects of the *Ribes* and *Rubus* projects.

03001 *Strawberry: breeding and associated genetic studies*

Screening for disease resistance

A trial, which involved 25 cultivars and selections, was planted in heavily red core infested land and scored for vigour and foliar symptoms of red core disease 16 months after planting. With the objective of reducing the number of plants required to assess field resistance to the disease only five replicates of single plants were used. However, although significant differences were obtained between the highly resistant cultivars Marmion, Olympus, Saladin and Troubadour, and the susceptible cultivars Redgauntlet and Cambridge Vigour, the standard error was relatively large so that a higher number of replicates will be used in future.

The average yields of the new cultivars, grown in replicated trials on heavily red core infested land, were Saladin 12.6, Silver Jubilee 9.8, Tantalion 9.9, Troubadour 19.5 t/ha respectively.

Fruit quality testing

Penetrometer readings on fruit are determined by skin strength and tissue resistance and provide an indication of the firmness and likely susceptibility of selections to bruising. Selection DZ66, a fifth generation derivative of a small, soft-fruited but highly red core resistant clone *Fragaria virginiana* I, proved to be exceptionally firm, even exceeding Totem a firm Canadian cultivar. It also showed promise in jamming tests as a possible replacement for imported cultivar Senga Sengana. It was early cropping but somewhat low yielding when grown as spaced plants, and may prove uneconomic to pick commercially.

Tests on fruit blast frozen at the WSAC indicated that the drip loss of Silver Jubilee was about 30% of cv. Cambridge Favourite and the lowest of all 27 seedlings and cultivars tested. Of 15 selections tested, only one had a higher drip loss than Cambridge Favourite indicating that selection can effect a considerable improvement on this aspect of freezing quality: two selections, G67 and FT88 proved superior to Tantallon and Saladin.

A likely new selection objective for fruits, particularly for mechanical harvesting, is the earlier development of red flesh, although fruits must not become excessively dark if left on the plant.

Mechanical harvesting

Trials with the MSU/CML capper at Auchincruive in 1976 showed that long and strong pedicels on easily decapped and necked fruit were desirable when selecting for machine decapping. With easily decapped fruit this machine preferentially removes the calyx by means of counter-rotating rollers but, if difficult to decap, the roller mechanism carries the fruit by the pedicel to a band knife which slices off the calyx. Selections especially suitable for both decapping methods should give maximum output.

Pedicel strength and decapping properties were measured in 1977 using a modified Correx tension gauge, with samples of hand-harvested trusses being taken for comparison to Norfolk for assessment on the machine decapper. It was found that these measurements could be taken as a guide to predict the performance of a selection when machine decapped. The standard processing cultivar Cambridge Favourite, which was easily decapped by hand, had a high proportion (45%) of its fruit roller decapped. However, due to the shortness of its pedicels and slightly sunken calyx, decapping by band knife was poor. Selection R115, of similar characteristics to Cambridge Favourite, performed in the same way on the decapper. Conversely Tantallon, which is more difficult to decap by hand, proved readily decapped only by the band knife, because it has strong, long pedicels on slightly necked fruit. Selection 65L111 combined the desirable characteristics of Tantallon and Cambridge Favourite, whereas other selections proved to be less suitable; when machine tested it was found to decap well, both by roller and knife mechanism, having long pedicels and necked fruit.

Advanced selections

Of 145 seedlings grown as four plant units in polythene tunnels, 26 proved to be of interest for breeding and for further field assessment. Selections from family 70PT cropped well with easily and cleanly decapped fruit suitable for processing. Unfortunately, being rather small-fruited, they will need to be crossed with selections having larger and earlier fruit to breed a very early, mechanically harvestable cultivar. For dessert use WT17, YH12, GU120 and GU171, from cultivar Gorella X red core field resistant lines, have proved interesting for further testing, having the large size of Gorella combined with firm attractive fruit.

Recent crosses

As the newly named cultivars are for main or late main season cropping, the new crosses made during the year aimed at extending the season by involving new early and late-fruiting continental cultivars.

Because improvement in fruit size accompanied by firmness is required for dessert outlets, the recognition of a Beltsville selection which combines these characteristics to a remarkable degree could prove valuable.

Meristem culture

Meristem culture has been employed increasingly for the *in vitro* propagation of our virus-tested selections. This technique allows the multiplication of stocks at all times and ensures a high health status in propagating material. When the facilities are fully developed, it is planned that only *in vitro* propagated plants will be despatched from the Unit. A modified culture medium, however, may be necessary for success with the new SHRI cultivars but, despite difficulties, 70 micro-plantlets or plants derived from them have been sent to ESCA, NSDO and trial centres for further propagation.

03003 *Strawberry: breeding systems*

Recurrent selection programme

The original programme was based on crossing five selections from each of two families designated G and AQ. Whilst three selections from family G, used as parents, have been named, all those from family AQ have been discarded. Family AQ transmitted proneness to June Yellows and, to a lesser extent, abortive flowers and woolly fleshed fruit and these problems led to the eventual abandonment of the programme. The few selections which remain are unlikely to become cultivars and serve only to confirm the decision to choose a substitute family for crossing with the G selections.

Family DZ was chosen as the replacement because of its high level of field resistance to red core, earliness, concentration of ripening and firm, red-fleshed fruit. The DZ selections have proved superior parents to the AQ selections when crossed with the G's. The parental values for yield components indicate that the DZ's transmit high values for fruits per truss, and high truss numbers per plant are obtained from individual parents of both gene sources.

Saladin (G52) continues to transmit large fruit size. Of the 10 parents used Saladin and DZ103 were the most promising both for future breeding and for potential cultivars. Saladin when selfed produced the most uniform and best family from among the selfed parents.

(H. J. Gooding, R. J. McNicol, D. MacIntyre)

03006 *Raspberry breeding and associated genetic studies*

Breeding for improved yield and growth habit

The most promising advanced selections in 1977 included 6820/54 and 6820/64, which yielded well in the NFT, and 7210/204, 7133R/40 and 719/9,

which showed promise in observation plots. Of these, 7210/204 was notable for its earliness and fruit quality and 7133R/40 and 719/9 were notable for high yield, compact habit and suitability for machine harvest. In tests by Crops Research Section both the quality and the removal of fruit achieved by harvesting with the Agricultural Sciences machine were particularly good for 7133R/40 and 719/9, apparently because they have both firmness of fruit texture and easy fruit abscission. Further selections with this combination of characters were chosen for inclusion in new observational plots. Further selection was also made for genotypes with either a strong expression of a particular yield component, or a high yield potential achieved by a good combination of yield components. Several selections notable for their high lateral numbers per cane were obtained from families derived originally from cv. Carnival but now three generations removed from this cultivar. It is interesting that high expression of this characteristic has been maintained through these generations and an inheritance study is in progress. These selections are being crossed with genotypes notable for their high yield per lateral in an attempt to improve yield potential further.

Studies were made of the incidence of 'multilaterals'—the occurrence of more than one lateral at a node—in nine families raised from five parents selected for high expression of this character in 1973. The means for families derived from three of them were above average for this character, indicating that the differences were heritable, but inheritance appeared to be complex because only a few plants showed a high expression. By contrast, families derived from a 'compact' parent which had an exceptionally high number of fruiting nodes had inherited a high expression of this character, indicating that dominant genes were involved.

Disease and pest resistance

Plants inoculated in the glasshouse with *Leptosphaeria coniothyrium* in 1976 were observed for lateral development in 1977. In general, lateral development in genotypes with small lesions in 1976 was relatively normal and failures of bud burst and lateral elongation were confined to the vicinity of the lesion. This indicated that internal damage was also slight and was related to the lesions' external length. *R. mesogaeus* was exceptional in having large lesions but good lateral development. The results confirmed that *R. pileatus*, *R. mesogaeus*, *R. coreanus* and the raspberry cv. Latham are potentially useful sources of resistance.

In an attempt to evaluate progenies of Latham, a field experiment was done in which five inoculations per plant were made on 1 July 1977 on three families: Latham selfed (19 genotypes), Latham x susceptible (38 genotypes) and susceptible x susceptible (36 genotypes). The mean size of the resultant lesions after one month was 43.0, 48.3 and 52.9 mm respectively, indicating that resistance tended to be only moderately effective. In the second family there was an indication of segregation for a major gene determining lesion

size. This is being studied further. A glasshouse experiment in 1977 indicated that the difference in lesion size for canes of Latham and the susceptible cv. Glen Clova was considerably influenced by inoculation date: it was not significant following July inoculation but highly significant following August or September inoculations. This suggests that resistance was effective only in relatively mature canes and that late field inoculations would be more discriminating.

Further glasshouse tests confirmed that stronger resistance than that of Latham occurs in *R. pileatus*, *R. mesogaeus* and possibly in *R. coreanus* and *R. cockburnianus*, and crosses between each of these species and the raspberry were made to test for resistance in the F₁ hybrids.

Plants of these species were also inoculated with agar inocula of *Didymella applanata* and *Botrytis cinerea* to obtain information on resistance to these pathogens. Measurements of lesion sizes indicated that *R. pileatus* was resistant to both pathogens while *R. mesogaeus*, *R. coreanus* and *R. cockburnianus* were resistant to *B. cinerea* but not to *D. applanata*.

Fruit from 14 genotypes of raspberry were compared for the incidence of fruit rot pathogens on five harvest dates by holding three replicates of 30 fruit at 20°C for 6 days. The incidence of *B. cinerea*, *Cladosporium* spp. and *Rhizopus* spp. was high enough for useful comparisons in samples harvested on 9 and 16 August only, when the mean percentage incidence of *B. cinerea* ranged from 51.2 to 96.0 with an overall mean of 77.4. The lowest percentage (51.2) was in genotype 7269/67, an advanced selection with very firm fruits, and a high percentage (86.4) was found in M30, which has been reported to be highly resistant in British Columbia. The mean incidences of *Cladosporium* and *Rhizopus* were only 28.3% and 11.2% but genotype 7269/67 showed a particularly high incidence of *Rhizopus*. Crosses were made to introduce genes for resistance to *B. cinerea* from *R. crataegifolius*, which has shown high resistance in Russia.

Tests were made to detect resistance to the raspberry beetle (*Byturus tomentosus*) in raspberries at the flowering stage. No resistance was detected among eight F₁ hybrids between black raspberry and red raspberry, but low larval counts were obtained for five first backcross hybrids derived from *R. coreanus*, supporting earlier evidence that resistance is being obtained from this species. Unequivocal results were obtained for seven derivatives of *R. phoenicolasius*.

(D. L. Jennings, A. Dale, Eleanor Carmichael)

Raspberry leaf spot virus (RLSV) and raspberry leaf mottle virus (RLMV) induce symptoms in some raspberry genotypes and infect others without inducing symptoms. Studies were continued to determine the genetic control of these differences, and further evidence was obtained to support the hypothesis that two dominant genes, designated *Ls* and *Lm*, confer the

ability to react to RLSV and RLMV respectively; segregation for genes *Ls* and *ls* was detected in cv. Glen Clova but not in the cultivars Lloyd George or Carnival and segregation for genes *Lm* and *ls* was detected in cv. Malling Landmark but not in Lloyd George, Glen Clova or Carnival. The characteristic symptom induced by both these viruses is a leaf mosaic, but some families included genotypes which developed a non-typical tip necrosis. The significance of this result is being investigated.

Tip necrosis is the characteristic symptom of black raspberry necrosis virus (BRNV) in black raspberry, and to study the inheritance of this reaction F_1 and F_2 generation hybrids from the cross of red raspberry x black raspberry were tested for their reaction to BRNV. Most of the F_1 hybrids tested remained free of symptoms but some showed a mild transient mosaic; of 51 F_2 hybrids grafted, 34 remained symptom free and 17 showed a severe mosaic but none showed tip necrosis within three months of grafting. A possible hypothesis is that a recessive gene or genes confer the ability to react, but that other genes in the black raspberry determine the tip necrosis symptom while genes in the red raspberry determine the mosaic symptom. This hypothesis is being tested.

Certain cultivars such as Viking and Cuthbert are immune from raspberry vein chlorosis virus (RVCV) and the inheritance of this immunity was studied in four families obtained by crossing these two cultivars with Malling Delight, a susceptible cultivar, and by selfing Malling Delight and Viking. Viking appeared to breed true for immunity, but the three families derived from Malling Delight each segregated for immune and susceptible genotypes. An hypothesis which would explain these results is that immunity from RVCV is conferred by a single recessive gene and that Malling Delight is heterozygous for it. This hypothesis is being tested by studies on other families.

(A. T. Jones, D. L. Jennings)

03008 *Breeding early erect blackberries and other hybrid Rubus berries*

The most interesting blackberries to fruit for the first time in 1977 were families derived from the American cv. Comanche; these have inherited the latter's very erect habit and early flowering, and selections from them were productive of good quality fruit. The spinefree progenies fruiting for the first time were generally too late and frequently sub-fertile, but some promising selections were made. The flowering dates of genotypes noted for early flowering in 1976 were considerably later in 1977, and in some instances the effects of delayed flowering were aggravated by slower ripening because ripening occurred when summer temperatures were beginning to fall. This emphasised the need for earliness of ripening to be based upon quick maturing as well as early flowering, and so the main objective of new crosses was again to combine good expression of both these characters.

Rubus glaucus, the Andean blackberry, is a tetraploid which has some characters typical of a raspberry and some typical of a blackberry. Analyses showed that its anthocyanins include cyanidin -3-sambubioside and cyanidin -3-xylosylrutinoside, two forms characteristic of black raspberry and not found in blackberries or red raspberries. It therefore seems likely that the species is a natural hybrid between a black raspberry and a blackberry. It is notable for its excellent flavour and was crossed with tetraploid spinefree selections of both raspberries and blackberries in an attempt to introduce an improvement in this respect.

Further study was made of the problem of colour change from black to red in frozen blackberries. For the genotypes studied the fruits which retained their black colour had a higher pH and a higher solids content than those which became red, suggesting that they were more advanced in ripeness when harvested. However, large differences between genotypes also occurred and these could not always be associated with differences in pH or in solids content. The cultivars Bedford Giant and Marion were the most affected but certain genotypes being used in the breeding programme were affected much less. Segregation for this tendency is therefore expected to occur among the breeding material.

Segregation for plants with a dwarf determinate habit occurred in two families of hybrids obtained by crossing the octoploid blackberry cv. Aurora with two tetraploid raspberries. Twenty eight out of 304 genotypes made normal growth until early July and then formed a rosette of short internodes which added little to their height. The remaining plants continued to grow indeterminately until the end of the season, at which time the average cane height of the two types was 121 and 238 cm respectively, canes of the determinate form being erect and those of the indeterminate one completely prostrate. Although the average height of the determinate plants was low, there was a range adequate for selection of relatively tall plants and further breeding from these offers the possibility of producing a compact, erectly growing cultivar of the Tayberry type.

The other improvement sought in hybrid berries is spinelessness, and to achieve this it is desirable to introduce a dominant gene for spinelessness into tetraploid raspberries or octoploid blackberries. Such a gene occurs in diploid species of the *Anoplobatus* sub-genus, which contains the flowering raspberries. Hybrids between the raspberry and *R. parviflorus* of this sub-genus were produced, and successfully treated with colchicine to produce tetraploids suitable for a programme of backcrossing to tetraploid raspberries. *R. parviflorus* was also crossed with a tetraploid blackberry, using the latter as maternal parent. The resultant progeny contained two distinct types of plant, one vigorous, spinefree and thought to be pentaploid and the other weak, spinefree and thought to be triploid.

(D. L. Jennings, Eleanor Carmichael, A. Dale)

A beneficial result of widespread and severely damaging spring frosts in England was that attention was drawn to those cultivars and selections on trial at both Brogdale NFT and Luddington EHS which were much less severely damaged than either cv. Baldwin or cv. Green's Black; either because they flowered later in the season, thus avoiding the most damaging frosts, or because the flower buds and flowers were less susceptible to low temperature injury. At both centres, cv. Ben Lomond began flowering about 17 days later than Baldwin and cropped at 8 t/ha (Baldwin 1.2 t/ha), and at Luddington EHS cv. Ben Nevis began flowering 8 days later than Baldwin and cropped at 6 t/ha. SHRI 93/28, an unnamed sister seedling of Ben Lomond and Ben Nevis had a flowering season almost identical to Baldwin and still cropped at 5.2 t/ha.

In a non-replicated observation plot of 32 genotypes at Luddington EHS, SHRI 238/36/14 (a late-flowering relatively early-maturing cv. Goliath x cv. Öjebyn hybrid), began flowering 25 days later than Baldwin and 9 days later than cv. Malling Jet. It was first picked on the same date as Baldwin, and cropped at 15.2 t/ha (Baldwin 5.9 t/ha). The interval between the dates of first flowering and picking was 87 days for 238/36/14 and 112 days for Baldwin. This selection, along with SHRI 7/189 (cv. Brödorp x cv. Amos Black), is currently being intensively propagated for commercial appraisal in the early 1980s.

Two productive, good quality, disease-resistant hybrids derived from Primorsk Champion, a cultivar bred from *Ribes dikuscha* in the USSR were submitted for trial to Brogdale NFT and Luddington EHS. These selections may be suitable for mechanical harvesting with a New Zealand Peco-type harvester.

It is pleasing to record that SHRI cultivars and selections grown at Agassiz, British Columbia have stimulated the interest of commercial growers in the cultivation of black currants.

Productivity, late flowering and season of ripening

Progenies of 238/36/14 crossed with ND17/7 (a second backcross *R. dikuscha* hybrid), Ben Lomond and cv. Westra were of particular interest because they combined high productivity and extremely late flowering with a relatively short period for fruit development and ripening. Fruit quality generally was satisfactory in the Ben Lomond and Westra hybrids but poor in the ND17/7 hybrids.

Of three late-flowering selections derived from two complex progenies of Seabrook's Black, one is prone to 'running-off' whilst two are notable for high ascorbic acid content combined with excellent juice colour, but suffer from an excessively spreading growth habit. Progenies of these selections crossed with Westra were subject to stringent selection in nursery rows for

disease resistance and erect habit and the survivors will bear their first crop in 1978.

Late-flowering hybrids of 7/189, 238/36/14, Ben Lomond, Seabrook's Black and a late-flowering accession *R. hudsonianum* have been used in further breeding.

Productivity, plant habit and premature fruit drop

Although spring frosts at SHRI were not a problem during the flowering period, low temperatures, cold winds and rain resulted in considerable premature fruit drop. Among hybrids previously considered promising for their freedom from the problem losses rarely fell below 15%, but loss of flowers in Brödorp, N43/6, Baldwin and Seabrook's Black averaged 21, 31, 35 and 51 %, respectively. One outstanding Westra x N43/6 hybrid from a population of 300 combined the desirable qualities of both parents, and another elite hybrid was selected from a progeny which combined germplasm from *R. nigrum*, *R. dikuscha*, and *R. bracteosum*.

Several progenies of Westra selected for plant habit combined with disease resistance cropped for the first time. The trend noted in last year's Annual Report was confirmed, at least in the first year of cropping, namely that very few plants with a Westra-type habit were sufficiently productive, though there were some which were highly productive but slightly less erect. Another common failing of these hybrids was an excessive production of shoots from the stools.

Resistance to gall mite and reversion disease

Hybrids of *R. nigrum* x *R. grossularia* and *R. nigrum* x *R. nigrum sibiricum* exposed for 2 years to natural infestation by infective mites were screened for galled buds in February-March and non-galled plants were later screened for symptoms of reversion virus. Twenty-two gall mite resistant and reversion-free hybrids were retained in the infestation plot for a third year's observation.

Fruit quality

Four hundred genotypes were assessed in 1976 for ascorbic acid content, juice colour, specific gravity, pH and juice volume per 100 g berries; 87 of them were also assessed for seed numbers and seed weight per berry, and a further 48 for gross polyphenols and tannins. Eight genotypes, including Ben Lomond and Ben Nevis, were superior to Baldwin for ascorbic acid content, 49 were superior to the best sample of Baldwin for juice colour, and 4 showed a better combination of ascorbic acid content and juice colour.

A study was made of the inter-relationships of several fruit characteristics. It was found that both ascorbic acid content and specific gravity were positively correlated with pH and negatively correlated with juice yield per

100 g fruit; that juice colour was positively correlated with ascorbic acid content and negatively correlated with berry weight while pH was negatively correlated with both berry weight and juice yield per 100 g fruit. Thus high values for ascorbic acid content, juice colour, specific gravity and pH were all associated with low juice yields from small berries. Other relationships found were that gross polyphenols and tannins were positively correlated with one another and with specific gravity, and negatively correlated with juice volume per 100 g fruit, and that seed weight as a percentage of berry weight (but not mean seed weight) was positively correlated with ascorbic acid content, specific gravity, pH, gross polyphenols and tannins, and negatively correlated with juice volume per 100 g fruit.

(M. M. Anderson, Judith Thomson)

03010 *Genetics of S-allele incompatibility system in
Brassica oleracea*

Partial self-compatibility in Brassica oleracea

Analyses were done on the numbers of seed set on progenies obtained by intercrossing or selfing eight inbred lines, each homozygous for one of four different S-alleles. The results showed that most of the differences between the progenies could be attributed to differences between the parents (general combining ability), but there were also significant differences attributable to the effect of selfing. Parents homozygous for highly recessive S-alleles tended to produce progenies with high levels of self-compatibility but there were significant differences between parents homozygous for the same S-allele. The level of partial self-compatibility of progenies heterozygous at the S-locus suggested that there was no allele interaction.

It has been reported that a heated small soldering iron applied to a self-pollinated stigma can aid seed set in self-incompatible *Brassica oleracea* inbreds ('thermally aided pollination' or TAP). Various TAP treatments were therefore compared with cross and self pollination of cabbage and Brussels sprout plants. Seed set and pollen tube penetration were used to assess the treatments, but in no instance was a TAP treatment significantly beneficial. The stigmatic papillae were affected by all treatments, appearing shrivelled after a short application of heat and being burnt off by prolonged application.

03011 *Brussel sprouts: breeding hybrid cultivars*

Yield components

In destructively harvested Brussels sprouts, uniformity of sprout size within the size grades acceptable for processing is important for producing maximum

yield. Previous work has shown that there are clear differences between cultivars for sprout uniformity and that sprout size is closely correlated with sprout weight. In order to investigate these differences further and to devise a sensitive measure of uniformity for inheritance studies, the fresh weights of five sprouts were measured from each of three zones of the stem: bottom—positions 11-15 from base, middle—positions 21-25 from base, top—positions 41-45 from base. Measurements were made on eight occasions between July and December for ten cultivars.

The most uniform cultivars had a short time span between the initiation of rapid sprout growth from top to bottom of the stem, and a similar rate of sprout growth at all three positions. The least uniform cultivars were those with very different growth rates for sprouts at the middle and top zones. In all cultivars, including the early maturing cultivars, growth rates of sprouts at all positions tended to decline at the same time, the smaller sprouts at the top showing no tendency to 'catch up' with those from the middle or base.

Preliminary results from the 1976 experiment on the inheritance of certain yield components in Brussels sprouts (Ann. Rept 1976) suggested that differences in the shape, appearance and morphology of the sprouts of the ten parent cultivars were probably inherited. This experiment will be repeated in 1978, and in preparation for this the characteristics of sprouts in the parent cultivars were studied. Clear differences were found for sprout colour and shape and for core size, leaf number, leaf area and leaf thickness. These differences were consistent within cultivars for sprouts of a range of sizes.

Five progenies of the half diallel grown in 1976 were selected on the basis of their final yield, height and sprout number, and ten plants from each were intercrossed at random to give a further generation of progenies for assessment in 1978.

(T. Hodgkin)

Improvement of glossy inbred lines

Fifteen pair crosses and all possible selfs were made on flowering cuttings of plants selected in 1976 within the cyclic single cross programme. The low number of pairs available, due to poor winter survival, necessitated resowing certain families. These were sown in a greenhouse and 12 weeks after germination 3 inch apical cuttings were removed and rooted. Following artificial vernalisation these were self pollinated. Green seed was removed 12 weeks later, germinated immediately and progenies tested for segregation of glossy foliage. Stock plants were planted out soon after taking cuttings and those found to be heterozygous for a glossy gene were lifted for flowering in 1978. This scheme replaces the need for retaining plants for progeny testing in one year followed by seed production the following year.

(A. J. Redfern)

03012 *Cabbage: breeding hybrid cultivars*

A trial of progenies and control cultivars was used for further assessment of superior combinations between a number of savoy cabbage inbred lines and the 'DK' and 'S' parent lines of cv. Celtic Cross. The maturity periods of the hybrids were related to the relative maturity periods of the savoy cultivars from which the inbred lines were derived and ranged from early October (Dwarf Ulm) to mid January (Alexanders No. 1 Late group progenies.). The 'DK' hybrids were later maturing, more winter hardy and erect but generally had looser heads and longer cores than the 'S' hybrids. The latter were very vigorous and tended to lodge.

Hybrids of the 'DK' and 'S' lines with first generation white cabbage cultivars and with inbred cabbage lines supplied by Asmer Seeds Ltd. were also grown in trial.

All trials showed an unusually high incidence of internal necrosis of cabbage heads. This damage first appeared in the earliest maturing lines soon after they reached maturity, in early November. No bacteria were associated with the damage, which is probably physiological and analogous to internal browning of Brussels sprouts.

External damage was not closely linked to maturity date and some early progenies stood very much better than certain late ones, which were winter killed as soon as they matured.

Intercrosses and selfs of 33 inbred savoy-cabbage lines were made to produce a partial half diallel for further genetical studies of maturity and factors affecting head characteristics. The material will be grown in 1978. Self compatibility and fertility assessments of the inbred lines were also made.

(A. J. Redfern, A. B. Wills)

03013 *Brassicac: isoenzyme analysis in Brassica oleracea*

Previously unexamined inbred lines and experimental and named hybrids received from British and Dutch seed houses were analysed for acid phosphatase in seeds and seedlings. Further determinations were done also on hybrid seeds from commercial crops of Brussels sprout and cabbage of known acid phosphatase genotypes. Results were similar to these previously obtained and, taken with results from the pilot testing scheme (Ann. Rept 1976), confirmed the suitability of the method for routine estimation of sib frequencies in hybrid brassica seed crops. Technical staff from five seed houses (British and Dutch) were given practical instruction in the technique.

Acid phosphatase isoenzyme band mobilities were compared in seeds of diverse origin, using brilliant yellow as a tracker dye. In addition to the four bands already known, a fifth, rare, band was found in wild cabbage. Leaf

(zone 7) acid phosphatase isoenzymes were similarly compared and their segregation analysed in F2 and backcross progenies of cv. Celtic Cross. Results were consistent with control at a single locus but further genetical experiments are planned because some allelic combinations have not yet been found.

Acid phosphatase was analysed in seeds and cotyledons of open pollinated varieties of *Brassica campestris*. Both tissues gave banding patterns resembling those of *B. oleracea*, indicating that gene control in these two species is similar but that band mobilities generally differ.

(Eveline M. Wiseman, A. B. Wills)

03015 Brassicac: genetics and cytology of Brassica oleracea

The search for linked markers for each chromosome of *B. oleracea* was continued. Progenies segregating 14 major genes were grown and 34 previously untested pair combinations were obtained, but none showed linkage. Included among the segregating genes was one for fused cotyledon (fc), which may facilitate the assessment of sibbing rates in F1 cultivars, because it can be recognised soon after germination. However, some progenies expressed this character poorly and its value is therefore doubtful. Fused cotyledon was shown not to be linked to le, Go-1, Hr-1, pg-1 or Fn. Among the more important of the remaining combinations that were independently inherited were Fn and Go-1, le and Go-1, Hr-1 and Go-1, Fn and Wh, Fn and cp-1 and Hr-1 and cp-1.

The first series of triploid plants obtained by crossing tetraploid and diploid calabrese had unstable numbers of chromosomes (Ann.Rept. 1976), but subsequent crosses gave stable triploids. These were crossed to diploid plants to obtain aneuploids. Only three seeds were obtained from 98 $3n \times 2n$ pollinations while 59 reciprocal pollinations yielded 68 seeds. The chromosome numbers of six seedlings grown from these seeds ranged from 17 ($2n-1$) to 22 ($2n+4$). It is intended to use these plants to establish trisomic lines to aid cytogenetic analyses.

(A. B. Wills, P. Smith)

03019 Calabrese breeding

Experiments to assess the partial self compatibility of field grown plants (Ann. Rept 1976) suffered severely from birds, pathogens and drought. Nevertheless, comparisons could be made between seed set on bagged and unbagged inflorescences of 213 plants. A mean selfing rate of 0.3 seeds per flower site occurred on bagged inflorescences compared with a mean out-crossing rate of 1.6 on unbagged ones. Twenty per cent of the plants set less than 0.05 self seed per flower site but these also produced less than average

(i.e. 1.2 seed per flower site) when outcrossed. By contrast, the highly self compatible plants set more than 3 self seed per flower site and set above average (i.e. 3.3 seed per flower site) when outcrossed.

The standard practice of lifting field grown material for pollination under glass has not proved suitable for calabrese plants grown to mature in late summer, due to pests and diseases and poor seed setting at the end of the year. Materials to initiate a programme of improvement by recurrent selection were therefore grown in the glasshouse. These have been selfed and test-crossed to the cultivars Bravo and Corvet to produce progenies for the first cycle of selection.

(A. J. Redfern, A. B. Wills)

NEW CULTIVAR OF HYBRID BERRY
TAYBERRY

The Scottish Horticultural Research Institute and the National Seed Development Organisation Ltd. have applied for Plant Breeders Rights for a new hybrid berry, to be known as the Tayberry, bred at the Scottish Horticultural Research Institute.

Stocks are being propagated by the Scottish Nuclear Stock Association Ltd. for commercial use and by a consortium in England for the amateur market.

Breeders's number 69102/51

- Origin* From a cross between the octoploid blackberry cv. Aurora and 626/67, a tetraploid raspberry of complex origin bred at SHRI.
- Canes* Vigorous, sturdy shoots produced in moderate to high numbers, spreading in young plants and later tending to become semi-erect. Dark green with anthocyanin pigments frequently intense and with dense, moderately sized and intensely pigmented spines. Sub-glabrous and weakly glaucous. The strong intensity of purple colouring is a characteristic of dormant canes.
- Leaf* Medium to deep green, frequently with red pigment, usually around margins. Petiole frequently red-tinged.
- Fruiting laterals* Usually about 1 foot long and displaying fruit well.
- Fruit* Very large, purple and long conical with high drupelet number. Medium firm, slightly glossy and highly flavoured. The plug is long conical and remains with the fruit when picked.

<i>Season of ripening</i>	Early (equivalent to a mid-season raspberry) and extending over a long period.
<i>Mode of propagation</i>	By root cuttings, leaf-bud cuttings or rooted stem tips.
<i>Yield</i>	Mean yield at SHRI for 1976 and 1977 was 10.9 t/ha.
<i>Use</i>	Dessert, freezing and jam manufacture; less satisfactory canned.
<i>Identification</i>	Distinguished from the Loganberry by the greater intensity of red pigments in young leaves, around the margins of older leaves, in the petioles and in dormant canes. Fruit are larger and more long conical, and ripening commences earlier. Fruiting laterals are longer.

FOUR NEW STRAWBERRY CULTIVARS

SALADIN, SILVER JUBILEE, TANTALLON AND TROUBADOUR

The Scottish Horticultural Research Institute and the National Seed Development Organisation Limited, have been jointly granted Plant Breeders' Rights for four new strawberry cultivars, Saladin, Silver Jubilee, Tantallon and Troubadour, bred at Auchincruive.

Descriptions of the new cultivars are based on a minimum of two years observation at Auchincruive of plants in their first main cropping year. All plants were grown on land heavily infested with red core disease caused by *Phytophthora fragariae*. Plants grown on sites free of this pathogen may therefore differ slightly from the following descriptions.

The terminology used is that of the International Union for the Protection of New Varieties of Plants.

SALADIN	Breeder's and NFT Number: 65G52.
<i>Origin</i>	Raised from a 1965 cross between 61AP60 and MdUS2650.
	The former was derived from Ruskin, Cambridge Vigour and Shasta and the parentage of MdUS2650 includes Blakemore, Howard 17, Midland and Redstar.
<i>Plant habit</i>	Dense, growth habit medium to erect and vigour medium to be strong.
<i>Leaves</i>	Dark to medium green, medium glossy and moderately bullate. Sometimes more than three leaflets, the terminal leaflet as long as broad. Basal angle obtuse and intermediate U to V shaped. Serrations mainly crenate with secondary serrations present, particularly towards leaflet apex. Petiole medium to strongly pubescent and pose of hairs slightly upwards.

<i>Stolons</i>	Medium in number and pigmented.
<i>Flowers</i>	Inflorescence beneath to level with canopy, flowers bisexual and medium sized. Time of flowering medium with first flowers sometimes deficient of pollen. Secondary flowers with five to six petals touching.
<i>Fruit</i>	Skin orange red, medium glossy and flesh light red to pale rose. Primary fruit wedged to conic, large and sometimes ribbed, later fruit medium sized, conic and longer than broad. Fruit firm to medium firm with good holding and transport qualities. Achenes sunken. Flavour moderate, medium sweet and medium acid. Fruit partly hidden to fully exposed.
<i>Calyx</i>	Usually level with fruit surface. Ease of removal poor, plug often not retained in fruit.
<i>Season</i>	Extended medium to late. Not remontant.
<i>Diseases</i>	High level of field resistance to red core, moderate resistance to mildew and some resistance to <i>Botrytis</i> . Susceptible in laboratory tests to <i>Verticillium</i> wilt and <i>Phytophthora cactorum</i> .
<i>Yield</i>	On red core infested land the mean yield from observation plots 1968-77 was 14 t/ha. Mean marketable yield from the NFT Multicentre Trial IV (six sites in 1976 and 1977) was 20 t/ha, more than 25% in excess of Cambridge Favourite. Post-harvest defoliation at SHRI (Dundee) following the first main crop resulted in a considerable increase in yield over intact controls.
<i>Use</i>	Having high yields of large fruit and a long cropping season it is potentially valuable for dessert including 'pick your own' outlets.
SILVER	Breeder's Number: 65G95.
JUBILEE	Number in NFT: S31.
<i>Origin</i>	Sibling of Saladin.
<i>Plant habit</i>	Open, medium to prostrate and of medium vigour.
<i>Leaves</i>	Medium to dark green, medium glossy and strongly bullate. Only three leaflets, the terminal leaflet broader than long with a very obtuse U shaped basal angle. Serrations crenate, with occasional secondary serrations. Petioles strongly pubescent and pose of petiole hairs slightly upwards.

<i>Stolons</i>	Medium in number and pigmented.
<i>Flowers</i>	Inflorescence beneath to level with canopy. Flowers bisexual and medium sized with ample early pollen. Petals on secondary flowers, five to six overlapping to touching. Time of flowering early to medium.
<i>Fruit</i>	Brick red, medium to glossy skin, size large to medium, shape longer than broad, mainly conic. Flesh pale rose to light red, medium to firm. Achenes sunken. Flavour moderate, medium acid, and sweetness weak to medium. Fruit usually exposed around base of plant.
<i>Calyx</i>	Level with surface of fruit. Ease of removal poor, often leaving the distal end of the pedicel attached to the fruit. Plug retained in fruit.
<i>Season</i>	Early to medium crop of short duration. Not remontant.
<i>Diseases</i>	Moderately field resistant to red core, slight resistance to mildew and some resistance to <i>Botrytis</i> . Some resistance, in laboratory tests, to <i>Verticillium</i> wilt and <i>P. cactorum</i> .
<i>Yield</i>	The mean yield from observation plots on red core infested land, 1968-77 was 9 t/ha. The mean marketable yield from NFT Multicentre Trial IV (six sites in 1976 and 1977) was 13 t/ha, similar to Cambridge Favourite and Redgauntlet.
<i>Use</i>	Dessert and freezing. Suitable for forcing.
TANTALLON	Breeder's and NFT Number: 65G48.
<i>Origin</i>	Sibling of Saladin.
<i>Plant habit</i>	Medium, prostrate to erect, open and of medium vigour.
<i>Leaves</i>	Medium to light green, medium glossy and moderately bullate. Leaflets three only, the terminal leaflet as broad as long. Basal angle obtuse and V to intermediate U shaped at base. Primary serrations crenate and secondary serrations occasionally present. Petioles strongly pubescent and pose of hairs slightly upwards.
<i>Stolons</i>	Few and pigmented.
<i>Flowers</i>	Inflorescence level with canopy and flowers bisexual and of medium size. Petals of secondary flowers five to more than six and overlapping. Late flowering.

<i>Fruit</i>	Glossy orange red, flesh light red to pale rose becoming dark red when over-ripe. Size medium becoming small, as long as broad ranging in shape from wedge in first fruit to conic. Medium to firm with long shelf life and good transport qualities. Achenes sunken. Flavour moderate, medium acid, not sweet. Fruit partly hidden.
<i>Calyx</i>	Level with fruit surface. Ease of removal poor but plug retained in fruit.
<i>Season</i>	Extended medium to late. Not remontant.
<i>Diseases</i>	Moderately high field resistance to red core, slightly resistant to mildew and some resistance to <i>Botrytis</i> . Susceptible to <i>Verticillium</i> wilt in laboratory tests but having some resistance to <i>P. cactorum</i> .
<i>Yield</i>	Mean yield from observation plots on red core infested land 1968-77 was 10 t/ha. The mean marketable yield from the NFT Multicentre Trial IV (six sites in 1976 and 1977) was 19 t/ha, over 20% in excess of Cambridge Favourite. Post-harvest defoliation at SHRI (Dundee) following the first main crop resulted in a considerable yield increase over intact controls.
<i>Use</i>	Canning, freezing, jam manufacture, and for dessert.
TROUBADOUR Breeder's and NFT Number: 65R70.	
<i>Origin</i>	Raised from a 1965 cross between 61AM68 (derived from Templar, Cambridge Vigour and Fairland) and MdUS2650.
<i>Plant habit</i>	Plants medium sized, of strong vigour with dense, medium to erect foliage.
<i>Leaves</i>	Medium to dark green, medium glossy and strongly bullate. Leaflets three only, the terminal leaflet as long as broad and the basal angle obtuse and V shaped. Serrations crenate, secondary serrations occasionally present. Petioles medium to strongly pubescent and pose of hairs slightly upwards.
<i>Stolons</i>	Many and pigmented.
<i>Flowers</i>	Flowering very late and inflorescence beneath leaf canopy. Flowers bisexual and medium to large. Petals of secondary flowers touching and five to more than six in number.
<i>Fruit</i>	Skin medium glossy and strong brick red becoming purple red when over-ripe. Flesh uneven pale rose when underripe becoming an even medium red to dark red.

Medium to firm, size medium to large but becoming small late in the season especially under dry conditions. Shape as long as broad, round conic to wedge, sometimes with an uneven surface. Achenes sunken. Flavour good to moderate, medium acid, medium sweet. Fruit partially hidden by foliage.

- Calyx* In a basin, easy to remove but plug sometimes not retained in fruit.
- Season* Very late, 50% harvest occurring approximately 10 days later than in Cambridge Favourite, similar to Domanil. Not remontant.
- Diseases* Highly field resistant to red core. Moderate resistance to mildew. Some resistance in laboratory tests to *Verticillium* wilt and *P. cactorum*. Susceptible to *Botrytis*.
- Yield* Mean yield from observation plots on red core infested land 1968-77 was 12 t/ha. Mean marketable yield from the NFT Multicentre Trial IV (six sites in 1976 and 1977) was 15 t/ha., similar to Cambridge Favourite but 10% above Domanil.
- Use* Processing and dessert, including 'pick-your-own'.

Identification

These four new cultivars differ from Cambridge Favourite in having longer pedicels and leaves which are darker and more bullate. Troubadour can be distinguished from Tantallon, Saladin and Silver Jubilee in having a superior runner capacity, longer petiolules, larger flowers and fruit which are more easily decapped. Silver Jubilee may be distinguished from Saladin and Tantallon by its slightly larger flowers and terminal leaflets which are broader than long and have a very obtuse base angle. Saladin is distinct from Tantallon in having darker leaves, numerous secondary leaf serrations and primary fruit which tend to be ribbed.

MYCOLOGY

R. A. FOX

High relative humidity has been shown to be an important factor in the spread of lesions of chocolate spot of *Vicia fabae* caused by *Botrytis fabae*; the pathogen has been shown to overwinter on dead plant trash and on groundkeepers.

The concept of *Fusarium avenaceum* as an important pathogen associated with die-back of raspberry canes, and previously reported as the cause of 'bud death' and 'lateral wilt' in cv. Glen Clova, has had to be modified, although the fungus does have a role in the midge blight syndrome. It now seems probable that some other symptoms of die-back, which in the past so severely affected cv. Malling Promise and occasionally other cultivars in Scotland, may be attributed to the cane blight fungus *Leptosphaeria coniothyrium* and, more recently, also to midge blight. The occurrence of latent infection of raspberry buds and flowers by *Botrytis cinerea* as a precursor to fruit rot, seems far less common than has hitherto been supposed.

Further work on the aerial spread of *Erwinia carotovora* has confirmed the importance of this mode of spread in relation to VTSC seed potato stocks.

SOIL MICROBIOLOGY AND ROOT DISEASES

02017 Biology of potato gangrene

Isolates of *Phoma exigua* var *exigua* and *Phoma exigua* var *foveata* were assayed for a wide range of enzyme activities both to reinforce histochemical observations on infected tissue and, further, to attempt to determine differences between the two varieties. In general, the results from histochemical tests were confirmed but the assays were not adequate to show major differences between the two varieties. Cellulase activity varied greatly between isolates of the var *foveata*. Cellulase levels, adequate to permit invasion of intact cells, required inocula with higher numbers of pycnospores of the var *foveata* than the var *exigua*, an observation which may relate to the apparent dominance of the latter variety in potato stems.

Surveys initiated in 1976, following observations in 1975 which suggested that contaminating bacteria might interfere with antibody production,

showed during 1976-77 that *ca.* 60% of isolates contained hitherto unsuspected bacterial contaminants. However, none was recorded in the latter part of 1977 nor were they detected when the survey was extended to isolates from the Netherlands and Scandinavia. Inoculation trials to damaged and undamaged tubers suggested that the presence of the bacteria enhanced penetration, especially in unwounded tubers. *In vitro*, the pathogen degraded cellulose more rapidly in the presence of the bacteria which, however, showed no cellulolytic ability when tested alone.

The mother tuber is potentially the most important source of inoculum and previous observations have shown that apparently healthy tubers may develop lesions post-planting, but that the rate of lesion spread thereafter is much affected by the soil environment. In early May, apparently healthy tubers were inoculated or not with the var *foveata*, stored for 1 week at 5°C to allow for rot initiation, planted in the field or stored in polythene boxes at 3°C or at 10°C and examined at 9-12 day intervals to estimate the surface area index of the rots. Although the soil temperatures were similar to those of the higher box storage temperature, the latter had the largest and the former the smallest rots with those at 3°C being intermediate in size. The limited development of rots in soil was associated with the dry soil environment and elevated temperatures affecting wound periderm formation together with antagonistic activity of components of the soil flora.

In relation to the foregoing, experiments were continued in the glasshouse to examine the survival of propagules of the var *foveata* when associated with fragments of potato tissues at two temperatures, 10° and 18°C, in field soil and in compost. Overall, survival was higher in compost than in field soil and at 10 compared to 18°C. Relating the results to field conditions suggests that propagules on the mother tuber at planting could survive to infect progeny tubers at harvest with progressively greater numbers being derived from lesions which develop after planting. The inimical effects of high temperature may be related, at least in part, to the low incidence of gangrene in recent dry hot summers and autumns.

Samples taken from the preceding experiment were used to assess the relative merits of using a selective medium as opposed to tuber baiting for enumerating soil populations. There was a good correlation between colony count on the selective medium and the number of tuber rots in baits ($r = 0.73$) but the former method was superior in that sensitivity and reproducibility were better, time and space requirements were less, identification of species was immediate on the medium and, in addition, some information was obtained on changes in populations of other micro-organisms.

In a glasshouse pot experiment, pre-germinated barley seeds were sown singly each above a small square of cellophane infested with pycnidia of the var *foveata*. The procedure was intended to mimic events in the field in which a growing seedling makes contact with a lesion on an infected tuber of a groundkeeper. There was no difference in emergence or general appearance of the seedlings from infested and non-infested pots. When sampled after 1

and 4 weeks from planting, 11 and 10 out of 12, respectively, of the seedlings proved to be infected although the number of foveata positive root and shoot pieces fell by half at the second date. After 8 weeks, infection was detected in only 1 of 3 treated seedlings but the isolation plates were heavily contaminated with *Trichoderma* spp. and *Rhizopus* sp.—fungi often associated with compost and possibly contributing to the apparent loss of infection. Infection was not detected in any of the seedlings grown in the control uninfested pots. Although it is feasible that barley plants may serve to assist in the persistence of the gangrene fungus during a rotation, more critical experiments are required firmly to establish their role.

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

02024 *Autecology of the strawberry red core fungus (Phytophthora fragariae)*

Sharp decreases in infectivity have been recorded regularly in freshly collected and in stored field soil samples when baited with *Fragaria vesca* during the period June-August. The decreases could be real or they might be explained, wholly or in part, by a loss of sensitivity of the bait plants due to high temperature and/or high light intensity in the glasshouse. To examine these alternatives, fresh soil samples from a red core site at SHRI were collected at 2-monthly intervals and baited in the glasshouse and in the controlled environment quarantine area. Samples of soil collected on the first sampling date, adjusted to 67% of maximum water holding capacity (MWHC) and stored at 3°C in polythene bags, were also baited at each subsequent sampling and the results of both types of sampling and baiting regimes compared.

In general, infectivity levels were higher in the quarantine area than in the glasshouse but in both regimes all samples showed marked declines in infectivity during the summer; the patterns were similar in both regimes over the year. Initially the stored samples were more infective than the fresh, but after the summer trough the infectivity levels of the latter were higher than those of the former.

It is unlikely that variations in the temperature of the water coming from the automatic irrigation system could have caused the fluctuations, but the bait plants may have varied in susceptibility through the year. These possibilities are being examined in growth cabinet experiments where the irrigation water temperature is constant and the bait plants (cv. *Baron Solemacher*) have been grown from seed under uniform conditions.

Soil samples were taken throughout the year in 100 mm sections, down to a depth of 500 mm. The highest infectivity levels found by baiting were invariably in the 100-200 mm section, the next highest levels being in the 0-100 and 200-300 mm layers, which had similar values; levels in the two layers from 300-500 mm were much lower than those of the other samples.

Infectivity levels of strawberry and grass plots at Auchincruive were also determined through the year. They were generally lower than those of the SHRI site the estimates for the strawberry plots being the higher.

The possibility of the fungus surviving in soil as mycelium was investigated. It was inoculated on to a defined sucrose/mineral salts/*B*-sitosterol agar medium, overlaid with 48 mm square pieces of nylon monofilament cloth (15 μ mesh) and incubated in the dark at 20°C for *ca.* 4 wk. The pieces of cloth, by then covered with a fine mat of hyphae, were stripped from the colonies, divided into six equal pieces (16 x 24 mm) and each piece buried in screened non-infested field soil in small sealed plastic pots. The field soil was either untreated or autoclaved and had been adjusted to 13%, 67% and 100% MWHC. The pots were incubated at 3°, 15°, and 30°C for periods of up to 2 months. When the pieces of cloth were removed, each was further sub-divided into 6 segments (8 mm square), five of which were used to inoculate separate bait plants by burying them in a small slit in the compost alongside each plant. The numbers of infected plants were recorded after 5 weeks. The remaining segment was kept at 12°C for 2 days in calcium nitrate solution and then for 1 day in distilled water before being examined for the presence of sporangia. The soil from the incubated pots was diluted 1:4 with compost and also baited, checks consisting of non-infested and naturally infested field soil. At the start of the experiments all 8 mm segments freshly obtained from a colony caused infection of the bait plants ($n = 40$) but large differences in the infective potential occurred soon after burial. In general, more infection was recorded from segments kept in the autoclaved soil, at lower temperatures, and at higher moisture levels. In those treatments where detection in the segments was high it was common also to detect infectivity in the soil left after the segments had been removed suggesting that some form of propagule had spread into the surrounding soil. No structures resembling oospores could be detected microscopically on the segments either before or after burying them. Sporangia were observed infrequently on the irrigated segments but only in those treatments where the percentage number of infected bait plants was high. Infectivity could still be detected at high levels in some treatments where the segments had been buried for 2 months in soil; for example, autoclaved soil at 3°C and 67% (MWHC) gave a 95% infection level.

(J. M. Duncan)

02013 Biology of root diseases in field pea and bean

Biology of Botrytis fabae in bean

Mechanisms affecting the rate of growth of lesions of *Botrytis fabae* on isolated *Vicia faba* leaves were investigated in a growth cabinet at 15°C, the optimum temperature for lesion extension, although on agar *B. fabae* grew fastest at 22°C. Lesions spread at the same rate in darkness as they did when

exposed to continuous light of 6000 lux from Philips warm white fluorescent tubes their diameters increasing by 5.0 mm/d and 0.2 mm/d at 100% and 65% rh respectively. In another experiment with continuous illumination, lesion diameter increased by 3.9 mm/d when exposed to a constantly saturated atmosphere but by only 1.1 and 0.4 mm/d when the humidity was reduced to 65% rh for either 8 or 16 hd. The hypothesis that changes with humidity in the amounts of O₂ and CO₂ dissolved in the water film within a leaf affect lesion spread was tested by exposing lesions to gas mixtures containing 1% or 20% O₂ and 5% or 0.03% CO₂ at 65% rh. Lesions remained non-aggressive in all four treatments, although growth on malt extract agar in 5% CO₂, 1% O₂ and 94% N₂ was 32% of that in air.

Many lesions at 65% r.h. developed lobes of necrotic tissue from which the fungus could not be isolated, suggesting that it may produce a toxin which moves in the transpiration stream. Culture filtrates of *B. fabae* grown in Czapek Dox liquid medium to which had been added 10 g malt extract and 1 g peptone per litre caused lesions, similar to those associated with *B. fabae*, when injected into healthy bean leaves. The osmotic potential of the culture filtrate was -3 bar, while that of the liquid medium, which caused no necrosis when injected into leaves, was -6 bar, demonstrating that the necrosis was not caused by an osmotic shock. The toxic fraction was ethanol-soluble and was not destroyed by autoclaving at 121°C for 20 min. nor by exposure to daylight for 7 days. The toxin was recovered from R_F 0.40-0.51 when run on Whatman chromatography paper no. 17 with isopropanol: water (3:2) as the solvent, but remained at the origin with n-butanol: pyridene: water (2:2:1). A heat-stable ethanol-soluble toxic fraction was also obtained from leaves infected with *B. fabae* but was absent from healthy leaves. Higher concentrations of either toxin were needed to produce necrosis of leaves 1 week after they had expanded than of those a week older.

Survival of *B. fabae* was investigated by burying pieces of bean stem bearing sclerotia 20 mm deep in field soil maintained at a moisture content of 43% field capacity at 12°C. After 49 days, 20% of surface-sterilized sclerotia produced a colony of *B. fabae* on agar. After a further 17 days viable *B. fabae* could not be recovered, but 90% of sclerotia gave rise to a colony of *Gliocladium roseum*, a fungus which has been reported to parasitize sclerotia of *Botrytis* spp. other than *B. fabae*.

Survival of mycelium on cellophane between autoclaved moist filter papers was studied at -2, +3, +10 and +15°C by placing small pieces of cellophane on agar each month. The fungus survived for 8 months at 15°C while at the lower temperatures it was still viable after 15 months.

Pieces of bean stem trash were collected during November and December. Those without sclerotia were surface-sterilized and placed on agar. Nine and 15 out of 50 pieces from each of two fields from which *B. fabae* had been frequently isolated during the summer produced a colony of the pathogen, indicating that the fungus may overwinter as hyphae on dead plants.

B. fabae was isolated from 12 out of 50 lesions from bean groundkeepers collected during February, suggesting that they also may form an important source of inoculum during the spring.

The survival of conidia on cobwebs placed out of doors in partial shade during mid-July was determined daily by washing spores from the webs with nutrient broth and determining viability after 24 h at room temperature. Germination fell from 94% initially to 18% after 1 day to 0.5% after 1 week.

A spore trap, consisting of a pump drawing 10 l of air per minute through 5 μ mesh gauze, was run continuously in a field at Invergowrie from 21 June 1977. Spores were washed from the gauze each week and plated on malt extract agar to which had been added 50 ppm each of aureomycin and streptomycin. *B. fabae* was not detected; *B. cinerea* was obtained in large numbers during the summer, then with decreasing frequency until the end of October and only occasionally during the winter months. Eleven colonies of *B. narcissicola* developed after plating spores collected between 20 and 27 July, but it did not occur on any other occasion. Narcissus bulbs were harvested from a field 1.5 km west of the spore trap on 22 July and conidia of *B. narcissicola* may have been released during the operation.

(J. G. Harrison)

02010 Seed quality—soil interactions and the effects on seedling emergence, growth and crop yield

Emergence trials within the International Seed Testing Association

The work of the Vigour Test Committee of ISTA during the triennium 1974-77 included an examination of the comparative emergence behaviour of seed lots of wheat, sugar beet and carrot in soil at sites throughout the world. There were differences in mean emergence due to sites and seed lots, and interactions between sites and lots. The interactions were analysed by a programme used by plant breeders to examine interactions between genotypes and environments, in which the regressions of lot means over sites on site means were compared. Regression coefficients were significantly different for wheat and carrot showing that emergence of some seed lots were more consistent over sites than others, while the seed lots of sugar beet reacted similarly to site effects.

Laboratory tests for vigour were more variable than those for germination and were not superior in predicting emergence from soil. Details of the results are presented in the Report of the Vigour Test Committee to the 17th Seed Testing Congress, 1977.

(D. A. Perry)

Development of the rolled towel vigour test for barley

The rolled towel vigour test was employed on 103 seed lots of cv. Golden Promise, 123 lots of cv. Midas, and 18 lots of cv. Mazurka spring barley seed by the Seed Testing Station, East Craigs, Edinburgh. Selected lots were retested at SHRI and sown in normal and excessively wet seed beds on 11 October.

Some inconsistencies in vigour test results between laboratories were found, due probably to variations in light intensity in the germination room at East Craigs. In the emergence test, 21 lots of Golden Promise emerged less well and with more variability between lots from the wet than from the normal seed beds and there was a seed bed x seed lot interaction. In contrast, seed bed conditions did not affect the emergence of 34 lots of Midas and lot means were only different at the 1% level of significance. Correlations of emergence with both germination and vigour test results were poor.

(D. A. Perry)

Effect of fungicides and seed bed conditions on carrot emergence

Eight seed lots of carrot cv. Chantenay of differing quality, were dusted with captan (Orthocide, Murphy Chemical Co. Ltd.), benomyl plus thiram (Benlate T, Du Pont Co. Ltd.) or carbendazim plus maneb (Granosan, Du Pont Co. Ltd.) at manufacturers recommended rates, or were not treated. They were sown at SHRI on 29 April into seed beds kept dry by translucent plastic covers, kept wet by trickle irrigation, or exposed to the natural climate. Seed lots and fungicides were randomised independently within seed bed treatments which were replicated fourfold. One hundred seeds were sown 12 mm deep in 1 m long rows.

Mean emergences in the natural, dry, and wet seed beds were 50.8, 9.9 and 54.4% respectively and seed lots differed significantly but with no interaction with seed bed condition. Fungicides had no significant effects on emergence in any environment although variability between replicates was high, particularly in the dry bed, which reduced the sensitivity of the experiment. When emergence was expressed as a percentage of viable seeds sown, significant differences remained and lots were ranked in a similar order to that for viability.

Correlations between germination and emergence in natural, dry and wet beds were good ($r = +0.88, +0.80, +0.97$ respectively), while vigour tests based on measurement of root growth on slanting wet paper towelling, or colorimetric estimation of reduced formazan compounds extracted from ground seeds were no better than germination as predictors of emergence. The results from this experiment and those previously described (Ann Rep 1976 p. 60) have shown that fungicide seed treatments have no consistent effect on emergence from carrot seeds.

(D. A. Perry)

Studies on barley seed mortality in soil

The interaction between the level of seed deterioration and soil moisture content on emergence of barley observed in field experiments at SHRI has been reproduced in soil under controlled environment conditions. Soil moisture contents of 29-30% caused proportionately greater mortality of deteriorated seeds than of non-deteriorated seeds at 20°C, while moisture contents of 23-26% had no selective influence. Germination of barley seed was inhibited by excessive water levels and daily recovery of ungerminated seeds showed that percentage mortality increased with time in soil. Studies have commenced to establish the cause of seed death in these conditions.

(D. R. Ellerton)

02025 *Rhizosphere and allied phenomena affecting plant health*

Potatoes

Work started during the year on the characterisation of rhizosphere and rhizoplane micro-organisms of the potato to study their effect on plant vigour and yield. To date, only the microflora has been examined and the species commonly present include *Rhizoctonia solani*, *Fusarium* spp., *Gliocladium* spp., *Penicillium* spp., *Phoma* spp., and *Cylindrocarpon* spp.; various other fungi were less common. There were no evident lesions on the roots with which these fungi were associated.

(A. J. Hargreaves)

PLANT AND PATHOGEN PHYSIOLOGY

02026 *The nature and implication of quiescent fungal and bacterial infections*

Isolated plant protoplasts

Rishitin at 300 µg/ml caused lysis within 30 min. when added to isolated plant protoplasts suspended in 7·0M mannitol. Lower levels (50 µg/ml) did not cause lysis but affected membrane permeability (detected as an increase in conductivity of the mannitol), and caused death within 24 h. Rishitin at 100 µg/ml had little effect on the rate of O₂ uptake by tobacco protoplasts compared to the addition of 100 µg phaseollin/ml which caused an initial increase in respiration followed by a decrease coinciding with protoplast death. The different response of protoplasts to the two phytoalexins suggests a difference in their mode of action; phaseollin possibly acts directly on respiration whilst rishitin appears to act directly on membrane integrity.

Phytoberin also caused lysis and a loss of viability of tobacco protoplasts, but only at higher concentrations than rishitin and with longer incubation periods. Phytoberin at 200 µg/ml did not cause complete loss of viability of protoplasts within 21 h, and at 100 µg/ml did not cause an increase in conductivity.

These results suggests that necrosis associated with the production of rishitin in an incompatible host/pathogen combination may be caused by the rishitin reaching a phytotoxic concentration.

(G. D. Lyon, M. Mayo¹)

Erwinia carotovora

Rishitin at 300 µg/ml rapidly decreased the O₂ uptake by cells of *E. carotovora* suspended in 0.1% peptone water and 100 µg/ml slightly decreased the rate within 30 minutes whereas phaseollin did not inhibit O₂ uptake. The effect on respiration may be a secondary response as 100 µg rishitin/ml causes immediate electrolyte leakage and an eventual lysis of cells. Because an intact cell envelope is required for bacterial respiration lysis would decrease the O₂ uptake. The cationic surfactant hyamine 2389 affected the viability of *E. carotovora* (as assessed by O₂ uptake) unlike the anionic surfactant Triton GR-5 and the non-ionic surfactant Triton X-100. Variation in the composition of the suspending medium affected the sensitivity of *E. carotovora* to rishitin and hyamine 2389, with Mg⁺⁺, and to a lesser extent Ca⁺⁺, decreasing the sensitivity. Divalent cations are known to be important components of bacterial membrane structure thus suggesting that rishitin may be acting at this site in a manner similar to a cationic surfactant.

(G. D. Lyon)

02018 Diseases of potato tubers

Growth and pathogenicity of E. carotovora in tubers

Growth of both wild and antibiotic resistant strains of *E. carotovora* var *carotovora* and *E. carotovora* var *atroseptica* in broth was similar at 10, 15, 20 and 25°C with optima at 25-30°C. At 30°C var *carotovora* grew faster than var *atroseptica* and at 35°C the latter, in contrast to the former, did not grow.

The pathogenicity of var *atroseptica*, as assessed by the ED50 of bacterial numbers required for induction of visible decay in infected tubers under both aerobic and anaerobic conditions, was greater than that of var *carotovora* at < 20°C, but less than that of var *carotovora* at > 20°C. When they were injected together into tubers in equal numbers and incubated under aerobic and anaerobic conditions, var *atroseptica* dominated the population in the decayed tissue at < 20°C while at > 20°C var *carotovora* was more frequent.

(M. C. M. Pérombelon, A. Ghanekar)

¹ Virology Section

Potato lectins: isolation, purification and properties

Studies were initiated on the role of lectins (plant haemagglutinins) in host parasite relationships. Lectin was extracted and purified from cv. King Edward tubers by an ethanol/HCl-acetone-sulphoethyl cellulose procedure. The lectin separated as a major band of mol. wt. ca. 100,000 with two low mol. wt. contaminating protein bands on sodium dodecyl sulphate gel electrophoresis. Assay by the agglutination index method with human red blood corpuscles showed an activity of 128 units per g tuber tissue.

More lectin was detected in filtered saline extracts of the tuber cortex and medulla than of the periderm (3 mm thick outer layer). Lectin activity in leaves was similar to that in tubers while potato berries (fruits) contained more. Considerable variation in lectin activity was found in the tubers of 14 cultivars tested; Arran Consul, Golden Wonder and King Edward contained most (ca. 128 units/g), while Majestic, Bintje, Maris Piper contained less (ca. 16 units/g), and it was least in Pentland Falcon.

The levels of lectin activity detected in tubers of King Edward and Majestic were little altered by anaerobic compared with aerobic inoculation at 20°C for 5 days.

Purified lectin solution (1000 units/ml) agglutinated all of 15 isolates of *Pseudomonas*, *Agrobacterium*, *Corynebacterium*, *Xanthomonas* and *Bacillus* which were not pathogenic to potatoes as well as *Escherichia coli*. Within the genus *Erwinia*, 12 out of 25 isolates of *E. amylovora*, *E. herbicola*, *E. carotovora* var *chrysanthemi*, *E. rhapontici*, *E. cypripedii*, and *E. uredovora*, which were not pathogenic to potatoes, were agglutinated, while 11 out of 28 pathogenic isolates of *E. carotovora* var *carotovora* and *E. carotovora* var *atroseptica* from potatoes and 3 out of 12 isolates from other hosts were agglutinated.

(A. Ghanekar, M. C. M. Pérombelon)

02015 Disorders of vegetables

Cavity spot of carrots

A total of 40 soil samples was collected from carrot fields on 22 farms in Tayside, air dried and passed through a 1 mm sieve. Aliquots of each soil were inoculated to surface-sterilised carrot disks and incubated anaerobically in the dark at room temperature. All the soils tested induced some rotting and although the extent differed, it was not related to the observed incidence of cavity spot in the fields from which they came. The incidence of the disorder must depend therefore on the development of anaerobic conditions and not on the distribution of the bacteria. Isolations from disks inoculated with soils revealed at least four different colony types of anaerobic, pectolytic, *Clostridium* spp, although the predominant form remained as described previously in Ann. Rept 1976, p. 62.

'Natural' cavity spot lesions collected from field crops in the autumn do not always yield the pectolytic *Clostridium* spp when incubated anaerobically and to test survival of the bacteria on plant material, carrot roots were artificially inoculated and kept in sealed pots for 5 days. Thereafter roots from half the pots were examined and *Clostridium* spp were isolated from all of nine lesions tested. However, after 52 days in a glasshouse at 20°C with a minimum water supply, only two out of seven lesions produced pectolytic bacteria comparable to those initially isolated. Furthermore, inoculated roots removed from pots immediately after treatment, washed and stored for the same length of time at 2°C in polythene bags, yielded pectolytic *Clostridium* from only one lesion out of six tested.

Healthy carrots inoculated with pectolytic *Clostridium* spp rotted rapidly when placed in anaerobic conditions at 20°C but root tissue surrounding lesions in carrots collected from field crops and similarly inoculated was immune to rotting. Histochemical tests on sections of tissue with 'natural' lesions showed the presence of limited wound periderm and an extensive reaction to the nitrous acid reagent for phenolics beneath the lesion.

Preliminary studies with oxygen and redox electrodes have shown that oxygen consumption of a carrot root of ca. 50 g fresh weight in air at 20°C was 0.38 cm³/g/h; that a water-saturated sandy-loam soil (5 vol air-dry soil and 3 vol water) became anoxic in a sealed container at 20°C within 30-40 h; and that the redox potential of an anoxic soil from a field with a cavity spot record fell more rapidly than that in soil from SHRI where cavity spot was rarely recorded.

(D. A. Perry)

02012 Seed quality, causes of its variation and its effect on yield

Causes of variation in vigour of barley seed

Barley cv. Golden Promise growing at SHRI was sprayed with urea at 20 kg N/ha, benomyl at 250 g/ha and both together at the same rates on single plots of 100 m². The chemicals were applied in solution at 400 l/ha on 5 July when the crop was at the immature ear stage (10.5.4 on Feekes scale), and on 22 July at the mealy ripe stage (11.2). A first harvest from 12 m² was made on 24 August when grain moisture content was 18% and a second on 10 October when moisture content was 31% following a period of wet weather.

Germination percentages of seed from the urea, benomyl, urea plus benomyl and the check plots at the first harvest were similar and averaged 97.5% and there were no differences in vigour detected by the rolled towel test. At the second harvest, germination fell to a mean of 81.5% and no protection against deterioration was apparent from either chemical. The seed will be used in emergence and yield experiments in 1978.

(D. A. Perry)

Phytophthora spp

In 1977 regular baiting for *Phytophthora* spp. was done in the drainage systems of the field at the West of Scotland unit, Auchincruive. Apples (cv. Golden Delicious) and plants of *Fragaria vesca* VS1 were put in bags made from Tygan netting and placed, as baits, in the outfalls of the field drains. Baiting was done throughout 1977, the baits being left *in situ* for 3-4 wk. Isolations were made directly from the apples and indirectly from the *F. vesca* baits either by inoculating the plants into apples or by planting them in compost with a fresh *F. vesca* bait plant. The two most common species of *Phytophthora* (IMI 195177 and IMI202518), as yet unidentified, were isolated on all sampling occasions except June when the drains were dry. Another unidentified isolate, D94—which appears very similar to *Phytophthora cambivora*—was isolated in April from one *F. vesca* bait and in August from apple baits. *Phytophthora megasperma* var *megasperma* was recovered from apples in November and *Phytophthora fragariae* was recorded on one *F. vesca* bait in May. *P. megasperma* var *megasperma* was recovered from soil at Craibstone (North of Scotland College of Agriculture), where raspberries had been grubbed out because of a root rot problem, and in Beaully Firth from a raspberry plantation affected by root rotting. *P. cambivora* and an isolate identical to IMI 195177 were recovered from diseased raspberry roots and soil from a site in Angus where a third papillate species was also observed on affected roots but was not recovered by any of several isolation techniques.

(J. M. Duncan)

Genetics of E. carotovora

In continued studies on the development of a conjugation system for orientated gene transfer in *E. carotovora*, the dynamics of phage Mu production have been studied at 41°C following the introduction into a strain of *E. carotovora* var *carotovora* of the plasmid RP4 :: Mu-Icfs 62 (Ann. Rept, 1976 p. 63-64). Maximum phage production was obtained in 6 h with ca. 25% loss of the plasmid and after 24 h plasmid loss exceeded 95%. Integration of the Mu into the bacterial chromosome, which would cause random mutations, was not detected when cultures incubated at 41°C for 6 and 24 h were centrifuged and the bacteria spread on media selective for resistance to nalidixic acid, sodium azide and sodium chlorate and for thymine-strains.

Lederberg's tetrazolium fermentation indicator medium was modified to allow the differentiation of strains able to utilize lactose, maltose and α -methyl glucoside from those which cannot. Most strains of var *carotovora*, var *atroseptica* and var *chrysanthemi* could be discriminated on this medium containing the appropriate carbon source.

(M. C. M. Pérombelon)

Phoma exigua

The production of pigments which diffuse into the medium help to differentiate *Phoma exigua* var *foveata* from *Phoma exigua* var *exigua* but pigmentation is not a constant character and frequently varies within a given isolate. Isolates may be divided into two broad groups—those predominantly producing a dark red pigment and those with yellow pigment becoming grey. Of over 100 fresh isolates recently examined, those from Denmark predominantly produced a reddish pigment whilst those from Scotland and the Netherlands predominantly produced the yellow pigment. However, sectoring is a continuous process in both groups and only a small proportion of sectors eventually become stable. Some isolates are difficult to assign to a particular group as pigmentation varies so much with sectoring. Single spore cultures from red pigmented isolates could give rise to isolates with yellow pigment and vice versa. Preliminary observations on inoculated tubers using isolates of the two pigmented groups suggests that there may be differences in diffusion of metabolites beyond the boundaries of lesions with the two types.

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

Rhizoctonia solani

Previous studies (Ann. Rept 1968 p. 33) showed that individual cells of all isolates of *R. solani* from potato tubers were multinucleate and not binucleate and should be assigned to the perfect genus *Thanatephorus* on the basis of their being multinucleate. The numbers of nuclei then observed were *ca.* 16 per cell but recent reports elsewhere suggest much lower numbers. In contrast to the previous extensive sampling, where isolates were obtained from tubers grown all over Scotland, intensive sampling was done on tubers from a single field at the Institute. In 11 isolates, 150 each of tip cells, Y cells and unbranched cells were examined. The numbers of nuclei in tip cells varied from 5 to 22, most having from 7 to 13; in the Y cells the numbers varied from 6 to 24, most having 8 to 17; and in the unbranched cells the numbers varied from 5 to 20 most having from 7 to 16 nuclei. There were no marked differences in the frequency ranges of numbers of nuclei between any isolates. In the remaining 39 isolates only enough cells were examined to establish the general pattern which was found to be similar. Thus, in general, the numbers of nuclei found were high and similar to those previously found in surveys at this Institute and higher than those reported elsewhere. It appears that a bias may be introduced if a disproportionate number of tip cells is examined.

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

02003 *Shoot disorders of cane and bush fruits**Cane diseases of raspberry**Cane blight*

Harvester wounds predispose young canes to cane blight (*Leptosphaeria coniothyrium*) which causes substantial yield reduction in the year following a mechanical harvest (Ann. Rept 1975 p. 58). Data on the number of canes affected by harvester wounds and the incidence of cane blight have indicated that vibrating finger wounds affected more canes than catching plate wounds, and although the incidence of vascular lesions on them was lower, it was considered that they accounted for the majority of the yield loss (Ann. Rept 1976 p. 70). To help improve machine design, the yield loss caused by cane blight at plate and at finger wounds was evaluated separately. The yields from cv. Malling Jewel, wounded in the previous season by either the fingers or the plates, or both together, were respectively 4.8, 24.5 and 43.4% lower than those from unharvested plots. The number of canes with finger wounds did not differ significantly between the plates plus fingers and fingers only plots. In the former treatment, more finger wounded canes became infected ($P < 0.05$) suggesting that canes clamped by catching plates received more, or more severe finger wounds thus increasing cane infection. In all treatments vascular lesions developed at the base of many canes, probably due to infection of abrasion wounds caused by old cane stubs but the harvester did not exacerbate the incidence which, at ca. 20%, was similar in all plots.

Although the fungicide dichlofluanid, when applied pre-harvest, mid-season after each machine pass (plates plus fingers) and also twice post-harvest, increased yield by 32% this figure was, in fact, a disappointing 30% less than that of hand-harvested check plots. The fungicide reduced lesions at finger wounds ($p < 0.05$) and there was a similar but non-significant decrease at plate wounds. However, levels of infection at harvester wounds were lower than in previous experiments. Much of the yield reduction could be explained by the lower number of canes tied-in indicating that the harvester had destroyed or caused the death of a proportion of the young canes before the time when they were being selected for tying-in.

L. coniothyrium was isolated in November from vascular lesions within 2 cm of harvester wounds, but not from other sites within the spreading lesion more distant from the point of infection. The possibility that toxins spread beyond colonising hyphae is being examined.

(B. Williamson, A. J. Hargreaves)

Midge blight

In July 1977 plots of cv. Malling Jewel were destructively sampled. Canes evidently affected by *L. coniothyrium* (spreading lesions) were excluded and only those with restricted vascular lesions beneath larval feeding areas were recorded. As in cv. Glen Clova, the potential yield (total green berries plus flowers) of each cane was not reduced until lesions covered more than 20% of the vascular cylinder of the bottom 30 cm of cane. Thus, midge blight does affect yield in Malling Jewel as it does in Glen Clova (Ann. Rept 1976 p. 64). However, splits in the epidermis and cortex develop less frequently in Malling Jewel than in Glen Clova and it should therefore be less affected by midge blight.

Midge blight is now considered as the probable cause of the symptoms of 'bud death and lateral wilt' described in Glen Clova in 1971 (Ann. Rept 1971 p. 47). The colonisation of failed buds or wilting laterals by *F. avenaceum* and other fungi as then reported is of little phytopathological significance. Nevertheless, *F. avenaceum* is now known to be important in the midge blight syndrome because it penetrates vascular tissues beneath periderm wounded by cane midge larvae.

Leptosphaeria coniothyrium was isolated in late June from spreading vascular lesions at the base of fruiting canes of cv. Malling Promise on a site with a long history of Rubens 'die-back'. The lesions extended proximally to the point of attachment of young canes which were stunted. In November, *L. coniothyrium* was the principal species isolated from similar lesions arising at the base of overwintering canes. Abrasion wounds caused by old cane stubs are the most likely infection courts. Therefore, it is possible that die-back condition which has so severely affected this cultivar and others in Scotland may be identical to cane blight, *i.e.* the infection of physical wounds by *L. coniothyrium*.

(B. Williamson, A. J. Hargreaves)

Cane death and root rot of raspberry

As three *Phytophthora* spp. (*P. megasperma* Drechsl. var *megasperma* IMI 195178; IMI 195177; IMI 202518) isolated from diseased raspberries and associated soil did not cause significant decreases in growth when inoculated singly to young canes of cv. Malling Jewel (Ann. Rept 1976 p. 65) they were re-tested in composite inocula for evidence of synergism. Neither double nor triple combinations had any effect on growth.

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

Bacterial galls of raspberry

In a field experiment designed to explore the potential of isolate K84 of *Agrobacterium radiobacter* var *radiobacter* to control gall development in

raspberry, young plants of cv. Malling Delight were inoculated in May by dipping the washed roots in different suspensions containing *ca.* 10^6 cells/ml of 5 pathogenic isolates of *Agrobacterium* alone and in 1:10 and 1:100 cell ratios with isolate K84. No galls were found on any roots when examined in November perhaps because of the near drought conditions which prevailed soon after planting. Biochemical tests showed that strains of *Agrobacterium radiobacter* var *tumefaciens* which had been isolated from galls of *Rubus* plants and which were pathogenic to *Datura stramonium* could not be assigned to either of Kerr's biotypes I or II. The bacteria were also insensitive *in vitro* to bacteriocin produced by isolate K84.

(M. C. M. Pérombelon, R. Lowe)

02022 Harvest disorders of soft fruit

Buds and flowers from several sites at the Institute were examined for the presence of superficial and latent infection by *Botrytis cinerea* at regular intervals from 10 June to 18 August. Tightly closed buds, open buds, or open flowers were dipped in 1% chlorox for 1 min, or 5% chlorox for 5 min., with teepol as a wetting agent added to the disinfecting solution. In some samples, the buds or flowers were halved and placed face down on malt agar plates, in other samples the flower parts were dissected and the sepals, stamens and receptacles plated separately to detect varying sites of latent infection. The plates were examined and *B.cinerea* colonies counted after 2 weeks and the numbers and kinds of other fungi also recorded. Until 21 July the number of *B.cinerea* colonies was so low that it might well be attributed to random contamination and at that date only 3 of 40 tightly closed buds and 4 of 18 young flowers yielded *B.cinerea*; the infection rate remained similar or occasionally lower in subsequent samples and rose only slightly by mid-August. Infection was more consistently detected in the flowers than in buds and levels varying between 25 and 50 per cent infected flowers were obtained only with the mild 1% chlorox treatment. There was no evidence of any particular part of the flower or bud being most readily invaded until a very late sample (18 August) in which a high proportion of the infection was detected in stamens. The population of 'other fungi' on buds and flowers also increased as the season progressed but at a higher rate than that of *B.cinerea*.

The level of sampling was far greater than any which has been attempted before. The results from this season do not support the thesis that a high proportion of fruit rots in raspberry are derived from latent infection of floral parts which does not become aggressive until the later stages of fruit development.

(R. A. Fox, E. Patricia Dashwood)

Contamination of VTSC stocks by the blackleg and other soft rot bacteria

As reported previously the trend for decreasing levels of tuber contamination in VTSC stocks during bulking continued in 1976-77. Most was found in stocks in their fourth and fifth years of multiplication and in contrast to previous years, over 50% of the contamination consisted of *E. carotovora* var *atroseptica*.

(M. C. M. Pérombelon, R. Lowe)

Contamination of foliage by E. carotovora

Survival of washed cells of antibiotic resistant strains of *E. carotovora* sprayed at fortnightly intervals on leaves of potato plants in the field rarely exceeded 48 h in mid summer during dry, sunny spells. During cloudy, wet weather they could be detected as long as the leaf surface was wet, but they died within a few days when the leaf surface became dry. The bacteria survived longer and multiplied in the cool temperature of late September and October when many leaves were senescent and frequently wet with rain or dew. No differences in the longevity of *E. carotovora* var *carotovora* and *E. carotovora* var *atroseptica* were found. At harvest time in October tubers from plants inoculated in September were found to be contaminated as were leaves and progeny tubers of neighbouring plants 1 to 2 m along and across the drills.

Both foliage and progeny tubers of plants grown from VTSC seed which have been tested and found free of *E. carotovora* and planted ca. 5 m from the nearest plants grown from infected seed were contaminated at harvest time by isolates of *E. carotovora* var *carotovora*. The isolates reacted similarly to bacteriocin typing as those present on the foliage of plants throughout the rest of the field. Less than 1% of *E. carotovora* isolates present on all plants were var *atroseptica*.

(M. C. M. Pérombelon, R. Lowe)

Spread of air-borne E. carotovora

Aerosols containing ca. 10^8 cells of *E. carotovora* were released at a ground level point source in the field under different climatic conditions. Selective media traps showed that up to 5.6×10^2 cells/m² were deposited 100 m downwind. These results agree more closely with the theoretical values obtained from diffusion/deposition models of Pasquill and Chamberlain than with the much higher values based on Gregory's model. Because of the low deposition coefficient of the particles only a small proportion is likely to be deposited and as dilution of the particles in the diffusion plume increases, the numbers deposited become increasingly small. Nevertheless, air-borne *E. carotovora*, produced in large numbers from a potato field when haulm is pulverized (Ann. Rept., 1977, p. 66-67), could still contaminate potato crops at least 100 m downwind.

(M. C. M. Pérombelon, R. Lowe)

Blackleg etiology: field studies

'A' grade and VTSC seed were inoculated after harvest by vacuum infiltration in suspensions containing different concentrations of *E. carotovora* var *atroseptica*, and then stored at 5°C. In the following season, crops from the 'A' seed contained *ca.* four times as much blackleg as those from VTSC seed, although the levels of contamination at planting were similar. The susceptibility to blackleg of nine cultivars grown from seed inoculated with *E. carotovora* var *atroseptica* as described above was compared by counting the number of diseased plants in plots planted with 540 seed per cultivar. As reported previously (Ann. Rept 1972, p. 51), there were significant differences in the disease incidence between cultivars, although Bintje with 12% plants affected was the most susceptible instead of Majestic, while Golden Wonder remained the least susceptible with 2% blackleg.

In both experiments blackleg incidence tended to be proportional to the level of contamination of the seed.

(M. C. M. Pérombelon, R. Lowe)

02005 Analysis of and screening for resistance to diseases of soft fruit

Red core of strawberry

The growth of *Phytophthora fragariae* on French bean agar incorporating 0.125, 0.25, and 0.5% L-sorbose was decreased at the lower concentrations and inhibited at the highest. Growth was not affected when the agar contained 0.25% glucose. The sporulation of only one isolate was increased on disks of agar containing 0.125, or 0.25% L-sorbose or 0.25% glucose.

When the susceptibility of cultivars, which had been similar to Cambridge Favourite after inoculation with a suspension containing 1000 zoospores/ml, was evaluated with the same inoculum (a mixture of races) at half the concentration of zoospores, no significant differences were detected. The same cultivars incubated for a further 2 and 6 weeks in an environment favourable for disease development showed no significant differences in susceptibility.

Although solutions of 25, and 50% sucrose applied as foliar sprays tended to decrease disease severity in susceptible cultivars in pot experiments differences were not significant.

Results from experiments to assess the effect of increasing the concentration of zoospores in inocula from 1000/ml to 2000, 4000, and 8000/ml on cultivars which were less susceptible than Cambridge Favourite have not been fully analysed.

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

Stamen blight of raspberry

Axillary buds inoculated by hypodermic injection of a spore suspension of the fungus into the apices, were the only ones to produce diseased flowers the following year. This result suggests that the low infections recorded in previous years could be due to premature tissue resistance of bud scales in young canes propagated in the glasshouse.

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

02007 *Biology of diseases of ornamental bulbs*

Narcissus basal rot

In 1977 there was a minor outbreak of narcissus basal rot (*Fusarium oxysporum* f. sp. *narcissi*) on progeny from twin scales being multiplied in the glasshouse at the North of Scotland College of Agriculture. The source of this infection is being investigated.

(A. J. Hargreaves)

PLANT PROTECTION

02001 *Chemical and cultural control and economic importance of diseases of cane and bush fruits*

Raspberry cane diseases reduced by vigour control techniques

The incidence of cane diseases on the replacement canes of cv. Glen Clova which are produced after the removal of the first flush of canes by dinoseb-in-oil, has been assessed previously by non-destructive sampling (Ann. Rept 1976, p. 70). However, vascular lesions beneath cane midge feeding areas are often more extensive than surface views suggest and when the periderm is removed by scraping, two types of vascular lesion may be distinguished. (1) A form restricted within the precise boundaries of midge feeding areas and colonised principally by *Fusarium avenaceum* and *Phoma macrostoma*. (2) A spreading stripe produced by *Leptosphaeria coniothyrium* (Ann. Rept 1976, p. 64).

Replacement canes from plots sprayed when first flush canes were 10, 20, 30, 45 and 60 cm high were cut in January and scored for cane botrytis (*Botrytis cinerea*), spur blight (*Didymella applanata*), and midge blight. Sixty-five per cent of canes in unsprayed plots were affected by cane botrytis but in sprayed plots the incidence was reduced progressively to 25% in those sprayed at 20 cm and 18% in those sprayed at 45 cm. Only 5% of botrytis lesions on unsprayed plots occurred in the cropping region of canes so that although vigour control would not be expected to increase yields directly by reducing bud failure, they might substantially reduce the likelihood of botrytis fruit rot. Dinoseb had little effect on the incidence of spur blight, but only 17% of canes in unsprayed plots were infected.

Cankers caused by infection of larval feeding areas of first generation raspberry cane midge (*Resseliella theobaldi*) were rarely recorded from sprayed plots but occurred on 20% of canes in unsprayed plots. In the latter 80% of canes were affected by second generation larvae (producing restricted vascular lesions following fungal infection) but infestation decreased progressively from 75% of those sprayed at 10 cm to 21% of those sprayed at 60 cm, the most rigorous treatment. Ten per cent of canes in unsprayed plots but only 3% of canes in plots sprayed at 10 cm had more than 20% of the vascular cylinder blocked by lesions (see this report p. 82) and in all other treatments midge infestation would not be expected to affect yield. Spreading vascular lesions caused by *L. coniothyrium* were present in 28% of canes in unsprayed plots but were reduced to 11% by spraying at 10 cm and almost eliminated by all other treatments. Overall, the results show that even when the least rigorous vigour control treatments are applied *i.e.* spraying dinoseb when canes are 10 cm or 20 cm high cane diseases are controlled to a level at which they should not adversely affect yield.

(B. Williamson, A. J. Hargreaves)

Chemical control of raspberry cane blight

Fifteen fungicides were screened *in vitro* for activity against *L. coniothyrium*. Imazalil, WL 47675 (Shell Bio Sciences Ltd.) and benomyl showed the highest activity (> 0.1 ppm, ED50 < 1.0 ppm); thiophanate-methyl (> 0.5 ppm ED50 < 5.0 ppm), vinclozolin and triforine (> 1.0 ppm ED50 < 10 ppm) were only slightly less effective. Candidate fungicides will be field tested in machine harvested plots in 1978.

(B. Williamson, A. J. Hargreaves)

02004 Chemical and cultural control and economic importance of strawberry red core

Chemical and cultural control

When etridiazole was incorporated into agar, growth of *Phytophthora fragariae* was decreased at 0.5, inhibited at 1.0, and hyphae were killed at 100 ppm. Captafol and dichlofluanid decreased growth at 0.5, and killed hyphae at 500 ppm. Aluminium tris (ethyl phosphonate) decreased growth at 0.75, and was fungicidal at 500 ppm whereas sodium ethyl phosphonate decreased growth at 75, inhibited growth at 500, but was not fungicidal at 10,000 ppm the highest concentration tested. Prothiocarb decreased growth at 1.0, but did not inhibit growth at 10,000 ppm. Motile zoospores in fungicide solutions of 1, 10, and 50 ppm encysted within 0.5 h compared to more than 3.5 h in water. The only exception was prothiocarb at 1 ppm in which zoospores encysted within 3.5 h. Zoospore germination varied from 0-10%

in all solutions, except those containing 1 ppm of each of the phosphonate fungicides, compared to 75% in water.

Aluminium tris (ethyl phosphonate), furalaxyl, imazalil, and propamocarb at 1000, 2000, and 3000 ppm were evaluated as soil drenches in pot tests. Only aluminium tris (ethyl phosphonate) at 3000 ppm resulted in a significant reduction in the number of infections. However, plants treated with the lower concentrations had large root systems with little rotting, more than 50 per cent of infections occurring in lateral roots. Plants treated with furalaxyl and propamocarb had larger root systems than untreated plants which were probably due to delayed infections. Imazalil was phytotoxic at all concentrations.

Field trials of fungicides were water-logged for several weeks during the winter months and so many roots were affected by non-specific rotting that little information on severity of red core was obtained from plants lifted for disease assessment. In one trial established in 1975 to compare etridiazole, prothiocarb, and pyroxychlor, only the prothiocarb soil drench resulted in a significant increase in yield. In the other, established in 1976, increases in yield were obtained from all treatments but these were not significant due to variation over the site. A comparison of the increases obtained from different treatments indicated that soil drenches of sodium ethyl phosphonate or aluminium tris(ethyl phosphonate) gave over 60% more fruit than untreated plants, compared to 57% following etridiazole soil drench, 27% following a foliar spray of sodium ethyl phosphonate and 5% from a captafol drench.

In studies of antagonists isolated from a soil suppressive of red core disease (Ann. Rept 1974, p. 61; 1975, p. 54) bacteria were tested for *in vitro* compatibility by dual culturing and by diffusate interaction. *Fragaria vesca* roots were dipped in double or triple suspensions of compatible isolates before planting in sterilized loam or soil-less compost. Several days later zoospores of *P. fragariae* were added to the soil. None of the treatments resulted in a significant reduction in disease severity.

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

02016 Chemical and cultural control of potato gangrene

Experiments were continued to examine changes in inoculum levels during the growing season. Tubers were sampled at intervals, given standard wounds and then stored at 3°C for 11 weeks before being scored for rots; periderm samples were taken at the same time for plating on a selective medium. In accordance with findings in some other years there were high inoculum levels in early August which then declined before increasing again towards the end of September. There was a high correlation between both methods of detection in contrast to the results of three previous years when there was none. In the first two years the scores from the periderm samples were significantly correlated with the incidence of gangrene which subse-

quently developed in storage, whereas in the third year only the tuber rot score was so correlated. Sampling stem sections 5 and 50 mm distant from the mother tuber showed similar trends in inoculum levels with a high proportion of positive results in late July and early August which decreased and then rose again in mid-September and October. The incidence in the 55 mm distant sections was much lower than those at 5 mm indicating that upward spread from the mother tuber was limited. The extent of the increases in positive stem samples late in the growing season was considerably greater than the increase in positive periderm samples.

Comparisons were made from samples of tubers taken early, mid and late season and given standard wounds at the time of harvesting and at the time of grading in December. The percentage of tubers developing rots from the early harvest was similar for the two times of wounding, decreased by half for the mid season sample, but increased by a factor of four for the late season sample. It is not yet possible to determine whether these changes are primarily influenced by changes in inoculum levels, changes in tuber susceptibility affected by maturity at harvest, or a combination of both factors.

(R. A. Fox, E. Patricia Dashwood)

PHYTOPATHOLOGICAL METHODS

02021 Immunofluorescent and fluorescent techniques in histology

The observations reported elsewhere (p. 80) on the instability of isolates of *Phoma exigua* var *foveata* may explain the erratic and poor results that have been obtained in previous serological work. The contaminating bacteria, thought possibly to interfere with antibody production, do not appear to do so as judged by the results obtained with contaminated or uncontaminated isolates.

(H. M. Wilson)

52029 Phytopathological methods

Satisfactory storage of working stock culture collections is a continuing problem. A programme is in hand for testing cultures of *Erwinia* spp., *Phoma* spp., and *Colletotrichum* spp. for survival by recognised freeze drying-vacuum methods. Preliminary results for *Erwinia* are promising but the survival rates for *Phoma* and *Colletotrichum* were disappointing. When isolates of *Phoma* spp. were cultured on potato tissue, freeze dried and vacuum stored, the subsequent recovered colonies had excessively high and unacceptable rates of sectoring.

(H. M. Wilson)

Virology

B. D. HARRISON

As a result of the temporary absence overseas of two of the Section's senior members, less research than usual was done on viruses affecting raspberry and bulbous ornamentals. However, of the other work on viruses affecting specific crops, that on viruses of carrot and grasses increased, and several viruses were included in comparisons of newly developed sensitive serological methods of virus detection and assay.

Protoplasts prepared from leaf cells were used in a wide variety of experiments on the behaviour of viruses at the cellular level. Although not a normal part of the virus genome, the satellite RNA of tomato black ring virus was found to induce the production in protoplasts of a specific polypeptide. Other work with protoplasts cast fresh light on two well-known kinds of interaction of virus strains in tissues—interference and cross-protection. Another interesting finding was of circular single-stranded DNA in the particles of two viruses from Africa, the first examples of this type of genome in plant viruses.

TOBRAVIRUSES

04002 *Viruses with nematode vectors and/or multipartite genomes*

Separation of long and short particles of tobacco rattle virus (TRV)

Although long and short particles of TRV strain CAM can be separated by two or three cycles of sedimentation in sucrose density gradients, recoveries are poor and only limited quantities of virus can be processed at any one time. Typically a week's work might be required to obtain less than a milligram of each type of particle, or less than 50 μg of extractable RNA-1 and RNA-2. A more rapid and efficient procedure for separating long and short particles was therefore devised. Frozen sap is thawed and clarified by low speed centrifugation, and polyethylene glycol (mol.wt. 6,000; PEG) and NaCl are added to final concentrations of 6% (w/v) and 0.2 M respectively. The precipitate contains mainly long particles, which are further purified by another cycle of precipitation under the same conditions, followed by sedimentation in the ultracentrifuge. Short particles are precipitated from the supernatant fluid of the first PEG precipitation step by increasing the concentration of PEG to 10% (w/v) and that of NaCl to 0.34 M, and are further purified by ultracentrifugation and a single cycle of sucrose density

gradient sedimentation. In a typical experiment about 10 mg of each type of particle was obtained in 2 days. The purity of the fractions, judged by electron microscopy, was comparable with the best achieved by the conventional procedure; the short particles were virtually free of long particles, and the long particles were contaminated by only about 10% by number (2.8% by weight) of short particles. In our experience, long particle preparations made by any method contain short particles in about this proportion, which cannot be further decreased by additional sucrose density gradient sedimentations. A sensitive test for contamination of long particle preparations with biologically active short particles is production of coat protein antigen in inoculated tobacco mesophyll protoplasts. When inoculated at 0.1 µg/ml, a sample of long particles prepared by the improved method induced antigen formation in only 3% of protoplasts, although addition of 0.1 µg/ml short particles to the inoculum increased this figure to 46%, showing that the long particles were highly infective. In similar tests with a sample of long particles prepared by the conventional method, adding short particles to the inoculum increased the proportion of protoplasts producing antigen from 74% to 78%.

(D. J. Robinson, M. A. Mayo)

Aggregates in inocula for protoplasts

Previous work showed that inocula consisting of TRV and poly-L-ornithine, each at 1 µg/ml, and either phosphate or citrate buffer, contain aggregates of, on average, about 20 virus particles. Further work, using carbon-film electron microscope grids treated with antiserum, showed that TRV inocula prepared in 0.05 M tris-HCl buffer, pH 8, contained aggregates consisting of many hundreds of particles; however, despite the much greater size of these aggregates, such inocula were as infective as those prepared in phosphate buffer. Inocula of tobacco mosaic virus also contained very large aggregates, whether prepared in phosphate, citrate or tris-HCl buffers.

(M. A. Mayo, I. M. Roberts)

TRV-induced proteins in tobacco protoplasts

When ³⁵S-methionine was added to cultures of protoplasts 2 h after inoculation with the CAM strain of TRV, up to three virus-induced radioactive polypeptides were detected in SDS-polyacrylamide gel electrophoresis of proteins extracted from protoplasts 20 h later. When protoplasts were irradiated with u.v. light (254 nm; 0.15-0.25J/cm²) before inoculation, incorporation into host proteins was inhibited preferentially and the TRV-induced proteins were more easily detected. Their estimated mol.wt. were 187,000 (band 1), 142,000 (band 2) and 31,000 (coat protein), approximately the same as those of the major products of translation of TRV RNA *in vitro*. Only bands 1 and 2 were found in extracts of protoplasts inoculated

with preparations of TRV long particles. Adding a preparation of TRV short particles to such inocula did not affect the radioactivity of bands 1 and 2, but resulted in the additional synthesis of the coat protein.

(M. A. Mayo)

Effects of metabolic inhibitors on early stages of TRV multiplication

In an attempt to divide the multiplication cycle of TRV in tobacco protoplasts into separate phases, different inhibitors were added at intervals to suspensions of inoculated protoplasts. The protoplasts were stained with fluorescent antibody to virus particles 2 days after inoculation, and the proportion in which the production of virus antigen was suppressed was taken as a measure of the extent to which TRV multiplication was inhibited. As with some other viruses, there was a short period immediately following inoculation when actinomycin D (25 µg/ml) inhibited multiplication in up to half the inoculated protoplasts; cordycepin (0.25 mM) had a very similar effect. Little inhibition was observed when either inhibitor was added 3 h or more after inoculation, although both inhibitors decreased incorporation of ³H-uracil by protoplasts about 3-fold. The parallel effect of two chemically dissimilar inhibitors strongly suggests that DNA-dependent RNA synthesis is a necessary prerequisite of TRV multiplication in at least some inoculated protoplasts, and that this synthesis is completed relatively early during virus multiplication. TRV multiplication can also be inhibited, in 50% or more of infected protoplasts, by thiouracil (10 µg/ml) for about 5-7 h post-inoculation, and by cycloheximide (1 µg/ml) for at least 10 h post-inoculation. This sequence of inhibitions resembles that reported for tobacco mosaic virus in leaf tissue.

(M. A. Mayo, D. J. Robinson)

Fractionation of infected tissue

Work was resumed to investigate the possible role of cell organelles, particularly mitochondria, in the multiplication of TRV. The concentration of mitochondria in crude extracts was estimated by measuring cytochrome C oxidase activity. Disruption of tobacco leaves in liquid nitrogen followed by differential low speed centrifugation gave preparations of mitochondria substantially free of chloroplasts. Centrifugation of such preparations in sucrose density gradients readily separated peroxisomes and microbodies from mitochondria which, however, were still associated with some fragments of chloroplasts. Attempts to study the distribution of infectivity among fractions from tobacco leaves infected with a defective isolate of TRV (strain CAM) were hampered by the unexpectedly rapid inactivation of infectivity, presumably by ribonuclease.

(R. M. Shields¹, M. A. Mayo)

¹ Sandwich student, University of Bath.

Physiology of leaves infected with the YS variant of TRV

White Burley tobacco plants infected with the YS variant of TRV (strain CAM) are severely stunted, and systemically infected leaves develop a pattern of bright yellow areas. Light and electron microscopy showed that cells in the yellowest areas contained fewer and smaller chloroplasts than those in green areas or in healthy leaves, and that these chloroplasts contained fewer grana. Chlorophyll content was much diminished in the yellow areas, but in the leaf as a whole chlorophyll content and the quantum efficiency of photosynthesis were not significantly different from those of healthy leaves or symptomless leaves infected with strain CAM, presumably because only a small proportion of the total leaf area was yellow.

Further analysis of the resistance to diffusion of CO₂ to the photosynthetic sites, which is greater in YS-infected leaves, and results in a lower rate of net photosynthesis at saturating light intensities, showed that the larger part of the increase in resistance, from 15 to 23 s/cm², was intracellular. Stomatal resistance was increased from 0.7 to 2.1 s/cm². YS-infected leaves had more stomata per unit area than healthy ones, but the mean length of the stomatal apertures was smaller. However, there was no significant difference in stomatal frequency and size between YS-infected and CAM-infected leaves, although only YS-infected leaves showed the increased stomatal resistance to diffusion. In both types of infected leaves, but not in healthy ones, there were some incompletely differentiated stomatal structures, suggesting that the development of the leaves was impaired. Presumably stomata in YS-infected leaves must differ from those in CAM-infected and healthy leaves in their ability to open properly.

(D. J. Robinson, D. K. L. MacKerron¹)

NEPOVIRUSES

04002 Viruses with nematode vectors and/or multipartite genomes

Estimates of molecular weights of nepovirus RNA species under denaturing conditions

The mol.wts of the RNA components of twelve nepoviruses were estimated by electrophoresis at 60°C in 2.0% polyacrylamide gels containing 8 M-urea. Hyperchromicity tests showed that under these conditions all the RNA molecules were fully denatured. For all the viruses the estimates for RNA-1, between 2.08×10^6 and 2.19×10^6 , were considerably lower than previously published values ($2.3-2.6 \times 10^6$), but may not be more accurate. In contrast, most estimates for RNA-2 and, where present, RNA-3 were not greatly

¹ Crops Research Section.

different from those previously reported, but are considered more accurate. On the basis of the mol.wt. of RNA-2, most of the viruses fell into one of three clusters. These are (i) RNA-2 of mol.wt. *ca.* $1.42-1.50 \times 10^6$ —raspberry ringspot, arabis mosaic, strawberry latent ringspot, tobacco ringspot, potato black ringspot and possibly mulberry ringspot viruses; (ii) RNA-2 of mol.wt. *ca.* 1.65×10^6 —tomato black ring, grapevine chrome mosaic and artichoke Italian latent viruses; (iii) RNA-2 of mol.wt. *ca.* 2.0×10^6 —cherry leaf roll and tomato ringspot viruses. Myrobalan latent ringspot virus, which is reported to be serologically related to tomato black ring virus, had a RNA-2 of much larger mol.wt. (1.90×10^6).

(A. F. Murant, Margaret Taylor)

*Translation of tomato black ring virus (TBRV) satellite RNA
in vitro and in vivo*

Some isolates of TBRV contain, in addition to the functional RNA species (RNA-1 and RNA-2), a satellite RNA (RNA-3) which is not essential for multiplication of the parent virus. In collaborative work with Dr Christiane Fritsch¹, RNA-3 from the beet ringspot isolate was translated in wheat germ extracts and in reticulocyte lysates into a single polypeptide of mol.wt. about 48,000, which represents the entire coding capacity of the RNA. A protein of identical electrophoretic mobility was synthesized in tobacco protoplasts infected with TBRV-S but not in protoplasts infected with a satellite-free derivative. The role of this protein is unknown, because RNA-3 multiplies in plants only in the presence of TBRV-RNA-1 and RNA-2, is packaged in TBRV coat protein, and produces no known phenotypic effects.

(M. A. Mayo, A. F. Murant)

Infectivity of RNA preparations

RNA was extracted from particles of potato black ringspot virus (PBRV), and from those of the New Jersey and eucharis mottle strains of tobacco ringspot virus by three different methods. When inoculated at $0.25 \mu\text{g/ml}$, preparations made using phenol or sodium perchlorate produced 50-80 lesions per leaf whereas those made using Pronase/sodium dodecyl sulphate were non-infective, although analysis by polyacrylamide gel electrophoresis indicated that most RNA molecules in all three preparations were essentially intact. RNA preparations made using Pronase did not contain material that inactivated preparations made using phenol. The results suggest that Pronase contains a component, possibly an exonuclease, that inactivates the RNA of these viruses, or that a non-RNA component necessary for infectivity is

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removed from virus RNA by treatment with Pronase. However, the infectivity of Pronase-treated PBRV-RNA was not restored by adding PBRV coat protein in the form of RNA-free particles.

(L. F. Salazar, B. D. Harrison)

Interactions in protoplasts of raspberry ringspot virus (RRV) strains

The interaction in mesophyll protoplasts of strains RRV-S and RRV-E was studied using fluorescent antibody to detect strain-specific antigen. Staining with fluorescent antibody was weak and generalized unless the protoplasts were also infected with the CAM strain of TRV, which induces RRV to form antigen aggregates and was therefore used routinely to make RRV antigen more easily detectable.

When tobacco protoplasts were inoculated simultaneously with equal amounts of the two RRV strains, both strain-specific antigens were produced in more than half the protoplasts. The proportion of protoplasts producing antigen aggregates of both strains depended on the ratio of particles of the two strains in the inoculum, but RRV-S had a greater specific infectivity than RRV-E and tended to dominate unless this difference was compensated for. When one strain and TRV were inoculated before the other strain, the strain inoculated second produced antigen aggregates in fewer protoplasts than when it followed a first inoculation with TRV only. Exclusion of the second strain increased with increasing interval between inoculations and was not overcome by increasing the inoculum virus concentration. It was less strong in RRV-E-inoculated than in RRV-S-inoculated protoplasts, in which it was total by 12 h.

Nicotiana benthamiana plants systemically infected with RRV-S did not develop additional symptoms after their recovered leaves were inoculated with RRV-E, but some RRV-S-infected protoplasts from recovered leaves produced RRV-E antigen after inoculation with RRV-E and TRV. This shows that some stages of RRV-E replication can occur in cells already long infected with RRV-S. However, RRV-E antigen aggregates were produced in only 11% of the superinoculated protoplasts, 99% of which became infected with TRV from the same inoculum, suggesting that partial protection exists and is virus-specific. The phenomena of interference and cross-protection between strains seem best explained by competition in cells for virus-specific sites or material, possibly RNA polymerase, that can be used in the replication of either strain.

(H. Barker, B. D. Harrison)

Inactivation and mutagenesis of tomato black ring virus (TBRV) by nitrous acid

Strain A of TBRV produces two nucleoprotein components, known as middle (M) and bottom (B), which contain RNA of mol.wt. 1.6×10^6 and

2.5×10^6 respectively and are both needed to produce infection. The ability of B particles or their extracted RNA to co-operate in producing infection decreased logarithmically with increasing time of exposure to nitrous acid. The effect on M particles was harder to assess because the untreated B component preparations with which they had to be mixed had variable residual infectivity attributed to contamination with M particles. Preparations of B component were still infective after six cycles of sucrose density gradient sedimentation, suggesting that they contained stable aggregates of M particles sedimenting close to B particles. However, this residual infectivity was removed by isopycnic sedimentation of B component preparations in caesium chloride gradients.

One possible symptom mutant was obtained when 100 isolates from single lesions produced by inocula containing treated B particles were inoculated to *Chenopodium quinoa* and *Nicotiana clevelandii*.

(R. L. S. Forster, B. D. Harrison)

VIRUSES OF FLOWER BULBS

04010 *Viruses infecting bulbous ornamentals*

Methods of detecting viruses in narcissus

Some of the viruses that occur in narcissus do not cause conspicuous symptoms, and the much needed information on the epidemiology of these viruses demands a rapid, sensitive and specific method of indexing. Enzyme-linked immunosorbent assay has these qualities and its suitability for detecting viruses in narcissus was therefore tested with narcissus mosaic and narcissus tip necrosis viruses, which have filamentous and isometric particles, respectively. By this method, narcissus mosaic virus was detected at concentrations down to 1 ng/ml, and using sap from infected narcissus leaves the test was only 10 times less sensitive than an infectivity test on *Chenopodium amaranticolor*. Narcissus tip necrosis virus was detected at concentrations down to 10 ng/ml. Both viruses were reliably detected in sap extracted by pestle and mortar from batches of 100 leaf pieces of which only one was infected, and also when these extracts were diluted with narcissus sap a thousandfold (narcissus mosaic virus) or a hundredfold (narcissus tip necrosis virus). Narcissus mosaic virus was also detected in sap from fleshy scales of dormant bulbs, but not when this sap was diluted more than tenfold. Addition of polyvinylpyrrolidone to the extracting buffer did not increase the detectability of either virus in leaf sap and indeed seemed to decrease the sensitivity of detection of narcissus mosaic virus about tenfold.

(W. P. Mowat)

Virus spread in narcissus

In the second of a series of trials to assess re-infection rates at different localities using narcissus yellow stripe as the test virus and allowing spread

to occur for 1 year, plots were planted in 1975 near Fettercairn, Kincardineshire, at Craibstone Farm, Aberdeen and at SHRI. At planting the incidence of yellow stripe was 11% and the increases after 1 year were 1%, 4.5% and 8% respectively.

(W. P. Mowat)

Lily viruses

In previous work in which tulip breaking and lily symptomless viruses were experimentally transmitted by aphids to new *Lilium* hybrids, one of them, the cultivar Odysseus (*L. tigrinum flaviflorum* x cv. Destiny) x cv. Golden Chalice), failed to become infected. Plants of this cultivar, later exposed to natural infection, were found to contain filamentous virus-like particles about 550 nm long. Attempts to transmit this virus by manual inoculation to a range of herbaceous test plants were unsuccessful.

(W. P. Mowat)

04011 Production of virus-tested bulb stocks

Propagation of virus-tested narcissus

In August, a second batch of virus-tested clones propagated at SHRI was released to the East of Scotland and North of Scotland Colleges of Agriculture for further multiplication by twin-scaling. This material consisted of three clones of cv. Carlton and one of cv. Sempre Avanti, totalling about 300 bulbs weighing 18 kg.

Further batches of twin-scales of these two cultivars were cut to maintain supplies of virus-tested material. After incubation for 12 wk at 23°C, 98% of the twin-scales survived and 88% formed bulbils, a much better performance than in the previous 2 years. The multiplication of virus-tested clones of the cultivars Fortune, Golden Harvest and King Alfred was also started, two of the Fortune master bulbs having been obtained by culturing meristem tips.

(J. Chambers, W. P. Mowat)

In last year's report reference was made to the possible use of thiram as a replacement for benomyl in the treatment of twin-scales, and 17% fewer of those soaked in thiram (0.24% suspension of 80% wettable powder) were suitable for planting than of those treated with benomyl (1g/l). However, the proportions of twin-scales planted that formed bulbils, and of bulbils emerging in 1977, were similar for the two treatments.

In a new trial twin-scales of two cultivars were treated with the fungicides benomyl (1 g/l), thiram (0.24% suspension of 80% wettable powder) and captafol (1 g/l), and with the growth promoter kinetin (1 mg/l), each alone

and in all possible pairs. The twin-scales were soaked in these preparations for 30 min. at room temperature and then incubated for 12 wk at 23°C. Almost all were suitable for planting. The proportion forming bulbils ranged from 82% for cv. Sempre Avanti treated with benomyl and kinetin to 100% for cv. Sempre Avanti treated with benomyl and thiram, and cv. Carlton treated with benomyl and kinetin.

(J. Chambers)

RUBUS VIRUSES

04003 Viruses infecting raspberry

Effects of raspberry bushy dwarf virus (RBDV)

In previous studies, raspberry plants infected with RBDV by inoculation or through seed have shown no symptoms. However, tests on field-grown raspberry plants with yellowing symptoms suggested that in some cultivars or breeding selections there was at least partial correlation between yellowing and infection with RBDV. Of 225 progeny seedlings from infected plants only two showed yellows symptoms and both were infected with RBDV. A further 23 seedlings were infected but showed no symptoms. Studies are continuing to find out whether RBDV can induce yellowing symptoms in some genotypes.

(A. F. Murant)

04004 Production of virus-tested raspberry stocks

Virus indexing and heat therapy

A large number of raspberry and other *Rubus* plants were indexed for viruses during the past 4 years. Many of the tests stemmed from a self-imposed Institute quarantine procedure under which all imported vegetative material is kept in an aphid-proof house until tests for viruses are completed. Only virus-free clones are later planted in the field. The results of these tests showed that most imported clones were virus-free, and no previously undescribed or non-indigenous viruses were found.

Tests on nearly 100 seedling clones from the SHRI and East Malling Research Station *Rubus* breeding programmes were another important part of this work. Both programmes have as a major objective the production of cultivars with resistance to the aphid *Amphorophora idaei*, which is the most important vector of aphid-borne *Rubus* viruses in Britain. This may explain the remarkable change in recent years, during which only a few plants were found to contain aphid-borne viruses whereas previously only a few were virus-free. Any infected seedling clones required for further assessment as

potential cultivars were freed from virus infection by heat treatment, as for example was the *Rubus* hybrid cv. Tayberry.

Virus-tested mother plants of 32 cultivars and advanced selections are now maintained in the gauze house. These include plants of all cultivars that are commercially important in Britain, and each year a selection of cultivars is propagated to produce young virus-tested plants for the Scottish Nuclear Stock Association. Before propagation, canes from each mother plant are fruited to ensure freedom from crumbly fruit disorder. Samples are also indexed to confirm their freedom from virus, by grafting scions to *Rubus henryi* and to the raspberry cultivars Malling Landmark and Norfolk Giant, and by inoculating sap to *Chenopodium quinoa*.

(J. Chambers)

VIRUSES OF UMBELLIFEROUS PLANTS

04007 *Viruses affecting umbelliferous plants*

Carrot mottle virus

Studies on the purification of carrot mottle virus were resumed. Infectivity in extracts from newly systemically infected leaves is unstable in phosphate buffer at pH 7 but more stable in tris buffer at pH 9, whereas that in extracts made 2-3 days later is relatively stable in both buffers. Infectivity both in 'early' tris buffer and 'late' phosphate buffer extracts sedimented as a rather broad band when centrifuged in sucrose density gradients, and eluted in or very near the void volume from Sepharose 2B columns. Infective fractions were very opalescent, and electron microscopy showed that they contained membranous material among which virus particles could not be recognised. These results may imply that the infective particles are attached to heterogeneous pieces of membrane, but attempts to detach them by treatment with detergents were unsuccessful. Of the thirteen detergents tested, most diminished or destroyed infectivity and the least damaging, Tween-80 at a final concentration of 0.1%, had no apparent effect on the distribution of u.v. absorbing material or infectivity in a Sepharose 2B column. Treatment with 0.01 M ethylene diamine tetra-acetate also had no effect on the distribution but was helpful in clarifying the extracts.

(D. J. Robinson, A. F. Murant, J. H. Raschke)

Experiments were begun to study the nature of the infective RNA found in phenol extracts of infected leaves. Preliminary results show that in sucrose density gradients it sediments with, or slightly more rapidly than, the largest host ribosomal RNA.

(E. Halk, D. J. Robinson, A. F. Murant)

Carrot red leaf virus

Electron microscopy of thin sections of the petioles of chervil infected with carrot red leaf virus revealed isometric virus-like particles *ca.* 25 nm in diameter. They were confined to phloem tissue. These observations and the previous findings that this virus is transmitted in the persistent manner by aphids suggest an affinity with luteoviruses.

(A. F. Murant, I. M. Roberts)

Virus transmission by aphids

In previous studies, virus-like particles of the semi-persistent virus, anthriscus yellows, were found embedded in a matrix of 'M-material' at a specific site in the foregut of viruliferous aphids (*Cavariella aegopodii*). Experiments were begun to find out whether other viruses are associated with their vectors in a similar way. Attempts so far to find virus-like particles in the anterior alimentary tract of *Myzus persicae* carrying beet yellows virus, or of *M. persicae* or *Brevicoryne brassicae* carrying cauliflower mosaic virus, were unsuccessful.

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

Viruses from Heracleum sphondylium

The virus described previously under the code-name HV2 occurs in naturally infected *H. sphondylium* plants without inducing symptoms and was named heracleum latent virus (HLV). Continued studies confirmed that it is a previously undescribed closterovirus resembling apple chlorotic leaf spot virus (ACLSV) in particle properties but is serologically unrelated. The particles of both viruses contain single-stranded RNA, estimated to have a mol. wt. of 2.8×10^6 by electrophoresis in polyacrylamide gels under non-denaturing conditions, or 2.1×10^6 by electrophoresis at 60°C in polyacrylamide gels containing 8 M-urea. HLV was completely degraded in the presence of 28% (w/v) CsCl. In isopycnic centrifugation in Cs₂SO₄ at 20°C, HLV gave a single major band of aggregated particles corresponding to a buoyant density of 1.24 g/ml. The value for ACLSV particles was 1.27 g/ml.

HLV was transmitted by the aphids *Cavariella aegopodii*, *C. pastinacae* and *C. theobaldi* from naturally infected *H. sphondylium* plants but not from chervil, coriander or carrot plants, whether these had been inoculated manually or by means of aphids. Present results are consistent with the hypothesis that aphid transmission of HLV is mediated by a helper virus that infects *H. sphondylium* but not other umbelliferous species tried. Naturally infected *H. sphondylium* plants that acted as sources of HLV for aphids contained at least four other viruses transmissible to chervil or coriander by *Cavariella* spp., but none of these, or anthriscus yellows virus, which assists transmission of parsnip yellow fleck virus, seems able to assist transmission of HLV.

(F. Bem, A. F. Murant)

04001 *Potato viruses, especially soil-borne viruses**New viruses from potato*

Two further viruses were obtained from South American potatoes. One was readily sap-transmissible, occurred in high concentration and produced isometric particles 28 nm in diameter and sedimenting at 53, 93 or 112S. The two fastest sedimenting components (M and B) are nucleoproteins. Both were found to contain two polypeptide species of mol. wt. 22,100 and 41,800. Both also contained single-stranded RNA of mol. wt. 1.4×10^6 (M particles) or 2.0×10^6 (B particles), and both were needed for infection. Two isolates were studied; isolate C proved to be serologically indistinguishable from another isolate found independently in South America by Fribourg *et al.* (*Phytopathology* 67, 969, 1977) and named andean potato mottle virus. Isolate H differed antigenically from isolate C and the type strain. All three isolates infect several solanaceous species but differ from one another in ability to infect *Gomphrena globosa* and *Tetragonia expansa*. Andean potato mottle virus is a typical comovirus.

The second virus was transmitted with difficulty by inoculation with sap from Santa Catalina potato plants with potato yellow vein disease to *Datura stramonium*, which developed systemic symptoms when heavily shaded. The same virus was detected consistently by graft inoculation of *D. stramonium* and was transmitted from *D. stramonium* to *D. stramonium* by inoculation with sap. In the year after grafting with infected *D. stramonium* scions, cv. King Edward and cv. Arran Victory potato developed interveinal yellowing. No virus other than that transmitted to *D. stramonium* was detected consistently in naturally infected Santa Catalina plants by electron microscopy or inoculation of indicator species with sap, but some plants contained potato virus Y. Ultrathin sectioning of leaf tissue containing both these viruses revealed electron-dense rods ca. 25 nm in diameter and of indeterminate length, in addition to the well-known structures commonly associated with potato virus Y.

The Andean region of South America seems to be a centre of diversity of potato viruses as well as of potatoes. Knowledge of the properties of viruses not found in Western Europe should help to prevent their introduction and spread in these countries.

(L. F. Salazar, B. D. Harrison, I. M. Roberts)

Insecticidal control of potato leafroll virus

In a field experiment in 1976, disulfoton granules (1.1 kg a.i./ha) were applied at planting time in the drills of some plots, to protect cv. Maris Piper potato plants from virus-carrying aphids during the early stages of

crop growth. Progenies of the six plants on each side of infectors were grown on in 1977. The incidence of potato leafroll virus in progenies from the granule-treated plots was 21% of that in untreated control plots. Although aphid migrations were early and large in 1976, plants in granule-treated plots were barely colonised until early July. However, demeton-S-methyl (240 ml a.i./ha) sprays applied at 2-weekly intervals beginning on July 5 did not give any additional control of virus spread in granule-treated plots.

The results obtained in this trial probably underestimate the effect of the granular aphicide on spread of virus within the plot. Virus incidence decreased with increasing distance from the infectors in control plots, but there was little such gradient in granule-treated plots. This suggests that much of the spread in granule-treated plots was caused by aphids that were viruliferous when they arrived, possibly when the crop was young. The results emphasize the longstanding general problem of how to prevent virus transmission by incoming viruliferous aphids, and illustrate the limitations of small-plot experiments for assessing insecticidal control of viruses that persist for long periods in their aphid vectors. Estimates of the control given in such trials probably underrate the value of similar treatments applied to whole crops.

(B. D. Harrison, J. A. T. Woodford¹)

04020 Viruses of grasses

Cocksfoot mild mosaic (CMMV) and phleum mottle (PMV) viruses

Enzyme-linked immunosorbent assay was used in a small-scale survey of the occurrence and incidence of CMMV in hedgerows and pastures within a 50-mile radius of Dundee. The incidence of the virus in cocksfoot in hedgerows was 1-20% (mean 9%), and in pastures was 0-15% (mean 6%).

A local isolate of CMMV (CMMV-D) was compared with a German isolate (CMMV-G, supplied by Dr W. Huth²) and a local isolate of PMV. The two isolates of CMMV differed in virulence, and were symptomatologically distinct from PMV in cocksfoot, timothy, barley and *Setaria italica*. The serological interrelationships of the three isolates were complex, but CMMV-G reacted the least strongly with PMV antiserum and CMMV-D reacted the least strongly with CMMV-G antiserum. CMMV-D reacted more strongly than the other isolates with antiserum to a Dutch isolate of CMMV (supplied by Dr D. Z. Maat³). Particles of the two CMMV isolates were purified from *S. italica* and those of PMV from barley. To prevent precipitation of PMV particles, it was necessary to resuspend ultracentrifuge sediments in 0.05 M tris buffer at pH 6.6-5, not at pH 7. Electron microscopy

¹ Zoology Section.

² BBA, Braunschweig, Germany.

³ IPO, Wageningen, The Netherlands.

showed that the 30 nm diameter particles of all isolates were badly damaged when stained with sodium phosphotungstate at pH 6.5 unless previously fixed with osmium tetroxide. Methylamine tungstate at pH 6.5 and uranyl formate/sodium hydroxide (pH 4.8) gave satisfactory results with unfixed virus.

Particles of all three isolates contained a single polypeptide species estimated by polyacrylamide gel electrophoresis to have a mol. wt. of 27,500 (CMMV-D and CMMV-G) or 28,500 (PMV); estimates made using 3.5-10% gels were similar. Particles of all isolates also contained two species of single-stranded RNA estimated by polyacrylamide gel electrophoresis in denaturing conditions to have mol. wt. of 1.5×10^6 and 0.5×10^6 . The proportion of the smaller RNA species differed between isolates and was largest for CMMV-D.

Other viruses

Particles of cocksfoot streak virus (CSV) were purified from cocksfoot but the yield was only about 1 mg per 100 g leaf; an antiserum was prepared. The virus culture also contained isometric virus-like particles, and when attempts were made to free CSV from these, they always reappeared after making one or two bulk cultures in cocksfoot. Plants containing the isometric particles in addition to CSV were more severely affected than those containing CSV only. The isometric particles did not react with antisera to CMMV, PMV, cocksfoot mottle or brome mosaic viruses.

An isolate of cocksfoot mottle virus was obtained from a cocksfoot plant with severe mottle and necrosis. It reacted with antiserum to the type strain (supplied by Dr P. L. Catherall¹) and its host range was similar. It did not react with antisera to PMV or CMMV.

A virus from a roadside *Agropyron* plant with chlorotic streak symptoms produced chlorotic streaking in wheat plants, which then contained flexuous filamentous particles that did not react with antisera to ryegrass mosaic or cocksfoot streak viruses. This isolate resembles agropyron mosaic virus.

(Lesley Torrance, B. D. Harrison)

EXOTIC VIRUSES

04014 *Identification of viruses in relation to diseases of other crop plants*

Nucleic acid of maize streak and cassava latent viruses

Previous work in collaboration with Drs K. R. Bock and E. J. Guthrie² showed that particles of each of these viruses yield two nucleic acid components, thought on slender evidence to be RNA. In further collaborative

¹ Welsh Plant Breeding Station, Aberystwyth.

² EAAFR0, Muguga, Kenya.

work with Drs Bock and Guthrie, and Dr M. Atkinson¹, the nucleic acids were found to be resistant to pancreatic ribonuclease and to alkali but were degraded by deoxyribonuclease and by S1 nuclease, indicating that they are single-stranded DNA. Hyperchromicity plots for cassava latent virus DNA were like those of single-stranded nucleic acid and provided no evidence that plus and minus strands were contained in different particles. Electron microscopy of the virus DNA showed that many molecules were circular and others linear, with the circular forms predominating in most preparations. Linear molecules were up to the length of but not longer than circular ones. From comparative measurements of the circular molecules and the circular single-stranded DNA of bacteriophage ϕ X174, maize streak virus DNA was estimated to have a mol.wt. of 0.71×10^6 and cassava latent virus DNA of 0.80×10^6 . These seem the smallest genomes yet found among independently replicating plant viruses.

(B. D. Harrison, H. Barker)

Relationship between pepper veinal mottle and tobacco vein mottling viruses

The type strain of pepper veinal mottle virus (PVMV) from Nigeria was found to be related to tobacco vein mottling virus (TVMV) from the USA in electron microscope serological tests. PVMV antiserum had a homologous reaction end-point of 1/1028 and a heterologous titre of 1/512, while TVMV antiserum had a homologous titre of 1/8192 and a heterologous titre of 1/512. These tests also showed an unusual feature. Many of the particles which had reacted with their own antiserum were disrupted ('ghosts') and were recognizable only by their antibody coating. Disruption of particles was sometimes prevented by fixing them using glutaraldehyde, and this did not affect their reaction with the antisera. However, resistance to disruption seemed to depend both on the antiserum and the dilution at which it was used.

(I. M. Roberts)

Pepper and tomato viruses from Argentina

In collaborative work with Dr O. Gracia², virus isolates from pepper and tomato were found to produce rod-shaped particles about 300 nm long that reacted with antiserum to the common strain of tobacco mosaic virus (TMV) in electron microscope serological tests. However, the relationship was not close. Another isolate from tomato also produced rod-shaped particles, but these were irregular in length and outline, had a distinct periodicity and did not react with TMV antiserum. Extracts from plants of several species infected with each isolate were examined, but only pepper and tomato consistently yielded virus-like particles.

(I. M. Roberts)

¹ Institute of Virology, University of Glasgow.

² INTA, Mendoza, Argentina.

Indexing yams from Barbados

Clones of *Dioscorea alata* cv. White Lisbon, obtained by Mr S. H. Mantell¹ from meristem tips or nodes of plants treated with hot air, were indexed for viruses by examining negatively stained extracts and by electron microscope serology. Most yielded filamentous particles that reacted with antisera to pepper vein mottle virus and to potato virus Y, but two seemed to be virus-free. No bacilliform particles were detected.

(I. M. Roberts)

TECHNIQUES

04014 Identification of viruses in relation to diseases of other crop plants

Comparison of sensitive serological techniques

The relative merits were examined of enzyme-linked immunosorbent assay (ELISA), antiserum-activated electron microscope grids and antibody-sensitized latex for detecting and assaying virus particles. ELISA was used successfully to detect cocksfoot mild mosaic, cocksfoot streak, phleum mottle, potato T, potato Y and raspberry ringspot viruses, in addition to the two narcissus viruses already mentioned (p. 96). In general, the test readily detected 5-10 ng virus/ml or less, and was not affected by plant sap. It detected potato virus Y when one infected leaflet was mixed with 300 healthy leaflets, and cocksfoot mild mosaic and phleum mottle viruses when one leaf in a hundred was infected. The test discriminated quite strongly between strains, with even relatively closely serologically related isolates giving a much less intense colour reaction than the homologous virus. This discrimination was mainly caused by a decreased reaction between the antibody-enzyme conjugate and particles of the heterologous virus strain. With more distantly related isolates, the decreased reactivity of the coating globulin also played a part in discrimination. To obtain conjugates that gave low background readings with virus-free sap, antisera with low titres to healthy-plant antigens should be used. A special problem was found with potato virus T, and is thought to be caused by binding of plant proteins to the virus particles.

Antiserum-activated grids were used successfully with a wide range of viruses. The method was slightly more sensitive than ELISA for detecting virus particles, was less affected by strain specificity, and was used effectively with relatively low-titred antisera. However, it was less accurate for quantitative assays and, because 10-15 min. was needed to examine each specimen, it was less suitable for dealing with large numbers of samples. The identity of

¹ CARDI, University of the West Indies, Barbados.

virus particles attached to antiserum-coated grids could be confirmed by exposing them to more antiserum, after which the particles were surrounded by a halo of antibody molecules.

Antibody-sensitized latex gives a quick, reliable and robust test for virus particles that is accurate quantitatively to within a factor of two. Although it was about 20 and 40 times less sensitive than ELISA and antiserum-activated grids respectively, the test nevertheless is sensitive enough for many purposes. For example, it detected accurately phleum mottle virus in batches of ten leaves of field-grown plants, only one of which contained virus.

ELISA and antiserum-activated grids were slightly less sensitive than infectivity tests for detecting raspberry ringspot virus in *Nicotiana clevelandii* sap, but more sensitive than infectivity tests for phleum mottle virus in barley sap. Potato leaf roll virus was not detected reliably by ELISA or antiserum-activated grids, using an antiserum supplied by Dr M. Kojima¹ and later found to work in Germany in tests by ELISA. Possibly the virus occurs in strains that differ serologically.

(I. M. Roberts, Lesley Torrance, B. D. Harrison, L. F. Salazar)

54015 *Ultrastructure of virus-infected plants and virus-carrying vectors*

Fixation of tissue for ultrathin sectioning

The use of PIPES (piperazine N-N'bis (2-ethanol sulphonic acid)) buffer as a vehicle for glutaraldehyde and osmium tetroxide fixatives at particular pH values and osmolalities was compared with conventional fixation schedules. Preliminary results suggest that PIPES buffer has advantages for root and leaf tissues infected with plant viruses. Cell organelles were distorted less, membrane systems such as the tonoplast, plasmalemma, nuclear envelope and endoplasmic reticulum were preserved better, and particles of the viruses studied so far were stained more intensely and recognized more easily.

(I. M. Roberts)

¹ Hokkaido University, Japan.

Zoology

D. L. TRUDGILL

Potato aphids and raspberry cane midge were less serious problems during 1977 following a colder winter and spring. However, work in progress on their ecology and control will be completed to ensure that any future increase in these pests can be predicted and the most effective control measures applied.

In raspberry, the root lesion nematode, *Pratylenchus penetrans* has been found to be widespread and field and pot studies suggest it is a damaging pest. At infested sites nematicides have given large improvements in growth.

Compared with virus-vector aphids little is known about the feeding behaviour of virus-vector nematodes, especially the virus-vector species of *Longidorus*. However, several *Longidorus* spp., including the three virus-vector species occurring in Britain have now been induced to feed on plant roots growing in clear agar. This breakthrough should enable us to study feeding behaviour in relation to virus transmission and the ecology of these nematodes.

05011 *Migratory plant parasitic nematodes associated with horticultural crops in Scotland*

Rotylenchus robustus damage to carrots

The effect of aldicarb (3.36 kg/ha), dazomet (336 kg/ha) and Telone II (225 l/ha) on the yield of carrot cv. Cluseed New Stump Rooted was investigated at a site with 181 *R. robustus* and 59 *Trichodorus* sp. per 200 g soil. Dazomet and Telone II decreased numbers of *R. robustus* by 92% and 81% respectively and dazomet increased yield by 131%, Telone by 213% and aldicarb by 38%. The greater improvement in yield given by the fumigant treatments compared with the aldicarb was probably a response to the release of nitrogen.

(B. Boag)

Hoplolaimidae of the British Isles

More than 95% of 4,000 soil samples examined contained spiral (hoplolaimid) nematodes. The most abundant and widely distributed was *Helicotylenchus pseudorobustus* which has a cosmopolitan distribution. In comparison, *H. vulgaris*, *H. varicaudatus*, *H. paxilli*, *H. canadiensis* and

H. digonicus were found only occasionally. *Rotylenchus fallorobustus* was the most numerous *Rotylenchus* sp. and with *R. goodeyi* was distributed throughout the British Isles. *R. pumilis*, *R. buxophilis* and *R. robustus* had more restricted distributions.

(B. Boag)

Ecology of Rotylenchus robustus

The life cycle of *R. robustus* is being determined by following the development of populations resulting from groups of 20 females and 15 males, added at monthly intervals to Sitka spruce seedlings growing in sterilised soil. After one summer, a mean of seven larvae per female had been produced, but none of these larvae had reached maturity at the end of the first calendar year.

Further evidence that *R. robustus* has a 1 year life cycle was obtained from an investigation into the seasonal fluctuations of *R. robustus* under 2-5 year old Sitka spruce trees. In soil samples taken at monthly intervals over a period of 5 years most larvae occurred during winter and spring and most adults in July and August. In this study *R. robustus* was found to be confined to the top 30 cm of soil, few being recovered between 30 and 50 cm deep.

(B. Boag)

05002 *Biology and ecology of trichodorid species and their role as virus vectors*

Studies of population development

Changes were studied in a population of *Trichodorus primitivus* at a site sown with a grass/clover mixture and with several arable crops. The population structure under the different crops remained similar to that previously reported (Ann. Rept 1976). Numbers under grass/clover increased from six per 200 g of soil in 1976 to 40 per 200 g in 1977. Numbers of trichodorids under grass, carrot, barley and swede increased slightly but remained small under pea, potato and fallow.

The effect of soil texture on numbers of a mixed population of *Trichodorus* spp. in a field soil (88% sand, 6% silt, 6% clay) was tested by mixing the soil with clean sand to increase the sand fraction to 94%. Pots (10 cm) of soil were sown with a mixture of ryegrass and clover and maintained at 17.5-18.5°C in a constant temperature cabinet or placed in a glasshouse with a temperature range of 8-30°C. During the year pots were sampled and the multiplication rates of trichodorids were found to be similar in the modified and unmodified soil. In both soils nematode numbers increased

but the rate of increase was greater, especially between May and October, in soil maintained in the constant temperature cabinet.

(T. J. W. Alpey)

Trichodorid survey

A further 282 records were added to the trichodorid computer file making a total of 3896 records. Mapping procedures have been developed using the Computer Areal Mapping system at ERCC. The system is flexible and facilitates mapping of distributions in specified areas, within defined limits, as well as within conventional mapped areas. The program facilities include a large range of computer drawn characters enabling many species or environmental factors to be mapped against several defined backgrounds.

(T. J. W. Alpey, P. Topham¹)

Transmission of tobacco rattle virus (TRV)

In a field experiment potatoes were grown in trichodorid-free soil or in soil infested with trichodorid nematodes carrying TRV (a cause of spraing) to test the time at which a growing potato crop is most susceptible to infection. During the growing season groups of 10 plants were lifted, washed and transferred between soils, taking care to avoid contamination. At transplanting the mean tuber diameters were measured.

Most spraing (15%) occurred in plants transferred from trichodorid-free soil to infested soil at 6 wk. after planting, before tubers were initiated; few tubers were infected on plants transplanted after progeny tubers had reached 3 cm diameter. In plants initially grown in infested soil the incidence of spraing was small and confined to plants transplanted before 10 wk., when tubers were less than 1.5 cm diameter.

(T. J. W. Alpey)

05007 *Ecology of Longidorus and Xiphinema spp. in relation to their role as plant pathogens*

Damage caused by Longidorus elongatus

The effect of aldicarb (3.36 kg/ha) and dazomet (336 kg/ha) on the growth of potato, swede and grass was investigated at a site with 132 *L. elongatus* per 200 g soil. At harvest in September dazomet had controlled the *L. elongatus*, and dazomet and aldicarb had increased the yield of grass by 198% and 12% and of swedes by 45% and 13%, respectively. The yield of potatoes was not increased by either pesticide.

(B. Boag)

¹ Crops Research Section.

Effect of crop on L. elongatus

At two separate sites the effect of cropping patterns on numbers of *L. elongatus* has been tested over 2 years. From samples taken before sowing and after harvest, swede appears to have been a good host for *L. elongatus*, maintaining or increasing numbers. Grass and potato were also hosts but with pea, numbers of *L. elongatus* decreased more than in fallow plots.

(B. Boag)

05003 *Chemical control of ectoparasitic nematodes with special reference to virus vector nematodes*

The effectiveness of two oximecarbamate pesticides, thiofanox and oxamyl, in controlling transmission of virus by *Longidorus elongatus* and by *Trichodorus* spp, were compared in a pot test. Transmission of tobacco rattle virus to *Cucumis sativus* bait plants by *Trichodorus* was completely prevented by oxamyl at a rate equivalent to 2.4 kg a.i./ha, but was not significantly decreased by thiofanox at twice this rate. Little virus transmission occurred in any treatment with the *L. elongatus*. Oxamyl significantly decreased *Trichodorus* numbers but not those of *L. elongatus* and thiofanox failed to decrease numbers of either nematode.

In a field trial, aldicarb at 1.68 kg/ha incorporated in the furrow at planting or foliar sprays of oxamyl at 5.6 kg/ha applied between 6 and 10 wk. after planting gave, at best, only partial control of spraing.

(T. J. W. Alphey)

Selection of nematodes resistant to nematicides

In a laboratory study *Panagrellus redivivus* was cultured on Nigon's Agar and treated with water or oxamyl solutions of 5 ppm, 150 ppm or 300 ppm at 2-weekly intervals to test whether resistance to the nematicide develops. After four treatments the multiplication rate of the nematode was decreased from 6.2 in the untreated water control to 2.2 (5 ppm), 0.2 (150 ppm) and 0.07 (300 ppm) by the oxamyl treatments.

(T. J. W. Alphey)

05004 *Feeding of Longidorus and Xiphinema spp. in relation to plant response and virus transmission*

Feeding of Longidorus spp.

Conditions favourable for studying the feeding of *Longidorus* spp. on plants growing in agar have been found and feeding by *L. attenuatus*, *L. caespiticola*, *L. elongatus*, *L. goodeyi*, *L. leptcephalus* and *L. macrosoma* has been obtained.

Preliminary observations on *L. elongatus* suggest that most nematodes follow a similar feeding pattern; feeding was always at the root-tip. Exploration of the root was frequently prolonged and penetration usually took several minutes. Nematodes fed at a constant depth, with the odontostyle almost completely protracted and the odontostyle was not re-positioned during a feed. Ingestion was preceded by a period, lasting 10-30 min., of almost complete inactivity. Ingestion frequently continued for several hours, broken at approximately hourly intervals, by short pauses lasting about 3 min. During these pauses two or three waves of contraction, confined to one side of the oesophageal bulb, were usually observed. These waves of contraction, which also were occasionally observed during the initial period of inactivity following penetration, may be part of the salivation process.

Unless disturbed, nematodes completely withdrew their odontostyle at the completion of a feed before moving away from the root. Retraction of the odontostyle was followed by up to 50 slow pulsations of the oesophageal bulb. Slow pulsation of the oesophageal bulb was also observed in some nematodes approaching the root.

(W. M. Robertson, D. L. Trudgill)

Transmission of viruses

Studies on the transmission of viruses by *L. elongatus* have continued. An experiment comparing the frequency of ingestion, retention and transmission of raspberry ringspot virus (RRV-S) and tomato black ring virus (TBRV-S) by two populations of *L. elongatus* (East Loan and Ballo Hill) has confirmed that rates of transmission may vary greatly between tests. Slash-testing detected virus in more than 50% of the nematodes from both populations exposed to each virus. Retention of the viruses, however, differed between populations. Most nematodes examined from the East Loan population contained virus-like particles retained on the odontostyle and, from the limited results available, RRV-S and TBRV-S appear to have been equally well retained. In contrast, both viruses appear to have been poorly retained by the Ballo Hill population.

From these results the East Loan population was expected to be an effective vector and the Ballo Hill population to be an ineffective vector of both viruses. The transmission results were not, however, as expected. TBRV-S was well transmitted by both populations, 60% of the nematodes from the East Loan and 30% from the Ballo Hill population transmitting virus, whilst RRV-S was poorly transmitted, less than 8% of the nematodes from both populations transmitting virus. These results suggest that retention of virus is markedly underestimated by present techniques and that some nematodes with retained virus may not have been able to infect *Petunia hybrida* bait plants with that virus.

(D. L. Trudgill, D. J. F. Brown)

05005 Ultrastructure of nematode vectors of plant viruses with reference to their feeding apparatus

The structure of the dorsal salivary gland has been examined in *Longidorus* and *Xiphinema* spp. as an adjunct to studies on feeding. In *Xiphinema* the dorsal gland contains several large ducts which are frequently dilated and visible, with the light microscope, in feeding nematodes. These ducts can also be dilated by treating live nematodes with methylene blue or glutaraldehyde buffered with cacodylate. In the *Longidorus* spp. examined, the duct system has, so far, not been traced with the light microscope. When thin sections were examined with the electron microscope, the ducts in both genera were found to be formed by invaginations of the gland cell wall but in *Xiphinema* the duct wall is greatly folded along its entire length when the duct is partially empty. These folds allow the ducts to dilate when full of saliva. In *Longidorus*, ducts with folded walls were found only close to the opening into the food canal. Posteriorly, small channels have been found but the existence of an extensive system of ducts has not been confirmed.

(W. M. Robertson)

05012 Ecology and control of *Pratylenchus* spp. associated with soft fruit

In a random survey, *P. penetrans* was found in seven of 19 raspberry plantations sampled in Angus and Perthshire and in nine of 14 sampled further north in other easterly parts of Scotland. In total *P. penetrans* has been found in 34 of 52 farms sampled during recent years. It was also found in fields which are to be planted with raspberries in the spring of 1978; six of seven such fields examined in the Blairgowrie area were infested.

In two field trials at sites infested with *P. penetrans* aldicarb (6.7 kg/ha) incorporated at planting greatly decreased nematode numbers and after 1 year the total length of cane per plot was increased by 25% and 48% respectively. Treatment with dazomet, applied in the previous autumn at 220 and 340 kg/ha, also controlled *P. penetrans* and increased the total length of cane by 62% and 70% respectively.

(D. L. Trudgill, D. J. F. Brown)

05010 Assessment of the damage caused by potato cyst and other plant parasitic nematodes in Scotland

In field trials at several sites, potato plants damaged by potato cyst nematode (*Globodera rostochiensis*) contained less phosphorus (P) and potassium (K)

and increased calcium (Ca) in the haulm dry matter than uninfested plants. Percentage nitrogen (N) was usually only slightly decreased whilst the effect of nematodes on magnesium (Mg) uptake varied between sites. At all sites nematodes greatly decreased the total amounts of N, P, K and Mg taken up because infested plants were also smaller than uninfested.

In a large pot (30 cm diam.) trial in the glasshouse the growth of potatoes infested with potato cyst nematode was improved only a little by luxury amounts of N, P and K fertiliser in the first 7 wk. of growth (see Annual Report 1976, p. 94). Analysis of leaves collected 7 wk after planting showed that nematodes had decreased the amounts of all three nutrients in the leaf dry matter, compared with uninfested plants. Infested plants receiving intermediate amounts of fertiliser contained levels of N (4.6%), P (0.23%) and especially of K (2.7%) in the leaf dry matter considered to be inadequate for optimum growth. Luxury amounts of fertiliser increased N (4.9%), P (0.33%) and K (3.3%) levels in the haulm dry matter at 7 wk after planting and greatly improved growth between 7 and 13 wk.

In a field trial nematode infested plants grew poorly and the growth and yield of heavily and lightly infested plants was unaffected by fertiliser. Analysis of leaf dry matter 11 wk. after planting showed that lightly infested plants receiving the standard rate (N, 175; P₂O₅, 175; K₂O, 250 kg/ha) of fertiliser contained sufficient N (5.2%), P (0.30%) and K (4.6%) in their leaf dry matter for optimum growth but that levels were probably inadequate in heavily infested plants (N, 4.3%; P, 0.19%; K, 2.1%). Increased amounts of fertiliser (2 x N, 2 x K, 3 x P) significantly increased percentage N and P in the haulm dry matter for both lightly and heavily infested plants but increased percentage K only in the lightly infested plants. However, levels of N (4.7%), P (0.23%) and especially of K (2.5%) in the heavily infested plants were still inadequate for optimum growth.

(D. L. Trudgill)

05001 *Ecology and control of pests (other than aphids) of horticultural crops in Scotland*

Raspberry cane midge *Resseliella theobaldi*

Biology

Numbers of cane midge larvae were fewer in 1977 than in the previous year. This lack of larvae was probably caused by a shortage of natural splits in primocanes when overwintering midges emerged in June. In a cv. Glen Clova plantation, the greatest numbers of emerging midges were trapped on 14 June, but egg laying in artificially slit canes reached a peak 6 days earlier. In an adjacent plantation of cv. Malling Jewel most eggs were laid on 17 June and most midges were trapped in emergence cages on 20 June. Midges

emerging in early July laid a few eggs in natural splits which formed after the dates of peak egg laying in artificial slits but the number found was considerably less than in the previous 2 years.

The greatest numbers of second generation midges were trapped in emergence cages on 16 August, coinciding closely with the dates when most eggs were laid, both on naturally and artificially split canes. Fewer second generation eggs and larvae were present in weekly samples of Glen Clova and Malling Jewel primocanes than in previous years and subsequent assessments of midge feeding lesions in primocanes from several plantations indicated that, with a few exceptions, cane midge larvae were scarce throughout eastern Scotland in 1977.

Chemical control

The insecticidal activity of tar oil (8%), dinoseb-in-oil (3%), dinoseb amine (1.5%) and the oil and emulsifier (3%) used in the formulation of dinoseb-in-oil, was tested in the laboratory on cane midge cocoons in soil. Each treatment was sprayed at rates equivalent to 1685 l/ha (6177 l/ha for tar oil) on to pots containing 10 cocooned larvae extracted from field soil. Emerging adults were trapped in clear plastic cages placed over the pots. Even in pots receiving only control sprays of water less than 50% of the midges emerged, but after sprays of dinoseb (both formulations) and tar oil only 2% emerged. Cocoons from unemerged midges were collected and, on dissection, many from the water sprayed control, and emulsion treatments, were found to have been parasitised. In a second experiment in which the same treatments were applied to cocooned pupae the pots were left for 4 weeks after most midges had emerged. Platygastriid wasps emerged in the control and emulsion treatments but not after sprays of dinoseb or tar oil. This parasite has been identified as *Synopeas craterus* Walker, and has not previously been recorded as a parasite of *R. theobaldi*.

These experiments confirmed our previous suggestion, based on field observations, that dinoseb-in-oil, applied to young raspberry canes to control cane vigour, can have a direct insecticidal effect on *R. theobaldi*.

The severity of midge blight and subsequent fruit yields were recorded in two field trials started in 1976 in an established plantation of Glen Clova at SHRI, which was heavily infested with midge (see Ann. Rept 1976, p. 96). In a biennially cropping part of the plantation, containing only primocanes in 1976, second generation midge damage in November, numbers of midge cocoons in the soil, and numbers of dead cane, were decreased most by a combined treatment consisting of tar oil winterwash (8% product) applied in February, and three sprays of fenitrothion (0.05% a.i.) applied on 11 June, 18 July and 2 August, 1976. Fenitrothion sprays alone applied on 18 July and 2 August were as effective as the combined treatment. Both treatments yielded an average of 17.4 t/ha, significantly more than the yield of 9.6 t/ha following treatment with tar oil, or 7.9 t/ha for HCH (0.01% a.i.), applied

10 June, or 10.5 t/ha for fenitrothion (0.05% a.i.), applied 11 June, and the untreated control at 6.7 t/ha.

In the second trial, on annual cropping Glen Clova, there were fewer larvae per cane in 1976 than in the biennial cropping experiment. In contrast with the results obtained in the biennial plots insecticides gave no significant improvement in midge blight, lateral shoot development or fruit yield, but two sprays of chlorpyrifos (0.08% a.i.), diazinon (0.11% a.i.) or fenitrothion (0.05% a.i.) applied to the base of young canes in May and June 1976, each reduced the numbers of midge cocoons found in the soil the following winter.

A problem in both the above small plot replicated trials has been second generation midges from adjacent rows migrating to lay eggs on canes treated successfully against first generation attack. To minimise this problem midge control was tested using much larger plots in two experiments begun in 1977.

The first experiment was a replicated trial in a commercial plantation of Glen Clova where the grower had applied dinoseb-in-oil to control cane vigour. Insecticides were applied by tractor-mounted sprayer at 1123 l/ha to 0.03 ha plots, each of 10 rows. No dinoseb was applied to part of each block. In the absence of dinoseb, midge damage was significantly decreased by fenitrothion (50% e.c.), 0.05% a.i. and chlorpyrifos (48% e.c.), 0.04% a.i. sprayed in mid and late June, but not by a mixture of 25% azinphos methyl and 7.5% demeton-S-methyl sulphone (Gusathion MS) at 0.1% product, or by HCH (20% e.c.), applied at 0.01% a.i. on 1 and 17 June or 17 and 26 June. If the insecticide treatments were averaged over plots with or without dinoseb then all treatments significantly decreased midge damage, although all plots treated with dinoseb had significantly less midge damage regardless of the insecticide treatments. The results suggested that when dinoseb-in-oil had been used to control cane vigour, insecticidal treatments to control cane midge would be unnecessary.

(J. A. T. Woodford, S. C. Gordon)

The second large plot experiment compared HCH and fenitrothion applied at different times during the emergence period of cane midge in five commercial plantations in Perthshire, three in Angus and one in Lanarkshire. At each site HCH (20% e.c.) 0.01% a.i. and fenitrothion (50% e.c.) 0.05% a.i. were applied at 1123 l/ha by tractor-mounted sprayer to unreplicated blocks, each consisting of 10 or more rows and occupying 0.2 ha. In November 100 canes were collected at random from each plot to assess midge damage, each sample being divided to enable independent estimates of damage to be made by SHRI and by the Colleges; very similar levels of infestation were recorded for any given sample. Despite large differences between the levels of infestation at the nine sites the insecticide treatments gave consistent results. HCH, applied in late May when midges began to emerge, followed by one spray of fenitrothion at the end of June significantly

decreased the percentage of infested canes from 38% to 24%. Fenitrothion in mid and late June was equally effective, and both treatments gave significantly better control than fenitrothion applied in late May and mid June, or HCH applied in mid and late June.

(J. A. T. Woodford, S. C. Gordon with P. Osborne¹, G. N. Foster²)

05008 The ecology of aphids infesting potato, raspberry and ornamentals

Potato

In contrast with the previous 2 years the numbers of potato aphids on crops of cv. Maris Piper at SHRI remained very low until the beginning of July. As in 1975 and 1976, migrants were found on potato plants in June but the primary migration in 1977 was much smaller and was undetected by the suction traps. On potato the maximum populations of *Myzus persicae* and *Macrosiphum euphorbiae* were found on 12 August, about 4 weeks later than in 1976. Though later in developing, the eventual populations of both aphids were five times greater than in 1976. Winged aphids were produced on potato during the second half of July and reached maximum numbers in mid August when most *M. persicae* and *M. euphorbiae* were caught in yellow traps adjacent to the crop and in the SHRI 12.2 m suction trap.

(J. A. T. Woodford, C. S. Aveyard)

05013 Control of aphids and virus diseases of potato, raspberry and ornamentals

Potato

The spread of leaf roll (PLRV) in the 1976 insecticide experiment was measured in 1977 by growing on the tubers from the cv. Maris Piper 'infecter units' from the 1976 experiment (see Virology Section report p. 101). A similar trial to assess the value of granular aphicides and foliar sprays was started in 1977. Disulfoton (1.1 kg a.i./ha) and thiofanox (0.73 kg a.i./ha) were applied in the furrow at planting to eight 0.02 ha replicated plots of Maris Piper (FS2). On untreated plots aphids began to increase rapidly after mid July. The increase in aphid numbers was delayed by 3 weeks in plots treated with disulfoton and in the thiofanox-treated plots very few aphids developed throughout the growing season. Five sprays of demeton-S-methyl (0.24 l a.i./ha), applied at fortnightly intervals from 23 June to four plots treated with each granule, slightly increased the numbers of *M. persicae*

¹ ESCA.

² WSAC.

(but not *M. euphorbiae*) in comparison with the plots treated with granules alone.

Bioassays of excised leaves from treated plants were used to assess the effectiveness of the granules in June when potato aphids were scarce. These tests suggested that the granular aphicides were not completely effective in the early stages of crop growth and did not give full protection until 28 June.

(J. A. T. Woodford, C. S. Aveyard)

Estate

W. I. A. JACK

The year was generally a satisfactory one, with the problems of weather and high production costs again being the predominating factors in estate management. Although not ideal, weather conditions were rather better than the extremes of the previous 2 years. Efforts directed towards the efficient use of labour and resources helped to achieve consistency of good standards of husbandry and relatively high yields of saleable products.

Farm and experimental crops

As the meteorological records show, the year started badly with the months of January to March being cold and wet. Severe flooding on 10 February left the land in a water-logged condition and hindered spring sowing and planting. However, drier weather in April and May helped good progress to be made with land work.

Farm crops included 38 ha barley, 12.1 ha hay, 4 ha grass, 1.1 ha potatoes, 4.3 ha fallow. The area of crops was increased by 7.9 ha compared with the previous year as more land was freed of field experiments and used for cereals and grass. Also, the potato area was increased this year due to the decision to grow seed potatoes for the Institute's 1978 potato experiments.

Barley drilling started on 27 March in difficult sowing conditions and was completed on 9 April. Plant establishment and weed control were both good and all fields looked well by early summer; mildew (*Erysiphe graminis*) was virtually non-existent. Harvesting started on 19 August, 16 days later than 1976; it was frequently interrupted by rain, being completed under somewhat difficult conditions by 10 October. The yield was 6.3 t/ha and grain samples in general were good, although moisture content at 18.8% made it necessary to dry the grain to a moisture level acceptable to the merchants; nitrogen content and quality were such that all was sold for malting.

Hay grew slowly in the early part of the spring but then made rapid improvement in early June and was secured in excellent condition. Cutting started on 23 June and baling was completed by 8 July, more than half the crop being sold directly from the field; a second cut from one field was taken on 11 August but was difficult to make. The yield of 9.6 t/ha was down 1.3 t/ha from 1976.

Potatoes grew well and protective routine spraying against pests and diseases was applied at regular intervals throughout the growing season.

Lifting was tedious and difficult but was completed by mid November, and a good clean sample of seed potatoes obtained with yields of 30.1 t/ha.

Field experiments included 14.4 ha raspberries, 5.6 ha black currants, 2.6 ha strawberries, 2.5 ha blackberries and hybrid berries, 0.3 ha blueberries, 3.9 ha vegetables, 3.4 ha potatoes, 0.7 ha field beans, 0.6 ha ornamental bulbs, 1.3 ha other crops; this represents a decrease of 3.4 ha on the previous year.

Fruit picking began with strawberries on 27 June, followed by black currants on 13 July, raspberries on 14 July, blackberries, hybrid berries and loganberries on 28 July, blueberries on 11 August and finally cranberries on 1 November. The weather was fairly settled throughout the fruit season and yields of strawberries, raspberries and black currants were high. Losses through botrytis were estimated at 17.4% in strawberries and were negligible in other soft fruit crops. The fruit was of good size and quality. The fruit crop sold totalled 12.24 t more than 1976 and included 55.4 t raspberries, a record production; 12.9 t strawberries, 4.47 t black currants, 0.99 t blackberries, 0.63 t blueberries, 0.21 t loganberries, 0.04 t Tayberries, 0.03 t cranberries.

Marketable produce from the vegetable trials totalled 11.34 t and included Brussel sprouts, beetroot, cabbages, calabrese, carrots, courgettes, French beans, leeks and peas. Trials of field beans harvested on 14 September gave average yields of good quality beans.

Apart from the month of October, which was very wet, the spell of fine weather persisted into December, and autumn and winter work programmes of stubble cleaning, winter wheat sowing, ploughing and estate maintenance were all well advanced by the time the land became unworkable. Labour resources were then directed to the removal of a poplar windbreak planted to protect fruit trees in 1955, and useful improvements were carried out to the car parking area adjacent to the main laboratory block.

New farm equipment acquired during the year included two Massey Ferguson 550 tractors, double furrow reversible plough, ridger, fertiliser barrow, side shift attachment for the fork lift truck, cage wheels and motorised lawnmower.

In January, the Institute acquired the tenancy of 1.5 ha of land in a walled garden at St Fort, Fife, which will be a useful isolation site.

Glasshouses

A large and varied programme of work was accomplished by the glasshouse staff this year; plant production at 124,607 was down by *ca.* 4,000 and included the propagation of 3,000 raspberry plants raised from root cuttings of virus-free stock for the SNSA; 6,000 raspberry plants from 54 cultivars

were also produced from root cuttings for domestic use; 800 strawberry plants of the new SHRI cultivars were propagated in preparation for an exhibit at Chelsea flower show in 1978; 3,000 plants of two French bean cultivars were grown for seed production and three successive sowings of brassicas produced plants for field work.

Extensive renovation to the heating system in the Pratten houses was carried out by the maintenance section; on completion, benches were renewed and four purpose-built pre-cast concrete mist propagation units installed in the west section of the range. A Hancock style insect-proof screen-house was erected and divided into 12 compartments, offering a facility for small groups of plants to be kept in isolation. A further insect-proof Filclair structure was erected to house the production of virus-tested clones of narcissus. Throughout the year useful improvements were carried out in the northern part of the glasshouse area and included an electricity supply to the cold glasshouses; access roads to the standing out area were surfaced with 50 mm scalpings; drainage problems were attended to, and a start was made on the renovation of the cold frame structures. New equipment acquired during the year included an electrically operated sprayer, irrigation systems and a tipping hopper for use with the fork lift truck.

Information Services

R. J. A. EXLEY

The catalogue type format now used in much of this Annual Report simplifies reference to the contents but makes more difficult the required introductory text, however modest in length, required from each Section. This is particularly so with Information Services for whom much of the year's time and effort 'evaporates' under the simple headings of 'Exhibitions', 'SHRI Association' or indeed 'Annual Report', for example.

When planning an exhibit it is important to try to match the topic and its depth of scientific content to the interests and intellect of the audience; regular attendance provides a familiarity that does much to mitigate the problems of making these judgements in respect of any particular Show. This year, for the first time, the Institute exhibited at The Royal Show in 'Vegetable 77', but a retrospective assessment of the suitability of the display is confused. Firstly, the audience appeared to represent an equal mix of extremes of lay public and professional agriculturalists, which is unusual at other Shows, and secondly, along with other contributors the SHRI stand was in a large PVC tent, with very hot dry sunny weather prevailing outside. The value of exhibits is difficult to assess but although the feedback to research is minimal it seems reasonable that the Institute should continue to expose aspects of its work in the interest of good public relations and to inform the agricultural industry.

LIBRARY

This is the second year in which the library has been in its new building and the use of its facilities has steadily increased. There was a slight increase in the loans of books and journals and a 10% increase in inter-library loans.

Library finances enabled the purchase of 65 books and a good stock of British Library loan forms.

During the year meetings were attended of the Scottish branch of ASLIB and of the local branch of the Scottish Library Association, as well as a one day conference on the use of the British Library lending services held at the Scottish Library, Edinburgh; the latter proved to be so successful that in future one is to be arranged annually.

Some new items of equipment were purchased during the year, amongst which was a Rotadex index system for the pamphlet collection; this will

simplify and up-date the current system and make it easier for the users to find the required information.

(Bente Bogen)

Visual Aids

Again an increase is recorded for the overall turnover of work in Visual Aids despite a decrease in electron micrographs processed due to a period of unservicability, and a change in the priorities of use, with the Zoology and Virology electron microscopes respectively.

	Jobs	Photography			Graphics	
		Colour	Monochrome	Diazo	E.M. Prints	Jobs
1976	1136	4465	2455	318	3413	122
1977	1454	4373	3275	440	1992	115

Exhibits on 'New Strawberry Cultivars' and sib identification in Brussel Sprout were produced for display at the Ayr Flower Show and The Royal Show respectively.

A new Marler Haley Econoscreen display system was used for exhibits at the Royal Show and Ayr Flower Show using 'home' produced Cibachrome colour prints. The system has proved to be very flexible, simple to use and, judging by unsolicited comment, very effective.

Cibachrome test prints incorporating standard colour values were sent to the Bulb Research Centre, Lisse (Holland) as a joint exercise in standardising the description of virus disease symptoms in narcissus.

Cine and video recording of the feeding behaviour of various species of nematodes was undertaken throughout the year. Over 1200 feet of 16 mm monochrome film was exposed from which a 12 minute edited film of Bright Field and Nomarski differential interference contrast sequences was produced; a substantial amount of knowledge and expertise has been gained in this exacting field of photography.

One of a series of time-lapse colour photographs on calabrese seedling emergence was selected by the Agricultural Research Council for the front cover of their 1976-77 Annual Report.

During two 30 minute flights, raspberry plantations in Perthshire and Angus infected with *Pratylenchus penetrans* were photographically surveyed in colour and colour infra-red to assess the extent of damage. The use of light aircraft for these surveys is not ideal for this purpose and a more stable flying platform, for example a helicopter, would solve some of the more acute problems.

In March the Scottish Branch of the Institute of Incorporated Photographers held a first ever seminar entitled 'Applied Photography in Scotland'

at the Institute. During the one day conference delegates visited the Visual Aids suite to view facilities and an infra-red television display.

A final year student from Dundee College of Commerce spent 3 weeks in the Section, during November, gaining practical experience in the preparation of graphics material for publications, slides and displays.

The Profotex exhibition of photographic equipment and processes was attended by T. G. Geoghegan and S. F. Malecki at Edinburgh on 24 October. M. I. McMaster and R. M. Dunsire attended the Graphics' 77 exhibition at Glasgow on 13 October.

(T. G. Geoghegan)

Scottish Horticultural Research Institute Association

Committee

<i>Chairman</i>	A. Logan	J. Niven	T. N. Thomson
	C. A. Acheson	J. G. Porter	J. S. Whitehead
	T. W. Dickie	J. R. Robertson	
	C. C. McIntyre	R. J. Smith	
	D. Morrison	P. C. Stewart	

Events

The 8th Annual General Meeting was held on 25 May. After the business of the meeting, short papers were read by Institute research staff on potato aphids and potato diseases.

The annual viewing of some of the field experiments was on 23 July when about 70 members attended.

There were two winter meetings. Since 1973 the Institute has worked to find techniques for managing the new raspberry cultivars with the potential for higher yields than cv. Jewel, but which can cause serious management problems because of their excessive vigour; an afternoon meeting on 17 February discussed for the first time in the UK the results of a comprehensive study into the use of chemical pruning for controlling cane vigour, and how this technique affects pests, diseases and management. On 17 November a meeting discussed recent research findings for the control of some soil-borne pests and diseases of soft fruit.

Publications

Bulletin No. 13 (April 1977)

'Cane Vigour Control in Raspberry'

Management factors in cane vigour control *by* H. M. Lawson and J. S. Wiseman, SHRI, p. 2-11.

Yield responses to cane vigour control *by* A. Dale, SHRI, p. 12-18.

The effect of cane management on raspberry cane midge *by* J. A. T. Woodford and S. C. Gordon, SHRI, p. 19-27.

The effect of vigour control techniques on cane diseases of raspberries *by* B. Williamson and A. J. Hargreaves, SHRI, p. 28-31.

Chemical control of cane vigour *by* H. M. Lawson and J. S. Wiseman, SHRI, p. 32-38.

Bulletin No. 14 (June 1977)

'The Problems of Seedling and Plant Establishment'

Seedbed or deathbed? *by* T. W. Hegarty, SHRI, p. 2-12.

The importance of seed vigour *by* D. A. Perry, SHRI, p. 13-19.

The influence of seed drill design on crop establishment *by* L. P. Bufton, NIAE, p. 20-33.

Weed germination patterns *by* H. M. Lawson, SHRI, p. 34-38.

Bulletin No. 15 (December 1977)

Proceedings of a Symposium on 'The Production, Processing and Utilization of the Field Bean (*Vicia faba* L.)' held at SHRI on 9 March 1977:

Restructuring the field bean plant *by* G. P. Chapman, Wye College, University of London, p. 2-9.

A breeder's approach to stabilising production in field beans *by* D. A. Bond, PBI, p. 10-16.

Relationship between seed set and duration of growth in spring beans *by* M. H. Poulson, PBI, p. 17-19.

Some factors influencing yield variation of field beans *by* P. D. Hebblethwaite *et al.*, University of Nottingham, p. 20-27.

Recent work at Rothamsted on factors limiting yields of field beans *by* A. Bainbridge *et al.*, RES, p. 28-38.

Yield components of field beans in Scotland *by* R. Thompson, SHRI, p. 39-42.

The conservation and storage of dry and moist field beans *by* M. J. Nash, University of Edinburgh, p. 43-46.

Field beans in feed formulations *by* A. D. F. Simpson, RHM Research Limited, High Wycombe, p. 47-56.

Processing to improve the nutritive value of field beans *by* D. G. Edwards, RHM Research Limited, High Wycombe, p. 57-62.

Nutritive value of field beans for poultry *by* J. M. McNab and B. J. Wilson, PRC, p. 63-72.

The value of field beans for pigs *by* V. R. Fowler, RRI, p. 73-79.

Field beans as a potential human food *by* G. D. Brown, RHM Research Limited, High Wycombe, p. 80-87.

Feasibility study on the culinary use of field beans *by* Margaret P. Woods, Queen Margaret College, Edinburgh, p. 88-91.

Occasional Publication No. 2

Raspberry Cultivar Trial 1971-75 *by* M. R. Cormack, pp. 29.

Meteorological Records 1977

01046 *Agro-meteorological recording*

Mylnefield

Although the spring and summer of 1977 were sunnier and had lower rainfall than average the air temperature was slightly lower than the mean in most months. January and February were cold and wet with considerably more snow than in recent years. November and December were also drier and sunnier than usual.

Wind

Windspeeds for the year were about 7.5% above the average. Particularly high winds occurred in March and April with gusts reaching 44 knots on 6 April. September, October and November also had windspeeds well above the average for these months. The summer months of May, June and July had very low windspeeds. The highest winds gusting to 48 knots occurred on 15 November.

Temperature

The winter of 1976-77 ended the series of mild winters, with temperatures in January and February being below average. In general terms 1977 has been slightly cooler than the average (probably made more noticeable by the warm summers of 1975 and 1976). March and December were the only months with temperatures much above the average. Although there was a cold snap at the end of November this lasted for about a week only before the weather turned mild again. The coldest day of the year was 12 January with a maximum of -1.1°C and a minimum of -7.0°C . The warmest day was 1 August with a maximum of 25.3°C and a minimum of 15.5°C .

Rainfall

The winter 1976-77 was very wet, with rainfall in the period January to March being 91% above average; February's rainfall was 3.5 times the average. Over spring and summer, April to September, rainfall was only 74% of the average.

The estimated* soil moisture deficit during the growing season reached a maximum of 128 mm in mid August,

* 'Potential Transpiration'—Technical Bulletin No. 16 MAFF (1957).

Sunshine and Solar Radiation

The total of hours of bright sunshine for the year was above average for the fifth consecutive year. This was due to the period April to August having 165 hours more sunshine than average, an increase of 20%.

Total solar radiation reflected the increased hours of bright sun, being also above average.

(D. K. L. MacKerron, G. C. Nicol)

Erratum

Ann. Rept. 1976, p. 108. Rainfall for October: instead of 13.5 read 138.5.

METEOROLOGICAL RECORDS 1977

AUCHINCUIVE

Temperature

Temperatures generally were much lower in 1977 than in the preceding year, but deviations from the average were very variable, with January, April and June being colder and March, July and October warmer than average. Accumulated day degrees above 6°C were well below last year's figures. In May there were a total of 11 ground frosts, but there was not the damage to strawberry flowers under polythene tunnels that might have been expected.

Rainfall

Until August, rainfall was particularly favourable for strawberry production. The relatively dry winter allowed ploughing and cultivations to take place under near ideal conditions with good drying winds. In contrast the wet months of March and April permitted residual herbicides to be applied with effect and planting to go ahead on schedule. May, June and July had below average rainfall resulting in almost total absence of *Botrytis*, even without the use of sprays. Since August, however, ground conditions have been very wet and this has seriously impeded the evaluation of autumn cropping selections and field clearing. Total rainfall has been very high with 255 mm more than average falling in this already high rainfall area.

Yields have been well below average possibly as a result of the 1976 summer drought.

Sunshine

After the exceptional summer of 1976, it is surprising to find that there were some 150 hours more of bright sunshine this year than last, with a corresponding increase in solar radiation levels.

(R. J. McNicol)

MYLNEFIELD 1977

Temperature

Month	Daily Air maxima		Daily Air minima		0.1m Soil		0.3m Earth		Accumulated Day degrees		Days Ground Frost	Potential Evap-oration mm	Rainfall		Bright Sunshine hours		Mean Daily Solar Radiation mWh cm ⁻²	Windspeed Km.h ⁻¹	
	Mean °C	DFA*	Mean °C	DFA*	Mean °C	DFA*	Mean °C	DFA*	Above 6°C	Below 6°C			Total mm	DFA*	Total	DFA*		Mean	DFA†
January	4.3	-1.2	-1.1	-1.1	0.4	-1.0	1.5	-0.8	2	149	28	2.0	72.5	+12.1	64.4	+12.2	53	11.5	-1.0
February	5.1	-0.6	0.4	+0.3	1.3	-0.2	2.3	-0.2	0	98	21	8.7	151.3	+107.9	77.2	+0.4	104	12.1	-0.5
March	8.8	+0.8	3.0	+1.4	4.1	+0.9	5.1	+1.0	32	37	15	39.0	56.3	+13.2	95.1	-10.1	185	17.1	+2.4
April	10.3	-0.9	3.2	+0.1	5.8	-0.5	6.7	-0.2	52	32	19	79.0	20.1	-21.6	193.5	+31.7	4372	17.7	+2.8
May	12.7	-1.1	5.3	-0.5	10.4	+0.3	10.0	+0.1	101	13	13	80.9	26.7	-32.0	201.6	+21.2	4500	10.5	-2.7
June	15.7	-1.2	7.9	-0.6	14.1	+0.3	13.1	-0.4	172	2	4	98.1	54.1	+2.9	201.1	+20.6	518	11.3	-0.6
July	18.9	+0.6	10.1	+0.2	16.5	+1.5	15.7	+0.7	257	0	0	99.2	36.7	-28.9	211.0	+38.1	4499	9.3	-1.7
August	18.0	+0.1	9.8	0	14.8	+0.8	15.1	+0.5	239	1	1	78.7	63.4	-10.2	202.0	+53.1	4427	11.2	+1.3
September	15.6	-0.3	8.4	-0.1	10.5	-1.1	11.9	-0.7	173	3	4	49.8	55.0	-1.2	113.0	-8.5	233	14.2	+4.1
October	13.3	+0.6	8.4	+2.3	9.3	+1.1	10.6	+0.9	148	2	3	25.0	100.1	+45.3	83.7	-8.1	134	15.1	+4.2
November	7.5	-0.7	1.8	-0.2	3.0	-1.0	6.1	+0.6	27	68	23	11.3	54.0	-4.7	86.0	+20.8	79	15.0	+3.0
December	7.3	+1.0	2.8	+2.0	3.1	+0.8	4.5	+1.0	16	47	19	7.8	41.8	-23.4	45.3	+1.0	33	13.5	+1.2
TOTALS	—	—	—	—	—	—	—	—	1219	452	150	—	732.0	+33.0	1573.9	+172.4	—	—	—

*DFA — Deviation from average 1954-1974

†DFA — Deviation from average 1959-1974

‡ Includes estimated values

Temperature °C

Month	Daily Air maxima		Daily Air minima		0.1m Soil		0.3m Earth		Accumulated Day degrees		Days Ground Frost		Rainfall		Bright Sunshine		Mean daily Solar Radiation		Windspeed	
	Mean	DFA*	Mean	DFA*	Mean	DFA*	Mean	DFA*	Above 6°C	Below 6°C	Total mm	DFA*	Total h	DFA*	mWh cm ⁻²	Mean Km/h				
January	5.3	-1.4	-0.3	-1.8	1.3	-1.9	3.0	-1.9	11	111	24	52.0	-38.3	67.3	+24.6	61.6	15.5			
February	6.5	+0.2	1.4	+0.5	2.1	+0.2	3.8	+0.2	7	55	19	67.3	-0.2	81.0	+7.1	123.5	17.3			
March	9.4	+1.8	3.7	+1.9	4.3	+0.3	5.5	+0.3	48	25	10	84.7	+44.9	70.2	-34.8	176.8	20.6			
April	9.7	-1.4	3.6	+0.4	5.8	-0.3	7.0	-0.3	54	28	8	75.1	+36.9	143.1	-24.9	344.9	17.9			
May	14.8	+0.7	4.9	-1.6	10.5	+0.1	10.3	+0.1	137	15	11	50.4	-6.3	254.5	+80.6	526.1	10.1			
June	16.1	-1.0	8.0	-0.5	13.9	-0.1	12.9	-0.1	94	1	0	36.1	-15.7	250.6	+44.3	588.2	11.7			
July	19.6	+2.0	11.2	+0.6	16.0	+0.7	15.2	+0.7	302	0	0	48.8	-21.1	244.6	+73.0	541.1	11.3			
August	18.3	+0.5	10.1	-0.7	14.3	+0.1	14.7	+0.1	268	1	0	137.6	+70.0	187.1	+34.1	385.0	9.5			
September	14.9	-0.8	8.8	0.0	11.0	-0.5	12.6	-0.5	187	3	1	134.4	+65.0	101.8	-23.9	223.7	12.7			
October	14.3	+1.3	8.9	+2.4	9.6	+0.8	11.3	+0.8	183	1	1	185.1	+114.3	94.5	-5.2	149.0	12.5			
November	8.4	-0.1	2.7	-0.2	4.1	0.0	7.6	0.0	44	51	13	135.5	+36.6	74.7	+19.1	76.0	15.9			
December	8.0	+0.2	3.8	+0.8	3.7	-0.7	5.4	-0.7	36	30	13	53.1	-30.8	45.2	+6.9	38.9	12.7			
TOTALS	—	—	—	—	—	—	—	—	1371	321	100	1060.1	255.2	1614.6	200.9	—	—			

* DFA — Deviation from average, recorded at Weather Station Department of Plant Pathology, West of Scotland College of Agriculture, Auchincruive, 1954-1975.

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INSTITUTES FOR AGRICULTURAL RESEARCH IN GREAT BRITAIN

The research programmes of all the research Institutes supported from public funds are co-ordinated by the Agricultural Research Council. The following is a list of Institutes. Most of them publish reports annually and details can be obtained from the Secretaries of the Institutes concerned.

ARC Institutes

Animal Breeding Research Organisation

Food Research Institute
Institute of Animal Physiology
Institute for Research on Animal Diseases
Letcombe Laboratory

Meat Research Institute
Poultry Research Centre

Weed Research Organisation

King's Buildings, West Mains Road,
Edinburgh EH9 3JQ
Colney Lane, Norwich, NR4 7UA
Babraham, Cambridge, CB2 4AT
Compton, Newbury, Berks RG16 0NN
Letcombe Regis, Wantage, Berks.
OX12 9JT
Langford, Bristol, BS18 7DY
King's Buildings, West Mains Road,
Edinburgh EH9 3JS
Begbroke Hill, Sandy Lane, Yarnton,
Oxford OX5 1PF

State-aided Institutes in England and Wales

Animal Virus Research Institute
East Malling Research Station

Glasshouse Crops Research Institute

Grassland Research Institute
Houghton Poultry Research Station
John Innes Institute
Long Ashton Research Station
National Institute of Agricultural Engineering
National Institute for Research in Dairying
National Vegetable Research Station
Plant Breeding Institute

Rothamsted Experimental Station
Welsh Plant Breeding Station

Wye College, Department of Hop Research

State-aided Institutes in Scotland

Animal Diseases Research Association

Hannah Dairy Research Institute
Hill Farming Research Organisation

Macaulay Institute for Soil Research
Rowett Research Institute
Scottish Horticultural Research Institute
Scottish Institute of Agricultural Engineering

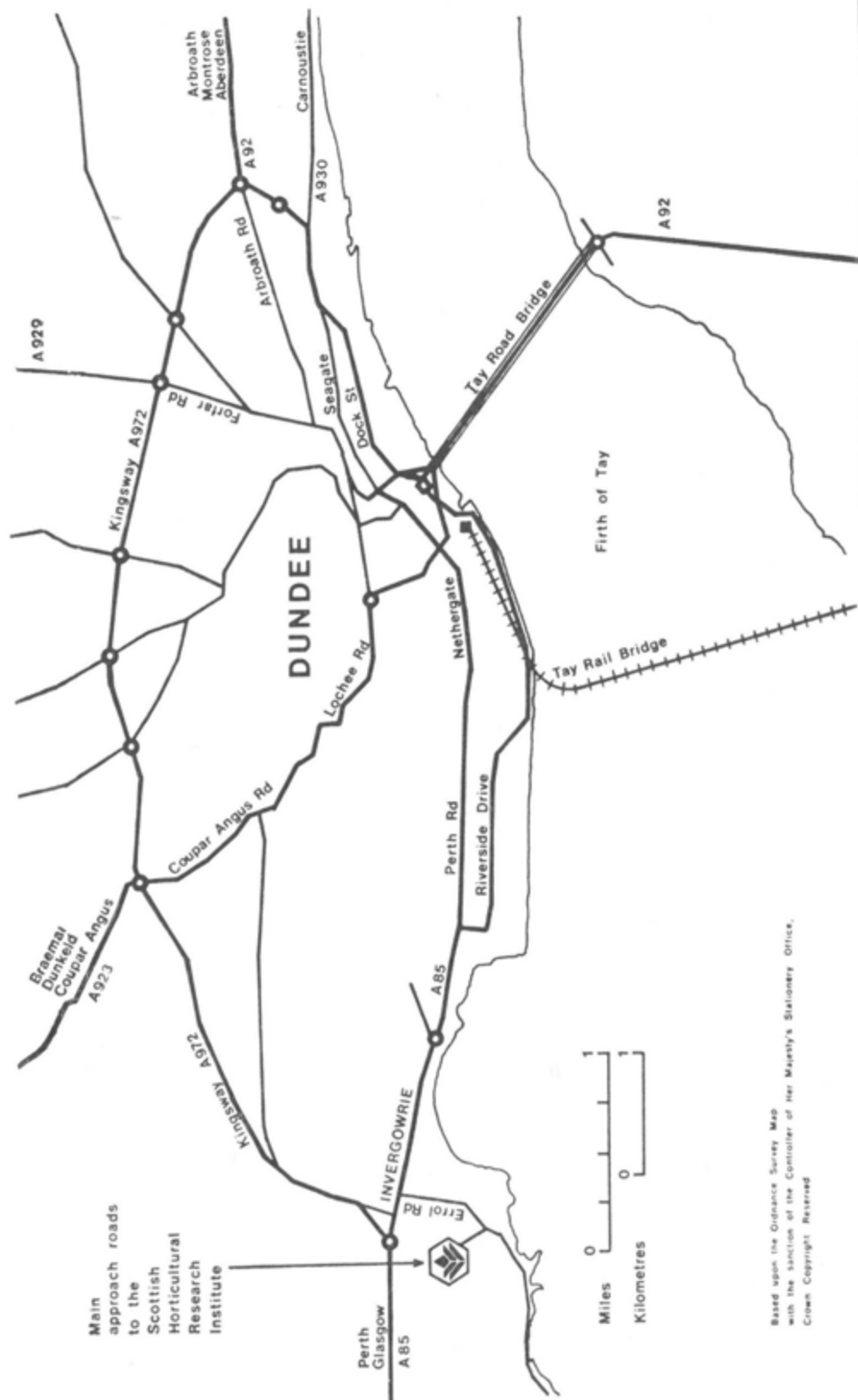
Scottish Plant Breeding Station

Pirbright, Woking, Surrey
East Malling, Maidstone, Kent
ME19 6BJ
Worthing Road, Rustington, Little-
hampton, Sussex BN16 3PU
Hurley, Maidenhead, Berks SL6 5LR
Houghton, Huntingdon PE17 2DA
Colney Lane, Norwich NR4 7UH
Long Ashton, Bristol BS18 9AF
Wrest Park, Silsoe, Bedford MK45 4HS
Shinfield, Reading RG2 9AT
Wellesbourne, Warwick CV35 9EF
Maris Lane, Trumpington,
Cambridge CB2 2LQ
Harpenden, Herts AL5 2JQ
Plas Gogerddan, Aberystwyth,
Cardiganshire SY23 3EB
Ashford, Kent TN25 5AH

Moredun Institute, 408 Gilmerton
Road, Edinburgh EH17 7JH
Ayr, Scotland KA6 5HL
Bush Estate, Penicuik, Midlothian
EH26 0PH
Craigiebuckler, Aberdeen AB9 2QJ
Bucksburn, Aberdeen AB2 9SB
Invergowrie, Dundee DD2 5DA
Bush Estate, Penicuik, Midlothian
EH26 0PH
Pentlandsfield, Roslin, Midlothian
EH25 9RF

ABBREVIATIONS

AAB	Association of Applied Biologists
ACAS	Agricultural Chemicals Approval Scheme
ARC	Agricultural Research Council
ASLIB	Association of Special Libraries and Information Bureaux
ATB	Agricultural Training Board
BA	British Association for the Advancement of Science
BBC	British Broadcasting Corporation
DAFS	Department of Agriculture and Fisheries for Scotland
EAAFRO	East African Agriculture and Forestry Research Organisation
ESCA	East of Scotland College of Agriculture
ERCC	Edinburgh Regional Computing Centre
EAPR	European Association for Potato Research
EHS	Experimental Horticultural Station
FBPP	Federation of British Plant Pathologists
HEA	Horticultural Education Association
IPCS	Institute of Professional Civil Servants
ISHS	International Society for Horticultural Science
JCO	Joint Consultative Organisation
NFT	National Fruit Trial
NIAB	National Institute of Agricultural Botany
NIAE	National Institute of Agricultural Engineering
NSA	Nuclear Stock Association
NSDO	National Seed Development Organisation
NSCA	North of Scotland College of Agriculture
PRC	Poultry Research Centre
RES	Rothamsted Experimental Station
RHM	Rank Hovis McDougall
RRI	Rowett Research Station
SNSA	Scottish Nuclear Stock Association
SRC	Science Research Council
VTSC	Virus tested stem cutting
WPBS	Welsh Plant Breeding Station
WSAC	West of Scotland Agricultural College



Main approach roads to the Scottish Horticultural Research Institute

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