

AJSD

**SCOTTISH CROP
RESEARCH INSTITUTE**



**FOURTH ANNUAL REPORT
1985**



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GOVERNING BODY

(AS AT 31st DECEMBER 1985)

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Professor M. B. Wilkins, Ph.D., D.Sc., A.K.C., F.R.S.E.

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<i>Secretary</i>	N. D. Anderson
<i>Assistant to Director</i>	R. J. Killick, B.Sc., Ph.D., M.I.Biol.

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J. Flight
J. Heeney
J. A. Young

- * Honorary Lecturer in the University of Dundee.
- † Honorary Senior Lecturer in the University of St. Andrews.
- + Honorary Lecturer in the University of St. Andrews.
- ‡ Visiting Professor in the University of Strathclyde.
- Honorary Professor in the University of St. Andrews.

GENERAL REPORT

C. E. TAYLOR

During the year, several publications appeared on agricultural research and development that will have far-reaching effects on the future structure and organisation of the Agricultural and Food Research Service (AFRS). In May, the Agricultural and Food Research Council (AFRC) published a discussion paper 'A Long-Term View of the AFRS' which was followed in October by the 'Forward Policy' which set out policy guidelines for management of research. It identified organisational changes in the AFRC which centred on the amalgamation of the present institutes to form eight new institutes, each under a Director of Research. This restructuring does not directly affect the Scottish Agricultural Research Institutes (SARIs) as they remain associated with, and are financed by, the Department of Agriculture and Fisheries for Scotland (DAFS), but the AFRC will continue to provide advice on agricultural research policy in Scotland and it is intended, when appropriate, that there will be integration of AFRC and SARI research programmes on an AFRS basis.

In May, DAFS issued a consultative paper, and in December, the definitive paper entitled 'A Strategy for Agricultural Research and Development' which set out proposals for the future strategy, organisation and management of agricultural R & D in the SARIs and the Colleges. The proposals seek to ensure the effective and flexible use of resources in the 'Scottish System' for new and emerging needs as well as continuing support for necessary ongoing research. Included in the structural changes is the foundation of a new Macaulay Institute from the Hill Farming Research Organisation (HFRO) at Edinburgh and the Macaulay Institute for Soil Research (MISR) at Aberdeen with a remit which will include wider aspects of agricultural/environment interactions in hill and upland areas. It is also the DAFS intention to transfer to SCRI some of the staff at MISR who are concerned with studies on arable soil fertility, crop nutrition and soil biology.

In addition to identifying structural changes, the DAFS paper also identifies future management arrangements involving the SARIs, Colleges and the Department which are seen as improving working relationships between these three organisations and providing an effective interaction between the Scottish System and the policy, advisory and management structures of the AFRC. A Joint Management Board composed of representatives of DAFS, SARI Directors and College Principals, together with AFRC representation, will provide a forum for discussion and decisions

on R and D policies, strategies and the use of resources. A representative of the Joint Management Board will serve on the AFRC Management Board and this should provide a means of rationalising research on a UK(AFRS) basis.

The Report of the Priorities Board, published in December, is a further document which indicates changes for agricultural R and D. Fortunately for the Institute, the Report supports expenditure, at an unchanged or an increased level, in most areas of our research programme. However, the Board's recommendation to privatise the part of plant breeding programmes concerned with cultivar production will, if implemented, require considerable changes in policy and organisation. So far, the Government has indicated its intention to privatise the National Seed Development Organisation (NSDO) which is responsible for the commercial exploitation of new cultivars from the public sector, and part of the AFRC Plant Breeding Institute's breeding programme. Such an arrangement will have considerable implications for the future structure of the SCRI plant breeding programme, particularly with regard to the commercial exploitation of cultivars or material at an earlier stage of development.

Apart from finance generated from Plant Variety Rights which are passed to the Treasury through NSDO, in the past there have been financial returns from scientific inventions or from undertaking contracts, but these have been limited to a small percentage of the total financial budget of an institute. Because of cuts in institute finances, commercialisation of research output is seen as a way of maintaining a substantial part of the research programmes. This requirement is already manifest in the formation of commercial companies by institutes, on an individual or group basis, or the association with commercial enterprises in Universities or the private sector. Also, because there are prospects of obtaining funds raised by levies from the agricultural and horticultural industries, as well as from the science-based private sector, some institutes have already begun to publicise their scientific capabilities in brochures and prospectuses. SCRI is already embarked on this course of action and has produced a coloured folder which contains leaflets explaining the areas of science which might attract outside investment. During the year, the Institute also signed contracts with several organisations for commercial exploitation of scientific expertise and in March took out a provisional patent through the British Technology Group on a naturally occurring compound.

The past year has again been one of satisfactory scientific progress, as is illustrated elsewhere in this Report. It will be apparent from the following reports that the degree of scientific flexibility and the co-operation between departments, which is a feature of SCRI, enables an effective response to be made to the rapidly changing needs of the

agricultural industry. Scientific activity continues to be supported by the continuing development of facilities, financed by DAFS.

Many individuals and groups visited the Institute and expressed an interest in its work. It was a pleasure to receive them.

The Institute frequently depends upon the help and co-operation of others, either individuals or organisations, without whose assistance the work would be greatly handicapped. The assistance may be from scientists with other organisations working on collaborative ventures, from farmers who generously make their land available for trials, from commercial companies undertaking testing work free of charge or from donations of finance or equipment. The Institute is most grateful to all its collaborators and very appreciative of the help that they give.

Staff of the Cereal Breeding and Data Processing Departments moved from Pentlandfield to Mylnefield. They have been accommodated in temporary buildings pending the provision of purpose-built facilities. The building programme continued. The conversion of the old store into an extension of the workshop was completed. The new propagation glasshouse and headerhouse neared completion and should be available for use from March 1986. New accommodation for administration was brought into use by completion of a new storey above the existing library. The new boiler house and the central services project were completed. The cereal crop handling building was well advanced by the end of the year and building began of the cereal breeding glasshouse. At the end of the year DAFS agreed on the plans for the new laboratory building to house cereal and soft fruit breeding, tissue culture, chemistry and data processing, and this is expected to be started in June 1986. Thus, I look forward to retiring as Director of SCRI in the knowledge that despite the vicissitudes of agricultural R & D, SCRI will continue to add to its scientific stature. My successor, Professor J. R. Hillman, was appointed in the autumn and will take up his duties in March 1986. He will do so with our warmest wishes for the future.

Governing Body

The death of Professor David H. N. Spence in April 1985 is noted with great regret. Professor Spence, of the University of St. Andrews, had been a member of the Governing Body since 1983 and served on the Staff Appointments, Chairman's and Finance Committees.

Mr John Arbuckle retired from the Governing Body, through age limitation, on March 1985. His wholehearted support for the Institute is illustrated simply by stating that he was the first Chairman of the Governing Body of the newly formed SCRI, following his Chairmanship from 1971 to 1981 of Scottish Society for Research in Plant Breeding, which was the management organisation for the Scottish Plant Breeding Station, Pentlandfield, and he also served on the Governing Body of the Scottish Horticultural Research Institute from 1971 to 1980.

Mr A. Logan was welcomed as a member of the Governing Body.

Financial Assistance

Bayer United Kingdom Ltd	£100
BASF United Kingdom Ltd	£50
Beecham Foods	£2,100
British Crop Protection Council	£1,000
Dow Chemical Co (UK) Ltd	£250
Elanco Products Ltd	£100
Farm Protection Ltd	£200
FBC Ltd	£500
May & Baker Ltd	£250
Monsanto plc	£200
National Seed Development Organisation	£482
Overseas Development Administration	£52,441
Potato Marketing Board	£18,292
Scottish Agricultural Industries plc	£300
Scottish Society for Crop Research	£1,240
United Biscuits Agriculture	£2,000

Appointments

M. A. Archibald	EW	Potato Breeding Department
A. N. E. Birch	HSO	Zoology Department
E. D. Bowman	ASO	Zoology Department
K. Brown	EW	Potato Breeding Department
W. E. Craig	ASO	Forage Brassica Breeding Department
J. Flight	Asst	Administration Division
	Storeman	
S. Forsyth	Spec. Typist	Administration Division
E. Fyffe	Spec. Typist	Administration Division
P. Lawrence	EW	Forage Brassica Breeding Department
A. Lundie	Craftsman	Engineering and Maintenance Division
C. J. McDougall	CA	Administration Division
F. M. McGill	ASO	Mycology and Bacteriology Department
S. E. Millar	ASO	Mycology and Bacteriology Department
J. A. Murray	EO	Administration Division
A. C. Newton	SSO	Mycology and Bacteriology Department
L. Pollock	CO	Administration Division
D. L. K. Robertson	EWIV	Estates Division
E. Scott	EWIV	Estates Division

Promotions

A. M. Campbell	SO	Mycology and Bacteriology Department
D. C. Cuthbertson	SO	Chemistry Department

H. V. Davies	PSO	Physiology and Crop Production Department
A. Dolan	SO	Mycology and Bacteriology Department
C. E. Henry	SO	Zoology Department
J. Hutcheson	Grieve	Estates Division
G. D. Lyon	PSO	Mycology and Bacteriology Department
R. J. McNicol	SSO	Soft Fruit Breeding Department
W. Powell	SSO	Potato Breeding Department
W. M. Robertson	PSO	Zoology Department
G. McN. Wright	SO	Physiology and Crop Production Department

Awards

M. Al-Hashimi	Ph.D., University of Dundee
R. A. Bain	Ph.D., University of Edinburgh
A. P. Brown	Ph.D., University of Edinburgh
J. Brown	M.Sc., University of St. Andrews
F. J. Dunn	SCOTEC Higher Certificate in Biological Sciences
J. G. Elphinstone	Ph.D., University of Dundee
K. Hamilton	SCOTEC Higher Certificate in Biological Sciences
S. M. Howie	SCOTEC Higher Certificate in Biological Sciences
N. L. Innes	Honorary Professorship, Department of Plant Biology and Ecology, University of St. Andrews
J. A. L. Joyce	SCOTEC Higher Certificate in Biological Sciences
R. Neilson	SCOTEC Ordinary Certificate in Biological Sciences Tayside Region Education Committee Prize as best student completing a SCOTEC course in Biological Sciences
R. A. O'Rourke	Higher National Certificate in Biology
W. Powell	Ph.D., University of Birmingham
S. P. Rawlings	Higher National Diploma in Biology

Resignations

M. A. Archibald	EW	Potato Breeding Department
M. Brownlie	ASO	Forage Brassica Breeding Department
I. D. Burdge	EWIII	Estates Division
S. A. Cootes	Tractorman	Estates Division
E. M. Davies	HSO	Forage Brassica Breeding Department
C. A. Donald	Spec. Typist	Administration Division
F. J. Dunn	ASO	Potato Breeding Department
P. T. Durajczyk	Spec. Typist	Administration Division
D. M. Farrer	SO	Cereal Breeding Department
R. L. Fyall	CA	Administration Division
S. Gowers	SSO	Forage Brassica Breeding Department
L. S. Love	P & GS, E	Chemistry Department
K. P. Mackie	ASO	Soft Fruit Breeding Department
J. J. Mitchell	ASO	Mycology and Bacteriology Department

Resignations continued

M. Morris	EWIII	Estates Division
S. C. Murray	ASO	Data Processing Department
J. A. Shepherd	EO	Administration Division
A. J. Sim	ASO	Forage Brassica Breeding Department
Mrs C. E. Thomas	SO	Cereal Breeding Department
W. Wood	ASO	Cereal Breeding Department

Retirements

A. Bruce, P & GS, Estates Division retired on 7 April after 31 years service.

W. Dick, Farm Grieve (Pentlandfield) retired on 19 October after 35 years service.

I. H. McNaughton, PSO, Tissue Culture & Cytology Unit retired on 28 February after 26 years service.

A. P. Thomson, EO, Administration Division retired on 31 December after 31 years service.

Redundancies

G. R. Drabble	EWI	Cereal Breeding Department
M. H. McGuigan	EWII	Cereal Breeding Department
R. A. Macleod	ASO	Cereal Breeding Department
E. P. Pendrieck	CO	Administration Division
M. Tulloch	EWII	Cereal Breeding Department
A. R. Whitelaw	EWII	Cereal Breeding Department

Visiting Workers

M. A. Abou-Elnasr (Ain Shams University, Egypt) completed his studies on plant virological techniques in May (Virology Department).

G. P. Accotto (Istituto di Fitoviologia Applicata, Turin, Italy) spent 2 weeks in June learning techniques for preparing nucleic acids for electron microscopy (Virology Department).

H. K. Hall, (DISR, New Zealand) arrived in July to spend 12 weeks studying aspects of raspberry breeding (Soft Fruit Breeding Department).

J. Julian (DISR, New Zealand) worked from 5-9 August on mechanical harvesting of raspberry (Physiology and Crop Production Department).

P. K. Koshy (Central Plantation—Crop Research Institute, Kerala, India) spent 1 week in June studying virus transmission by nematodes and methods for detecting viruses within vector nematodes (Zoology Department).

A. Lahtinen (Maatilahallitus, Kasvintarkastustoimisto, Finland) spent 6 weeks in May and June studying the thermal requirements for development of the rootknot nematode *Meloidogyne hapla* (Zoology Department).

S. K. Manohar (ICRISAT, Hyderabad, India) spent 1 week in November learning techniques used in immuno-electron microscopy and scanning electron microscopy (Virology Department).

T. Ploeg (Agricultural University, Wageningen, The Netherlands) spent 3 months from mid June to learn the techniques used for studying virus transmission by nematodes (Zoology Department).

D. V. R. Reddy (ICRISAT, Hyderabad, India) spent 3 weeks in April-May learning methods of synthesizing complementary DNA and its use in virus detection (Virology Department).

G. S. Shekhawat (Division of Plant Pathology, Central Potato Research Institute, Simla, India) completed 8 months working on bacterial soft rot of potato (Mycology & Bacteriology Department).

K. Sikkema (University of Utrecht) spent 6 months working on phytoalexins produced by *Brassica* spp. (Mycology & Bacteriology Department).

J. Stanley (DISR, New Zealand) worked from 5-9 August on nitrogen metabolism of the potato (Physiology and Crop Production Department).

J. E. Thomas (Queensland Department of Primary Industries, Australia) arrived in July to spend a sabbatical year studying geminiviruses and luteoviruses (Virology Department).

Research Assistants

R. A. Bain (PMB Research Assistant) continued studies of infection of potato by soft rot erwinias and of blackleg etiology in Israel (Mycology and Bacteriology Department).

M. R. Groom (MAFF Research Assistant, jointly with University of Dundee) continued studies of cavity spot of carrot (Mycology and Bacteriology Department).

T. D. Heilbronn (PMB Research Assistant) conducted a 1 year investigation of the components of tuber size variability in farm crops of potato (Physiology and Crop Production Department).

S. Pritchard and W. McGavin (funded by BTG) both worked on screening natural plant products as nematocides (Zoology Department).

Research Students

O. Acosta (Post-graduate student funded by ICETEX, Colombia) began studies on the replication of raspberry ringspot virus in protoplasts (Virology Department).

P. J. Burgess (SERC-RCCA post-graduate student, jointly with the Department of Mycology and Plant Pathology, Queen's University, Belfast) began studies on the ecology of soft rot erwinias on the potato phylloplane (Mycology and Bacteriology Department).

M. J. Farmer (AFRC post-graduate student) continued her studies on nepovirus proteins (Virology Department).

S. K. Hemida (Post-graduate student funded by University of Assiut, Egypt) continued his studies on the properties of parsnip yellow fleck and anthriscus yellows viruses (Virology Department).

J. Hinton (SERC-RCCA post-graduate student, jointly with the Department of Biological Sciences, University of Warwick) completed studies on the genetics of *Erwinia carotovora* (Mycology and Bacteriology Department).

W. W. Kirk (AFRC post-graduate student) concluded his studies on leaf development and growth of the potato (Physiology and Crop Production Department).

L. Leach (SERC-RCCA post-graduate student, jointly with King's College, London University) continued her studies on the role of neurosecretion in nematode development (Zoology Department).

L. V. Lopez Llorca (Stevenson Fellowship) continued his study on the fungi attacking cereal cyst nematode in Scotland (Zoology Department).

L. A. Perryman (AFRC post-graduate student) continued studies on irradiated pollen as a means of gene transfer in plant breeding (Potato Breeding Department).

W. Stone (SERC-RCCA post-graduate student, jointly with University of Birmingham) continued studies on frost tolerance and plant habit in the black currant (Soft Fruit Breeding Department).

Sandwich Course Students

A. van den Boom (Agricultural University, Wageningen) worked on incompatibility in the swede (Forage Brassica Breeding Department).

A. J. H. van Doesum (Agricultural University, Wageningen) studied the identification of weed seeds by image analysis (Physiology and Crop Production Department).

S. Downie (Dundee College of Technology) assisted in studies of the nitrogen nutrition of the potato (Physiology and Crop Production Department).

M. Duckworth (Sheffield City Polytechnic) developed computer programs for the European Plant Parasitic Nematode Survey and processed data for mapping distribution data on a national and European scale (Zoology Department).

J. Janson (Agricultural University, Wageningen) worked on aspects of cold tolerance in black currant (Soft Fruit Breeding Department).

H. A. Karsten (Agricultural University, Wageningen) worked on the construction of a data-base for cereal herbicides (Physiology and Crop Production Department).

L. Mur (Coventry (Lanchester) Polytechnic) investigated factors affecting callus formation from mature barley embryos and studied the *in vitro* tuberisation in potatoes (Potato Breeding Department/Tissue Culture and Cytology Unit).

K. J. Smith (Dundee College of Technology) studied elicitation of phytoalexins by pectic enzymes from *Erwinia carotovora* (Mycology and Bacteriology Department).

N. T. Smoktunowicz (Sunderland Polytechnic) completed her project on weed seed banks in arable soils (Physiology and Crop Production Department).

M. W. C. Tarbuck (North East London Polytechnic) studied the infection of potato leaves with *Alternaria solani* (Potato Breeding Department).

Visits Abroad

T. J. W. Alphey visited ORSTOM Muséum National d'Histoire Naturelle, Paris, France, 26–29 October to attend the second meeting of the Steering Committee for the 18th International Symposium of the European Society of Nematologists.

M. M. Anderson visited the fruit breeding departments of the Swedish University of Agricultural Sciences at Balsgård and Alnarp and trial grounds of A. B. Findus (Nordveco), Bjuv, Sweden. He also visited the Agricultural Research Centre, Institute of Horticulture, Piikkio, Finland, the Agricultural University of Norway, Ås-NLH and Kisi Agricultural Research Station, Nes-Hedmark, Norway. The visits were made from 6–16 August to assess progress in *Ribes* breeding, the trialling of black currant germplasm and arrangements for closer collaboration.

R. A. Bain visited the Volcani Center, Israel for 4 weeks in May to work on the joint project on potato blackleg supported financially by the PMB and the Volcani Center.

A. N. E. Birch visited INRA, Rennes, France, 20–22 November to attend the IOBC/EEC Joint Experts Meeting on Integrated Plant Protection in Field Vegetables.

B. Boag and P. B. Topham visited the Instituto de Edafología y Biología Vegetal, Madrid, Spain, 22–29 October to discuss collaborative work on the ecology and biological control of nematodes, especially *Heterodera avenae*.

P. D. S. Caligari with J. Brown visited Valencia, Spain from 20–24 May to harvest trials and assess the performance of potato clones. With M. F. B. Dale he visited Israel from 10–19 June to harvest and assess potato clones undergoing commercial assessment and trials to assess resistance and tolerance to *Verticillium* and *Alternaria*.

M. F. B. Dale visited Spain 15–20 September to harvest trials and assess potato clones.

J. M. Duncan toured research establishments in Heidelberg and Braunschweig, Germany and in Wageningen and Wilhelminadorp, The Netherlands from 10–21 June to discuss current research on *Phytophthora infestans* and on soil borne diseases of soft fruit.

R. P. Ellis visited Gore, New Zealand between February and April to select spring barley plots; he also visited Waite Agricultural Research Institute, Australia to discuss barley breeding and research.

R. A. Fox visited the Institute for Agricultural Plant Breeding, Wageningen, The Netherlands, 23–26 April for an EAPR Editors' Meeting and to discuss liaison on potato pathology research with Dutch and German workers.

B. D. Harrison visited Italy, 27 May–3 June for discussions on plant virus research at laboratories in Bari, Milan and Turin, aided by a grant from the British Council. On December 19 he served on an Academic Jury of the University of Strasbourg.

J. R. T. Hodgkin visited a number of INRA centres and Universities in France from 1–12 July 1985 to discuss molecular genetics research with brassicas and novel techniques in brassica breeding. At the University of Perpignan he gave a seminar on the work of SCRI.

N. L. Innes was from 4–8 September at a special Donors' Meeting Niamey, Niger and a meeting of the Executive Committee of the Governing Board of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). He also chaired an ICRISAT Programme Committee meeting at Hyderabad, India from 12–15 October.

D. L. Jennings visited the Potato Research Station, Toolangi, Victoria, Australia from 1 December 1984–5 April 1985 to study aspects of raspberry development.

A. T. Jones and A. F. Murant attended the XIII International Symposium on Tree Fruit Virus Diseases, held at Bordeaux, France, 17–22 June.

R. J. Killick visited the Institute for Agricultural Plant Breeding, Wageningen from 24–25 April to attend an EAPR Editors' meeting.

A. M. Lennon visited Colombia, 11–25 October to exchange information on cassava viruses with scientists at the Centro Internacional de Agricultura Tropical, Cali, in connection with ODA-funded work at SCRI.

G. R. Mackay visited Brussels 25–27 March to attend an EEC/IBPGR Workshop on old potato cultivars, the cost of which was met by the EEC. He visited Egypt and Cyprus from 17–24 May to see trials of SCRI potato cultivars and clones near Cairo and in the Nile Delta and to harvest and assess breeders' trials in Cyprus. He visited Tunisia and Algeria, 4–12 June to attend the breeders' open days at CPRA Tunisia and potato trials in Algeria, his costs were supported by NSDO to whom he reported on commercial aspects of his visit. He also visited the INRA breeding station at Landerneau, Brittany, France from 23–29 September to discuss possible collaborative work and visit centres of potato breeding in that area; the visit was supported by the Thyne bequest.

K. J. Oparka visited the USA, 28 July–23 August. He attended Potato Association of America Annual Conference, Boise, Idaho (28 July–1 August) and from 1–10 August visited Washington State University Potato Research Group.

M. C. M. Pérombelon visited Valencia, Spain, 24–27 March, to discuss the joint project between SCRI, Luis Matutano SA and Instituto Valenciano de Investigaciones Agarias on blanking in potato crops caused by erwinias. He also participated in discussions at INRA, Paris, 27–28 March, concerning collaboration on erwinia genetics.

W. M. Robertson visited Professor B. M. Zuckerman at the University of Massachusetts, Amhurst, 22–25 April for discussions on host recognition in nematodes, and also gave a talk on carbohydrates in virus vector nematodes to the Biology Department.

C. E. Taylor attended two meetings as a member of the Scientific Council of the Istituto di Nematologia Agraria, CNR, Bari, Italy from 1–3 April and 24–27 June.

D. L. Trudgill attended a meeting in Paris, 19–22 November of the Specialist Panel formed by the European Plant Protection Organisation to re-define resistance to and pathotypes of potato cyst nematodes.

J. A. T. Woodford spent 24–26 April at the Department of Animal Physiology, Wageningen, The Netherlands for discussions on aphid feeding behaviour and training in aphid stylet cutting.

Conferences at which papers were given

(Names in parenthesis are joint authors)

22 January	<u>Sociedad Española de Microbiología, Valencia, Spain</u>	
	D. J. Robinson	African cassava mosaic virus and its relationships to other geminiviruses
23 January	<u>East of Scotland College of Agriculture Fruit Growing Conference, Dundee</u>	
	M. R. Cormack	Interaction between raspberry and machine
21–22 February	<u>Royal Society of Edinburgh, Scottish Food and Drink</u>	
	C. E. Taylor	Horticultural food crops
28 February	<u>Irrigating Potatoes Conference, UKIA, Silsoe College, Silsoe</u>	
	D. K. L. MacKerron	Timing of irrigation in relation to yield and quality of potatoes

28 February – 1 March	<u>UB Agriculture Seed Growers' Conference, Pitlochry</u> R. A. Jefferies	Irrigation of cv. Record for seed production
1 – 5 April	<u>AFRC Electron Microscopists Conference, Aberystwyth</u> C. E. Henry (W. M. Robertson) (G. D. Lyon) I. M. Roberts	Use of cytochemical probes to study mode of action of phytoalexins Tips – <i>ad nauseam</i>
10 – 12 April	<u>AAB, Virology Group, Cambridge</u> W. P. Mowat A. F. Murant (J. H. Raschké) D. J. Robinson	A simple and rapid enzyme immunoassay for detecting and identifying plant viruses Studies on viruses that depend on luteoviruses for transmission by aphids Detection of tobacco rattle virus infections by spot hybridization
22 May	<u>AAB, Edinburgh, Quality Objectives and Techniques in Plant Breeding</u> J. E. Bradshaw M. F. B. Dale R. P. Ellis (J. S. Swanston)	Improving the nutritional value of fodder kale Breeding for quality characteristics in potatoes Breeding for improved malting quality
2 – 7 June	<u>Sixth International Conference on Plant Pathogenic Bacteria, Maryland, USA</u> M. C. M. Pérombelon M. C. M. Pérombelon (J. C. D. Hinton, ¹ G. P. C. Salmond ¹)	Pathogenesis by pectolytic erwinias Factors affecting blackleg development A rapid method to identify soft-rot erwinias directly from plant material Application of cloning technology to <i>Erwinia carotovora</i> spp. <i>carotovora</i>

¹Department of Biological Sciences, University of Warwick

4–7 June	<u>Rockefeller Foundation Conference on Vectors of Pathogens affecting Human, Animal and Plant Health, Bellagio, Italy</u> B. D. Harrison Plant virus transmission systems in which virus particle protein plays a key role
12–14 June	<u>EEC Expert's Meeting – Weed Control in Vine and Soft Fruits, Dublin, Ireland</u> H. M. Lawson Volunteer crops as weeds in soft fruit plantations
14–15 June	<u>IVth International Symposium on Small Fruit Virus Diseases, Bordeaux, France</u> A. T. Jones Association of dsRNA species (M. A. Abou-Elnasr ¹) with some virus-like diseases of small fruits (M. A. Mayo) (M. J. Mitchell) A. T. Jones Recent research on viruses and virus-like diseases of <i>Rubus</i> in Scotland (M. J. Mitchell) (D. L. Jennings) (S. C. Gordon) A. F. Murrant Some biochemical properties of raspberry bushy dwarf virus (M. A. Mayo) (J. H. Raschké)
24–28 June	<u>4th International Symposium on Flower Bulbs, Noordwijkerhout, The Netherlands</u> W. P. Mowat Methods of virus-indexing for virus-tested narcissus stocks
8–10 July	<u>EMBO Workshop on the Molecular Biology of Plant Pathogenic Bacteria, JII, Norwich</u> M. C. M. Pérombelon Pathogenicity of soft rot erwinias
29 July – 3 August	<u>International Society for Horticultural Science, Fourth Rubus and Ribes Symposium, Norway, Sweden and Denmark</u> D. L. Jennings Breeding for spinelessness in blackberries and blackberry-raspberry hybrids: A review D. L. Jennings Bud suppression ('blind bud') in raspberries (G. R. McGregor ²) (J. A. Wong ³) (C. E. Young ³)

¹Visiting Worker

²Potato Research Station, Victoria, Australia

³Department of Agriculture, Tasmania

	B. Williamson (R. J. McNicol)	Pathways of infection of flowers and fruits of red raspberry by <i>Botrytis cinerea</i>
	C. J. Wright ¹ (P. D. Waister)	Canopy structure and light interception in the red raspberry
18 – 23 August	<u>Second International Conference on Phloem Transport, Asilomar, California, USA</u>	
	K. J. Oparka (B. Marshall) (D. K. L. MacKerron)	Carbon partitioning in a potato crop in response to applied nitrogen
26 – 30 August	<u>EAPR, Physiology Section, St. Andrews</u>	
	H. V. Davies	The distribution and fractionation of calcium in developing and sprouting tubers
	P. A. Gill (P. D. Waister)	Origins of stem competition and its effects on tuber number
	T. D. Heilbronn (D. K. L. MacKerron) (P. Smith)	Light interception in the early stages of canopy development – technique
	R. A. Jefferies (D. K. L. MacKerron)	The influence of soil water restrictions on tuber numbers
	W. W. Kirk ² (B. Marshall)	Leaf development and growth in the field
	D. K. L. MacKerron	Canopy development and senescence and light interception as modified by nitrogen nutrition
	B. Marshall (R. Thompson)	Tuber-size distribution
	K. J. Oparka (B. Marshall) (D. K. L. MacKerron)	Alterations in carbon partitioning in response to applied nitrogen
10 – 12 September	<u>UK/France Workshop on Forage Brassicas, SCRI</u>	
	M. J. Allison	Chemical analysis of forage brassicas
	J. E. Bradshaw	Swede, kale and turnip breeding
	J. R. T. Hodgkin	Strategic studies on forage brassicas
	W. H. Macfarlane Smith	Rape breeding
	A. B. Wills	The work of the Forage Brassica Breeding Department, SCRI

¹Department of Agriculture and Horticulture, University of Nottingham School of Agriculture

²Research student

13 September	<u>AAB, London</u> B. D. Harrison (A. M. Lennon) (D. J. Robinson)	Variation in African cassava mosaic virus
20 September	<u>Plant Biotechnology Forum, Edinburgh University</u> H. Barker M. A. Mayo	Use of isolated protoplasts to study virus resistance in potato Protoplasts for studying tomato black ring virus genome functions
21 September – 3 October	<u>NATO Advanced Study Institute on Cyst Nematodes, Martina Franca, Italy</u> C. E. Taylor D. L. Trudgill	Quarantine and legislation Concepts of resistance, susceptibility and tolerance in relation to cyst nematodes
24 – 26 September	<u>AAB, Reading, Improvement of the Efficiency of Crop Production</u> H. Barker R. P. Ellis W. M. Robertson J. A. T. Woodford	Influence of potato genotype on potato leafroll virus spread by aphids Environmental response in barley Carbohydrates in virus vector nematodes Bench-mark trials to monitor potato leafroll virus spread in Scotland
21 – 22 October	<u>DTI UK/Hungarian seminar on Fruit Production and Processing, Centre for European Agricultural Studies, Wye College, Kent</u> C. E. Taylor C. E. Taylor C. E. Taylor C. E. Taylor	The production of virus-free stocks of raspberry and other <i>Rubus</i> Raspberry production, including mechanical harvesting, in relation to market outlets Black currant breeding with reference to market needs and production problems Breeding of raspberry and other <i>Rubus</i> in relation to specific market outlets

6 November	<u>Scottish Diagnostic Virology Group, Edinburgh</u> P. R. Massalski	Properties of monoclonal antibodies to potato leafroll virus
8 November	<u>Virus Tested Stem Cutting Growers' Association Meeting, Aviemore</u> P. D. Waister	Seed for precision growing
12–14 November	<u>Farm Shop and Pick Your Own Association Annual Conference, Solihull, England</u> M. R. Cormack	Raspberry yield components
18–21 November	<u>British Crop Protection Conference – Weeds, Brighton</u> H. M. Lawson (J. S. Wiseman)	Tolerance of seed potato crops to a range of selective graminicides
	H. M. Lawson (J. S. Wiseman)	Evaluation of new residual herbicides for use in seed potato crops
	H. M. Lawson (J. S. Wiseman) (D. H. K. Davies ¹) (M. C. Richards ¹)	Tolerance of potato crops to glufosinate-ammonium applied as an early post-emergence herbicide
	H. M. Lawson (J. S. Wiseman)	Evaluation of glufosinate-ammonium and paclobutrazol for control of cane vigour in raspberry
	H. M. Lawson (J. S. Wiseman)	Evaluation of glufosinate-ammonium for runner control in strawberries
20 November	<u>Scottish Society for Crop Research Conference on Scottish Seed Potatoes for Export, Dundee</u> R. A. Fox	Pathogens in relation to seed potato exporting
	G. R. Mackay	The SCRI strategy for breeding for export
	P. D. Waister	Influence of climate and agronomy on the performance of seed potatoes overseas

¹Crop Division ESCA

20–22 November	<u>IOBC/EEC Joint Experts' Meeting on Integrated Plant Protection in Field Vegetables, Rennes, France</u>	
	A. N. E. Birch	Preliminary observations on swedes with known resistance and susceptibility to turnip root fly in Scotland
10–13 December	<u>New Methods of Diagnosis in Plant Protection, Wageningen, The Netherlands</u>	
	M. C. M. Pérombelon (V. M. Lumb ¹)	A rapid method to identify and quantify soft rot erwinias on potato seed tubers
16–18 December	<u>AAB/BCPC, University of Cambridge</u>	
	B. Boag (D. J. F. Brown)	Soil sampling for virus vector nematodes
16–20 December	<u>EAPR/EUCARPIA, Breeding and varietal assessment, Cambridge</u>	
	J. Brown	The efficiency of early generation selection
	C. P. Carroll	The use of diploid (<i>phureja</i>) germ plasm
	D. R. Glendinning	The gene pool of modern potato varieties
	G. R. Mackay	General breeding strategy in the UK (invited speaker)

Conferences Organised

I. A. Cowe and D. C. Cuthbertson organised an NIR Users Group Meeting on Techniques for Monochromator Systems at SCRI Pentlandfield, 17–18 September.

M. F. B. Dale helped organise the AAB meeting on Quality Objectives and Techniques in Plant Breeding in Edinburgh on 22 May.

P. D. Waister, D. K. L. MacKerron and B. Marshall organised the EAPR Physiology Section meeting, St. Andrews, 26–30 August.

M. A. Mayo was co-organiser of a meeting at Churchill College, Cambridge, 24–26 June entitled Molecular Organization of Positive-strand Viruses, sponsored jointly by the Society for General Microbiology and the Federation of European Microbiological Societies.

M. C. M. Pérombelon served on the International Advisory Board for the Sixth International Conference on Plant Pathogenic Bacteria, Maryland, USA, 2–7 June and organised, jointly with Dr A. Collmer, a meeting of the International Erwinia (soft rot) Group.

C. E. Taylor organised (with Professor F. Lamberti) the NATO Advanced Study Institute on Cyst Nematodes at Martina Franca, Italy from 21 September–3 October.

¹Research Student

Courses Organised or Contributed to

Four members of staff from the Physiology & Crop Production Department contributed to a Crop Physiology course at the University of Dundee in January.

Three members of staff from the Plant Breeding Division gave a series of lectures on plant breeding to students in the Department of Plant Biology and Ecology at the University of St. Andrews from 4–8 February.

S. C. Gordon and J. A. T. Woodford contributed lectures and practicals on soft fruit pests, potato aphids and the control of aphid transmitted viruses for the Pest Module of the BASIS Training Course on Crop Protection at WSAC, Auchincruive on 17 October.

Members of staff from several departments contributed to lecture courses for students of Dundee and St. Andrews Universities.

Courses Attended

D. J. F. Brown, B. Boag and D. L. Trudgill attended the AAB Workshop on identification of root-knot nematodes found in the British Isles at RES, Harpenden, 11 December.

M. Brunton attended a RMS course on Principles of Electron Microscopy, University of Leeds, 15–19 April.

R. J. Clark attended the Data Communications Course held at the ERCC on six Monday afternoons starting 21 January.

A. Dolan and J. Heilbronn attended a course on the BBC Micro-computer at ERCC, 2–4 December.

A. E. Grant and R. Keith attended a course on safe operation and routine maintenance of Rough Terrain Fork Lift Truck organised by Sidlaw Training Group in co-operation with the ATB and held at SCRI on 4–5 November.

J. Heilbronn attended an 'Introduction to EMAS' course at ERCC, 8–9 October.

B. Marshall attended a workshop on modelling water movement and uptake in soils using microcomputers at Edinburgh University from July 2–4.

P. J. Stewart attended a Fortran programming course at ERCC, 14–18 October.

Invited Lectures

M. J. Allison gave a lecture to students of Glasgow University on An Analytical Chemistry Service to the Scottish Crop Research Institute in the Chemistry Department of Glasgow University on 13 November.

P. D. S. Caligari gave a lecture on the measurement and assessment of competition interactions to the Genetic Department, University of Edinburgh on 10 December.

B. D. Harrison gave lectures on geminivirus research at three universities/research centres in Italy in May-June, and at the Institut de Biologie Moleculaire et Cellulaire, Strasbourg, France on 19 December. He also spoke on luteovirus research in the Botany Department, Glasgow University on 26 November.

N. L. Innes gave a lecture to the Department of Plant Biology and Ecology at the University of St. Andrews on Breeding for Plant Resistance to Diseases on January 22. He also lectured on the Contribution of Science to the Breeding of Improved Cultivars at the Annual Meeting of the British Association for the Advancement of the Science at Strathclyde University on 27 August.

D. L. Jennings gave a lecture on Soft Fruit Breeding to students at the Royal Botanic Gardens, Edinburgh on 11 June.

G. R. Mackay lectured on potato breeding to a group of Italian visitors at DAFS:ASS, Edinburgh on 12 September. He also gave a seminar to students of crop production at the Faculty of Agriculture, University of Newcastle on 6 December.

D. K. L. MacKerron lectured on water relations and irrigation of soft fruit at the AGM of Tay Valley Branch of NFU of Scotland, Forfar, 22 January. He also lectured on water relations and irrigation of potato at Turriff, North of Scotland College of Agriculture, 25 February.

R. J. McNicol gave a talk on Soft Fruit Breeding to the Royal Caledonian Horticultural Society, Edinburgh on 15 January.

B. Marshall gave a lecture on crop research and the agricultural industry to the Agricultural Society (Student section) at University of Newcastle on 28 November.

W. Powell lectured on the use of doubled haploids to the Department of Plant Biology and Ecology, St. Andrews University on 22 February and on the production and use of random inbreds in barley breeding to the Genetics Department, University of Birmingham on 3 December.

D. J. Robinson spoke on the comparative molecular biology of tobamoviruses at the Institute of Virology, Oxford on 19 December.

R. L. Wastie lectured on potato diseases to students at Coventry (Lanchester) Polytechnic on 14 February.

B. Williamson gave a lecture on the biological basis of control measures for raspberry diseases to a meeting organised by Bayer UK Ltd at Forfar on 11 April and he also lectured on control of raspberry grey mould at a meeting of the SNFU, Coupar Angus, 28 May.

J. A. T. Woodford gave a lecture on agrochemicals at a conference on Pesticides organised by Friends of the Earth at the Centre for Human Ecology, Edinburgh University on 14 December.

Editorial Duties

- P. D. S. Caligari Junior Editor of *Heredity*
- R. A. Fox Executive Editor of *Potato Research*
- B. D. Harrison Editor of *Association of Applied Biologists*
Descriptions of Plant Viruses
Member of Editorial Board of *Intervirology*
- J. R. T. Hodgkin Joint Editor of *Eucarpia Cruciferae Newsletter*
- A. T. Jones Member of Editorial Board of *Annals of Applied*
Biology
- R. J. Killick Editor of *Crop Research*
Editor of *Potato Research*
- H. M. Lawson Member of Editorial Board of *Annals of Applied*
Biology
- G. R. Mackay Member of Editorial Board of *Heredity*
- M. A. Mayo Editor for plant virology of *Journal of General*
Virology
- A. F. Murrant Editor of *Association of Applied Biologists*
Descriptions of Plant Viruses
- D. A. Perry Member of Editorial Board of *Crop Research*
- D. J. Robinson Member of Editorial Board of *Journal of Virological*
Methods
- C. E. Taylor Joint Editor of *Nematologia Mediterranea*
Associate Editor of *Journal of Horticultural Science*
Member of Editorial Board of *Crop Research*
- P. B. Topham Editor of *Crop Research*
- D. L. Trudgill Consulting Editor of *Plant and Soil*
- P. D. Waister Associate Editor of *Journal of Horticultural Science*
Associate Editor of *Crop Research*
- A. B. Wills Member of Editorial Board of *Crop Research*
Joint Editor of *Eucarpia Cruciferae Newsletter*
- J. A. T. Woodford Member of Editorial Board of *Annals of Applied*
Biology

Service on Committees

- T. J. W. Alpey Co-ordinator and UK representative of the European
Plant Parasitic Nematode Survey
Member of the Steering Committee of the 18th
International Symposium of the European Society
of Nematologists
- M. M. Anderson NFT Black Currant Panel

B. Boag	Member of the Ecology Committee of the Society of Nematologists Nematology and Scottish Representative on the European Invertebrate Survey Committee
D. J. F. Brown	Secretary and Treasurer to the European Society of Nematologists
M. R. Cormack	NFT Scottish Soft Fruit Panel
I. A. Cowe	International Association of Cereal Chemists
M. F. B. Dale	AAB – member of Plant Breeding Group Committee
R. P. Ellis	Institute Representative BAPB, Cereal Crop Group BAPB Representative on COSAC Recommended List Consultative Committee and Institute of Brewing Working Party
R. A. Fox	Association for Crop Protection in Northern Britain – Secretary/Treasurer of Standing Committee
S. C. Gordon	Member of the AFRC Pesticide Application Research Discussion Group AAB – member of the Pesticide Application Group Committee
B. D. Harrison	Advisory Committee, <i>Advances in Virus Research</i> AFRC/SERC/DTI Plant Biotechnology Committee Steering Group III on Pathogenesis and Symbiosis Visiting Group, Institute of Virology, Oxford
N. L. Innes	BAPB Main Committee Board European Association of Plant Breeders (EUCARPIA) Governing Board, ICRISAT Chairman, Programme Committee, ICRISAT
W. I. A. Jack	NFT Scottish Soft Fruit Panel
D. L. Jennings	NFT Raspberry Panel NFT Scottish Soft Fruit Panel SNSA Adviser to Committee
R. J. Killick	Institute of Biology, Scottish Branch Council
H. M. Lawson	ADAS/WRO Liaison Group AFRC Fruit Weed Control Group BCPC R & D Sub-committee – Weeds ISHS Working Group on Weed Control in Vegetables SAC/SCRI Weeds Group
W. H. Macfarlane Smith	BAPB Oilseed and Industrial Crop Group Plant Variety Development Panel SCRI/ASS/COSAC Forage Brassica Working Group

- G. R. Mackay BAPB Member of Main Committee
Member of Interdepartmental and users committee for
post entry quarantine for potato material for
breeding and scientific use
- D. K. L. MacKerron Convener of Working Group on Water Relations in
Potato Production, EAPR, Physiology Section
- J. W. McNicol ERCC, member of Research Council's Users'
Committee
Convener ERCC, UCSD User Group
- R. J. McNicol EMRS Strawberry Research Workshop
NFT Strawberry Panel
NFT Scottish Soft Fruit Panel
NFU Strawberry Breeding Sub-committee to the
Soft Fruit Committee
- B. Marshall SEB Environmental Physiology Group Committee
Maximum Yields/Yield Constraints of Cereals
Working Group
- M. A. Mayo XIV International Congress of Microbiology,
Virology Programme Sub-committee
- W. P. Mowat Convener, SNSA Bulb Technical Committee
AAB Virology Group Committee
- A. F. Murant ISHS, Chairman of Working Group on Small Fruit
Viruses
International Committee on Taxonomy of Viruses,
Member of Executive Committee and Plant Virus
Sub-committee
- M. C. M.
Pérombelon Chairman, International Erwinia (soft rot) Group
- M. S. Phillips AAB Nematology Group Committee
- I. M. Roberts Chairman, AFRC Electron Microscope Advisory
Group
Safety Representative, Royal Microscopical Society
Education Committee
- C. E. Taylor AFRC Plants and Soils Research Committee
Chairman ACAS Scientific Advisory Committee
Chairman European Plant Parasitic Nematode Survey
(European Science Foundation)
Chairman SCRI/ASS/COSAC Liaison Group
ECRE Board of Management
NFT (Brogdale) Advisory Committee
PMB Research and Development Committee
Publications Committee, *Journal of Horticultural
Science*

- SNSA (Flower Bulbs) Adviser to Committee
Tayside Regional Council, Steering Group for market opportunities in the agrifoods sector
Technical Committee, Glasshouse Investigations Unit for Scotland, WSAC
University of Strathclyde Sub-Board for the Degree of B.Sc. in Horticulture
- R. D. Taylor ATB Horticultural Training South of Scotland Committee
Scottish Association of Young Farmers' Clubs Proficiency Tests, Council for Agriculture: Horticultural Panel
- R. Thompson MAFF Research Consultative Committee
Other Arable Crops, Technical Secretary
Secretary DAFS Maximum Yield/Yield Constraints of Potatoes Working Party
SCRI/COSAC Liaison Group
- P. B. Topham Edinburgh University, Member of Edinburgh Computer Users' Committee
ERCC, Member of Research Councils' Users' Committee
- P. D. Waister AFRC/DAFS/MAFF Fruit Committee
Chairman DAFS Maximum Yield/Yield Constraints of Potatoes Working Group
Co-Chairman EAPR Working Group on Tuber Numbers
SCRI/ASS/COSAC Liaison Group
- R. L. Wastie BSPP – member of Council and Programme Committee
- A. B. Wills AAB – member of Plant Breeding Group Committee
SCRI/ASS/COSAC Forage Brassica Working Group
- G. Wood Farmplan Computer Systems Ltd. Member of review panel for Arable Program Development

Exhibitions and Poster Sessions

- 9 – 12 April *New Developments and Techniques for Virus Detection*, AAB, Cambridge
dsRNA in vicia cryptic virus particles
Detection of viruses in cassava
Genome properties and relationships of Indian peanut clump virus
- 12 April *Mathematical Association Annual Conference*, Dundee
Digitising the potato canopy – mathematical aspects
Modelling the potato crop

- 8 May *Auchincruive Horticultural Exhibition*, WSAC
Controlling clay coloured weevil in raspberry
- 12 June *Irrigation Demonstration*, Kettle Farm, Fife,
ESCA and UKIA
Water supply and potato production
- 12 – 13 June *Microtech 1985*, Dundee Technical College
Micro-computer and the identification of nematodes
- 13 June *Better Fruit Growing*, ADAS, Brogdale, Kent
Know your enemies
- 24 – 27 June *Alvey Conference 1985*, Edinburgh University
Use of the computer as an aid to the identification
of nematodes
- 24 – 28 June *4th International Symposium on Flower Bulbs*,
Noordwijkerhout, The Netherlands
The production of virus-tested narcissus in Scotland
- 26 – 30 August *EAPR, Physiology Section*, St. Andrews
Potato physiology at SCRI
- 9 – 14 September *EUCARPIA Conference*, Berlin, Germany
The detection of linkage using doubled haploids in
barley
A comparison of cross prediction methods in
Spring Barley
- 18 – 19 September *Invertébrés Menaçants – Menacés Leur Surveillance*,
Gembloux, Belgium
Species associations among plant-parasitic
nematodes in Britain and Belgium
- 23 – 24 September *Farm Electronics '85* National Agricultural Centre,
Stoneleigh
The HERBREX herbicide data-base
- 18 – 21 November *British Crop Protection Conference – Weeds*, Brighton
The HERBREX herbicide data-base
- 16 – 20 December *Breeding and variety assessment*, EAPR/EUCARPIA,
Cambridge
Breeding for resistance and tolerance to PCN
Screening for resistance to diseases and pests

Radio and Television

E. Brydon, 22 October, Nuts and Berries, *BBC 2 Scotland*.

N. L. Innes, 27 August, Contribution of Plant Breeding to Agriculture,
BBC Radio Scotland.

D. L. Jennings, 28 August, Machine Harvesting of Raspberries,
Grampian Television.

INDEX OF RESEARCH PROGRAMME

PU 1 To provide improved cultivars of potatoes and more efficient breeding methods

- (a) Breed improved cultivars of potato for the UK.
- (b) Breed potatoes for export potential and select suitable cultivars by overseas trialling.
- (c) Study the genetics of potatoes and improve breeding and trialling methods.
- (d) Develop new potato breeding material from primitive and novel germplasms.
- (e) Improve, and use, screening methods for resistance and tolerance to pests and diseases of potatoes.
- (f) Develop and use screening tests for selected biochemical compounds in potato breeding material.
- (g) Maintain and evaluate the Commonwealth Potato Collection.

PU 2 To provide improved cultivars of cereals and more effective breeding methods

- (a) Breed cultivars of spring barley with improved adaptation to northern Britain and better malting quality.
- (b) Breed cultivars of winter barley with improved yield and malting quality.
- (c) Study biochemical genetics of barley.
- (d) Study genetics of barley and develop breeding methods.
- (e) Improve, and use on barley breeding material, screening methods for fungal disease resistance.
- (f) Develop and use automated tests for malting, distilling, brewing and milling quality.
- (g) Trial extension crops.

PU 3 To provide improved cultivars of soft fruit and more effective selection methods

- (a) Provide improved cultivars of raspberry and study relevant characters.
- (b) Provide improved cultivars of black currant and study relevant characters.
- (c) Provide improved cultivars of blackberries and *Rubus* fruit.
- (d) Identify strawberry genotypes from the EMRS programme adapted to the Scottish environment.

PU 4 To provide improved cultivars of forage crucifers and more effective breeding methods

- (a) Breed improved swede cultivars and investigate breeding methods.
- (b) Breed improved kale cultivars and investigate breeding methods.
- (c) Breed improved fodder cabbage cultivars and investigate breeding methods.
- (d) Breed improved turnip cultivars and investigate breeding methods.
- (e) Breed improved rape cultivars and investigate breeding methods.
- (f) Multiply and stabilise breeders selections: and trial selections in collaboration with other organisations.
- (g) Investigate novel combination of genomes to produce breeding material.
- (h) Investigate tissue culture and new methodologies and use them to produce breeding material.
- (i) Study genetics of brassicas and formulate improved breeding methods.
- (j) Study S-allele incompatibility in brassicas.
- (k) Devise, and use on brassica breeding material, screening methods for fungal and virus disease resistance.
- (l) Develop and use, screening tests for important compounds in brassica breeding material.

PU 5 Potato physiology

- (a) Investigate the physiology of the response of the potato crop to radiation, temperature and water supply.
- (b) Define the physiological processes involved in dry matter partitioning in the potato plant.
- (c) Study the physiological basis of inter-sprout competition in the potato during the pre-emergence growth phase.
- (d) Make simulation studies of the growth and development of arable crops.
- (e) Measure the effects of mineral nutrition on growth and development of potatoes (with MISR).
- (f) Determine the factors influencing dry matter content and sugars balance of potato tubers.
- (g) Investigate the phasing of inter- and intra-plant competition in the potato crop.

PU 6 Husbandry of soft fruits

- (a) Investigate physiological factors affecting the maturation and quality of raspberry fruits.
- (b) Analyse dry matter partitioning, and compensation between yield components in cane fruits.
- (c) Study physiological and cultural factors affecting the mechanical harvesting of soft fruits.
- (d) Identify cultivars and design production methods for soft fruit crops.

PU 7 Environmental and cultural factors influencing yield and quality of arable crops

- (a) Investigate the effects of cultural practices on the growth and development of the potato crop.
- (b) Investigate the effects of cultural practices, environment and genotype on the growth and development of grain legumes.
- (c) Devise methods for the production of vegetable crops under northern conditions.

PU 8 The biology and control of diseases and pests of barley crops in northern Britain

- (a) Investigate the biology of over-winter root diseases to improve control strategies.
- (b) Investigate the biology of leaf diseases to improve control strategies.

PU 9 The biology and control of diseases and pests of soft fruit crops in northern Britain

- (a) Improve control by studying the biology of fungal and bacterial diseases of *Rubus*.
- (b) Devise improved control strategies for insect and mite pests of cane fruit.
- (c) Elucidate the role of nematodes in planting disorders of soft fruit and develop control measures.
- (d) Study properties, spread and control of *Rubus* and *Ribes* viruses and devise diagnostic methods.
- (e) Produce virus-free stocks, assess virus resistance and index British and imported raspberry and other *Rubus* genotypes.

PU 10 The biology and control of diseases and pests of forage crops in northern Britain

- (a) Develop control measures by studying the biology of fungal diseases of brassica forage crops.

- (b) Develop and evaluate a screening test for resistance to turnip root fly.
- (c) Investigate the pathogenicity and control of nematode pests of forage brassicas.
- (d) Devise detection, diagnostic, screening and control methods for forage brassica viruses.

PU 11 The biology and control of diseases and pests of narcissus crops in northern Britain

- (a) Devise detection methods and determine properties and epidemiology of narcissus viruses.
- (b) Produce and maintain virus-free stocks of narcissus, and monitor field propagation.

PU 12 The biology and properties of non-indigenous plant viruses

- (a) Devise detection and diagnostic methods for, and characterise, cassava viruses.

PU 13 The biology and control of diseases and pests of potatoes in northern Britain

- (a) Study the biology and assess the effects of fungal and bacterial diseases of the growing potato plant.
- (b) Study the biology and assess losses due to fungal and bacterial diseases of stored potato tubers.
- (c) Elucidate mechanisms of quantitative resistance to potato diseases.
- (d) Elucidate survival processes of potato pathogens by studying their autecology.
- (e) Devise methods to control diseases of potato.
- (f) Study the ecology of the aphid viruses and the factors determining virus spread.
- (g) Devise methods of controlling virus spread in potato.
- (h) Improve management of cyst nematodes in seed potato land and control of damage in ware land.
- (i) Elucidate resistance in potato and the effect of growing resistant cultivars in populations of potato cyst nematode.
- (j) Understand and assess effectiveness of virus resistance mechanisms in potato.
- (k) Devise and improve detection methods; examine occurrence, variation, transmission and ecology of potato viruses.

PU 14 Ecological aspects of weeds, pests and pathogens leading to control methods

- (a) Predict the control of weeds and herbicide performance in crop rotations.

- (b) Study the ecology and control of weeds and unwanted crop vegetation in agricultural and horticultural crops.
- (c) Study the biology and ecology of pests to identify the means of their control.
- (d) Investigate the control of nematodes by nematotoxic chemicals.
- (e) Monitor the genetic population structure of plant pathogens in the field.
- (f) Determine the interactions among the soil biota that effect major root pathogens and root function.

PU 15 Host-parasite and vector mechanisms

- (a) Identify and elucidate the nature and effects of natural products on recognition sites on plants and aggressors.
- (b) Identify and elucidate the effects of pre- and post-formed host and pathogen compounds on sequences in pathogenesis.
- (c) Determine the components of host and pathogen affecting their recognition, interactions and ensuing pathogenesis.
- (d) Investigate the resistance and host status of plants in relation to their response to pest attack.
- (e) Investigate the structure and behaviour of virus vectors especially mechanisms of retention, transmission and specificity.
- (f) Elucidate mechanisms of virus transmission by aphids.
- (g) Elucidate the genome organisation of viruses and molecular aspects of their biological properties.
- (h) Determine the activity of DNA copies of plant virus RNA genes and the effect of their incorporation into plant genomes.

PU 16 Development of experimental techniques

- (a) Develop Near Infra-Red analyses to predict specific biochemical components in crops, pathogens and host/pathogen interactions.
- (b) Devise methods for the electron microscopy of viruses, fungi and bacteria.
- (c) Devise and improve methods for detection and diagnosis of plant viruses and virus strains.

CEREAL BREEDING

N. L. INNES

The success of the spring barley breeding programme, in which the main aims have been to produce improved cultivars for northern Britain with good malting quality and disease resistance, especially to powdery mildew, has been marked by the continued recommendation of the cultivars Tweed and Heriot on the Scottish Agricultural Colleges Recommended List for 1986. There were signs that the resistance of these two cultivars to powdery mildew was, like that of other commercial cultivars, less effective than when the cultivars were released. Nevertheless, general resistance still compares favourably with other recommended cultivars. Moreover, favourable reports on both cultivars were received from a number of farmers and maltsters. The cultivars Ayr and Esk have been added to the National List and granted Plant Breeders Rights. Both cultivars gave high yields in official trials, and Ayr has been included in Recommended List Trials for 1986 in both Scotland and England.

During 1986 staff transferred from Pentlandfield to Mylnefield and there has been considerable re-organisation, with a fresh influx of support staff to replace those who opted against transfer to Mylnefield. Inevitably there have been minor disruptions to work, partly through delays in the building programme. In anticipation of a reduction in State support for cereal breeding, two vacant research leader posts have not been filled. Effort into the breeding of spring and winter barley is now roughly equal, although the commercial breeding of winter barley, which was only started in 1980 and has been disrupted by a number of staff changes, lags behind that of spring barley.

Breed improved malting cultivars of spring barley [PU 2(a)]

Cultivars Heriot and Tweed performed well in the 1985 SAC Recommended List trials. Tweed retains its general recommendation for growing in Scotland in 1986 whilst Heriot continues to have a provisional general recommendation.

Cultivars Ayr and Esk yielded in National List trials, ranking first and third respectively. Both have been awarded Plant Breeders Rights and Ayr will be included in both NIAB and SAC RL trials in 1986. Cv. Forth performed poorly in NLT2 and is unlikely to proceed further. Seven submissions were in NLT1 in 1985. Of these, SCRI 843 and SCRI 844 were best, yielding 102 and 104% respectively of the controls. As both are similar and unlikely to be distinguishable, SCRI 843 was withdrawn,

as were the other five entries which failed to show an improvement over the controls. Micro-malting tests suggest that SCRI 844, which goes forward into NLT2, is likely to be of good malting quality.

All the SCRI entries in 1985 NL trials were grown in two advanced trials at The Murrays farm. In the first, there were also six control cultivars: Doublet, Golf, Klaxon, Kym, Triumph and Heriot in a cultivar \times nitrogen experiment. Three levels of nitrogenous fertiliser were used - 90, 112 and 135 kg N/ha. The highest yielding entry was Klaxon, followed by SCRI 845 and Ayr. No significant cultivar \times nitrogen interactions were detected although Ayr and Golf showed a higher than average response to increased nitrogen. The second trial had four replicates of all the AFRC entries in 1985 spring barley NL trials plus the cultivars Doublet, Golf, Klaxon, Kym, Triumph, Heriot and Golden Promise. Two replicates were harvested when ripe but the other two were exposed to the weather for a further 4 weeks to determine the effects of a late harvest on the cultivars. It was not possible to assess grain and head loss in the plots before harvest but some yield loss had occurred before the first harvest and some cultivars showed over 10% loss in yield between the two harvests.

Although there were 18 stocks in Joint Main Trials (JMT) and secondary multiplication in 1985, none outyielded the best control (Klaxon), therefore there were no new submissions for NL trials in 1986. A further 18 selections from the 168 in primary progeny trial and multiplication in 1985 have been entered into JMT and secondary multiplication in 1986.

Twenty selections were made from the material in second bulk trials in 1985 and 20 single plants from each were multiplied in New Zealand during 1985/86. Among promising selections was one from the cross between cultivars Golden Promise and Magnum in which Magnum pollen was irradiated. It had inherited a number of characteristics from Magnum, including height, and resistance to powdery mildew and *Rhynchosporium*.

One hundred and sixty selections from 950 in first bulk trials in 1985 were retained for further evaluation in second bulk trials. Two nurseries comprising F_4 rows from the SCRI programme and a third containing F_3 rows from the WPBS were screened. From a combined total of over 13,500 rows, 1,200 were retained for evaluation in first bulk trials in 1986.

There were nearly 300 F_2 populations grown in 1985, 100 of the crosses being assessed in F_3 cross prediction experiments. One hundred and twenty populations were sent to New Zealand for multiplication during 1985/86 and the best of the crosses in the cross prediction study will be returned together with some experimental crosses.

(W. T. B. Thomas, J. S. Swanston, R. P. Ellis, A. Young and D. Farrer)

Breed improved malting cultivars of winter barley [PU 2(b)]

Selections from the SCRI programme and the PBI exchange material were trialled at three sites. The highest yields were obtained in Aberdeenshire where cv. Igri yielded over 10 t/ha; about 4 t/ha higher than in Angus or East Lothian. The most promising material, similar in yield potential to Igri, has been sown in a further series of trials. A further 1500 F₄ lines were received from the PBI and will be examined in the Scottish environment. Work started on the use of cross prediction and the use of infra-red photography to quantify frost damage.

A comparison of spring and winter cultivars sown in the spring and autumn continued. An investigation of variation in the growth of the crop canopy showed that most of the resultant effects on yield were due to changes in the number of ears/m² and grains/ear indicating that, of yield components, grain size is the least affected by the environment. The spring barley cv. Nairn showed good yield potential from autumn drilling indicating the advantages of earliness and stiff straw in an adverse season.

(R. P. Ellis, A. Young)

The genetics of some malting quality, yield and agronomic characters [PU 2(d)]

Data scored on single rows of the five spring barley crosses in the Triple Test Cross experiment done in collaboration with J. L. Jinks¹ were analysed. The variates were single plant yield (derived from the row yield and number of plants in the row), thousand grain weight, milling energy, percentage acid-soluble beta-glucan content, percentage nitrogen content and predicted diastatic power (scored on two crosses only). These variates were all measured on the row bulk of seed. Single plant yield, thousand grain weight, milling energy and diastatic power were all highly heritable but much of the variation was due to dominance and there was also evidence of epistasis for milling energy and diastatic power. Percentage acid-soluble beta-glucan content and percentage nitrogen content were not highly heritable. Early generation selection for any of these six variates would therefore be unreliable.

Three of the five crosses were also analysed in a study of doubled haploids, random F₃ lines and single seed descent lines. Additive genetic variation for percentage acid-soluble beta-glucan content was found but there was no evidence of epistasis. There were some large negative additive genetic correlations between this character and both thousand grain weight and height (which were measured on individual plants) in the doubled haploid populations. These correlations were much less in the single seed descent populations, suggesting the existing of repulsion linkages between the genes. Univariate predictions of the numbers of

¹Genetics Department, Birmingham University

lines expected to transgress the parental range for percentage acid-soluble beta-glucan content made from estimates derived from both doubled haploid and random F_3 lines agreed well with the observed numbers of single seed descent lines transgressing the parental range. Bivariate predictions between percentage acid-soluble beta-glucan content and some agronomic characters also agreed well with observed numbers.

Whereas it appears that successful early generation selection of individual plants for percentage acid-soluble beta-glucan content is not feasible, it seems possible to use this variate in cross prediction techniques to discriminate between crosses.

Cultivars possessing *Hordeum laevigatum* in their pedigree were found to have higher levels of acid-soluble beta-glucan and lower levels of alpha-amylase than other cultivars, even those of moderate or poor malting quality. The *H. laevigatum* derivatives also had higher milling energy scores than cultivars with good malting quality, although their milling energy did not greatly exceed those of other poor quality cultivars. These findings suggest the introgression of undesirable factors associated with the powdery mildew resistance gene M1-v, derived from *H. laevigatum*.

Genetical analysis of MM23, a high diastase mutant from cv. Maris Mink isolated by screening germinating grain with abscisic acid, showed that a simple model of gene action explained the larger part of the differences from Maris Mink in most of the characters examined. This mutant is of interest because of its erect habit which is conditioned by a change in growth hormones. The original aim was to select mutants with an altered pattern of gibberellic acid metabolism and hence more rapid germination. The alterations in growth hormone metabolism identified in MM23 are associated with a range of other genetic modifications affecting agronomically significant characters.

(W. T. B. Thomas, J. S. Swanston, W. Powell, R. P. Ellis)

The use of random inbred lines in barley breeding [PU 2(d)]

Experiments have been conducted to evaluate the use of doubled haploids and single seed descent lines in barley breeding. The univariate cross prediction method (*Ann. Rep. 1984*, 49) was extended to bivariate, tri-variate and quadivariate predictions. It was also demonstrated that it is possible to make joint predictions jointly for mean performance and environmental sensitivity.

Random inbred lines produced by doubled haploidy (DH) and single seed descent (SSD) were compared to examine the role of linkage in the genetic control of agronomic characters. Estimates of additive genetic variance from DH and SSD samples did not differ significantly. Thus linkage disequilibrium is not an important component of the genetic architecture of these characters in the five crosses investigated. The relationship between pairs of characters were investigated using F_1 and

F₂ derived DH and SSD lines. In this case linkage disequilibrium and pleiotropy were factors influencing the relationship between quantitatively varying characters. The linkages were generally in the coupling phase and pleiotropy positive. The practical implications of these findings are that the properties of recombinant genotypes in DH and SSD samples should not be significantly different.

Studies involving random inbred lines were extended to pedigree inbred lines derived from the same cross. Several agronomic character including height, yield and its components were studied and the means of the pedigree inbred lines were found to be higher than those of the single seed descent lines but this could be attributed to different levels of inbreeding between the two samples associated with significant dominance for all characters except main stem yield. The means of the single seed descent lines and doubled haploid lines did not differ significantly except for thousand grain weight, which was attributable to coupling linkages between epistatic genes. The study showed that desirable recombinant lines can be produced by either doubled haploidy or single seed descent but that caution should be exercised in fixing major genes in the early generations of a breeding programme, due to the possibility of indirect selection against desirable characters. Only if pedigree inbreeding was to result in an increase of desirable recombinants in the early stages of a programme would it be superior to the production of random inbred lines. The choice between pedigree inbreeding, single seed descent and doubled haploidy should therefore be made on the basis of non-genetical considerations such as cost.

In an experiment at The Murrays farm and Queenstonbank (Scotland) and at two sites at PBI, Cambridge (England) with random lines from the cross between cultivars Golden Promise and Ark Royal, yield showed significant interactions between Scotland and Cambridge and between tall and short genotypes. Tall genotypes were more consistent and higher yielding at the drier Scottish sites than were short.

(W. Powell¹, P. D. S. Caligari², W. T. B. Thomas, R. P. Ellis)

The effect of intergenotypic competition on selection processes in barley [PU 2(d)]

Analyses of the effects of competition on the selection process in spring barley (*Ann. Rep. 1983, 50*) were extended to the between plant variances. Competition affects the between plant variance and hence estimates of heritability. Furthermore seed germination can be affected by the competitive interactions experienced by the parents. These two features of intergenotypic competition complicate and confound methods used in early generation selection in barley breeding programmes and support the view that early generation selection should be avoided.

(W. Powell¹, P. D. S. Caligari²)

¹Tissue Culture Unit

²Potato Breeding Department

The use of pollen irradiation for limited gene transfer [PU 2(d)]

The use of pollen irradiation as a potential breeding tool was extended to a wider range of crosses in spring barley. Observations on the M1, M2 and M3 generations from three crosses confirmed that pollen irradiation can cause deviations from expected segregation ratios for certain characters. The reduced fertility observed in the M1 and M2 generations of these crosses could be problematical in breeding programmes. At the highest dose rate for the cross TS117 × cv. Scots Bere there was no expression of the six-row character, which is controlled by a recessive paternal factor. Five more crosses have been made to compare inbred lines from crosses with and without irradiation. At present, however, pollen irradiation appears to have greater potential for research than for practical breeding.

(R. P. Ellis)

The influence of seeding rate on some random inbred lines [PU 2(d)]

Yield trials conducted by SCRI have been sown at seed rates typical of those used in Scotland, which are greater than those used in England and Wales. This could result in selection of lines which, although performing well at higher rates, might not be suitable for growing at lower seed rates. Previous seed rate experiments have all been done with commercial cultivars which, by the nature of their breeding and testing, will have been evaluated under a range of seed rates. An experiment was therefore carried out with a number of random inbred lines grown in a split-plot trial at four seed rates ranging from 135 to 202 kg/ha. Analysis of plot yields revealed significant interactions between lines and seed rates, particularly for lines possessing the *erectoides* dwarfing gene. Further investigations into these interactions are being made to determine the best plant breeding strategy.

(W. T. B. Thomas)

Development of new sources of disease resistance [PU 2(e)]

Lines from a programme in which cv. Golden Promise was back-crossed to a number lines with mildew resistances derived from *Hordeum spontaneum* were evaluated as progeny rows. A number of lines which were homozygous for resistance genes was selected for further evaluation in 1986.

Two groups of material from WPBS, incorporating sources of partial mildew resistance, were evaluated. The first group comprised F_8 lines of biparental crosses between parents exhibiting high levels of partial mildew resistance. The second comprised F_4 lines of crosses of the partially mildew resistant material crossed to a high yielding commercial cultivar with an ineffective major gene resistance to powdery mildew. Many lines from the second group exhibited good levels of

resistance to powdery mildew in the field and some from the first group also looked promising. Selected lines will be evaluated further in 1986.

(W. T. B. Thomas)

Trial cereal crops in collaboration with other organisations [PU 2(g)]

Spring oats, spring and winter barley, and winter wheat trials were grown as part of the BAPB trialling system. One spring barley trial was also grown as part of a Joint European collaborative exercise. The Cereal Breeding Department continued to test under Scottish conditions new lines of spring oats and, for the first time, winter oats, on behalf of WPBS, and also triticale, spring and winter barley for PBI.

Owing to financial restraints and a reduction in staffing, there will be no BAPB winter wheat and joint European spring barley trials in 1985/86.

(A. Young)

NEW BARLEY CULTIVARS

AYR

National List and Plant Variety Rights – 1985

<i>Origin</i>	Ayr was selected from the cross (Goldmarker × Athos) × (Goldmarker × Magnum)		
<i>Straw length</i>	4 cm shorter than cv. Triumph		
<i>Straw strength</i>	Slightly weaker than Triumph and stronger than cv. Kym		
<i>Maturity</i>	1 day earlier than Triumph		
<i>Disease resistance*</i>		Ayr	Triumph
	Mildew	8	2
	Yellow rust	(4)	8
	<i>Rhynchosporium</i>	5	5
	Brown rust	5	7
<i>Malting quality</i>	Post harvest dormancy – short Hot water extract – similar to cv. Golden Promise		
<i>Yield potential</i> ¹	National List Trials 1984/85	Ayr	Triumph
	England and Wales	113%	90%
	Scotland	109%	97%

*On a 1-9 scale. High scores indicate greater resistance.

¹Yield potential values are % of mean of controls.

ESK

National List and Plant Variety Rights – 1985

<i>Origin</i>	A sister line of Ayr		
<i>Straw length</i>	2 cm taller than cv. Triumph		
<i>Straw strength</i>	Slightly weaker than Triumph and stronger than cv. Kym		
<i>Maturity</i>	4 days earlier than Triumph		
<i>Disease resistance*</i>		Esk	Triumph
	Mildew	8	2
	Yellow rust	(7)	8
	<i>Rhynchosporium</i>	7	5
	Brown rust	7	7
<i>Malting quality</i>	Post harvest dormancy – short Hot water extract – similar to cv. Golden Promise		
<i>Yield potential</i> ¹	National List Trials 1984/85	Esk	Triumph
	England and Wales	111%	90%
	Scotland	100%	97%

*On a 1-9 scale. High scores indicate greater resistance.

¹ *Yield potential* values are % of mean of controls.

FORAGE BRASSICA BREEDING

A. B. WILLS

The number of teams concerned with the production of new cultivars was reduced to two. This followed a planned reduction in staff numbers and has involved a change in the leadership of swede breeding. In consequence, during the year, a review was made of the objectives and methods for swede breeding, and of the breeding materials available.

Our work on the biology of pollen germination was extended, in cooperation with the University of Cambridge, to a study of the effects of a fungal toxin on pollen. We are now testing the possibility that resistant plants can be recognised by measuring the response of their pollen to toxin, as suggested by the finding that pollen grains and somatic tissue respond similarly to the same toxin concentrations.

Breeding new cultivars of swede [PU 4(a)]

Following a review of swede breeding practices and objectives, during which most of the current breeding material was evaluated, it was decided for the immediate future to continue pedigree breeding as the preferred method of producing new cultivars. Alternative inbreeding methods such as single seed descent and androgenesis have attractions for the future, and research into the latter has already begun (see PU 4(h)). Also, it was decided that research into some aspects of hybrid breeding of swedes should continue (see PU 4(i)).

High yield is a major selection criterion for new cultivars but in recent years the importance of disease resistance has also been emphasised. Thus the selection DBOxbbd, which will be included in NIAB pre-National List Trials in 1986, has good mildew resistance as well as a high yield of dry matter at medium dry matter content. It is winter hardy, with purple skin, yellow flesh and has an attractive appearance. It was bred from cv. Bangholm Magres \times cv. Champion. High yielding, mildew resistant lines were also identified in 1985 in the F_5 of cv. Bangholm Ruta \times cv. Bangholm Sahna and in the F_4 of cv. Bangholm Magres \times cv. Criffel. Lines combining good clubroot resistance with an acceptable appearance and adequate yield were identified in the F_3 of crosses between lines with clubroot resistance from the experimental Dutch stubble turnip population ECD04 and lines selected primarily for yield from modern swede cultivars.

(J. E. Bradshaw, D. J. Gemmell)

Turnip root fly resistance in swede [PU 4(a)]

The roots of the high dry matter SCRI cultivars Angus and Melfort are less mined by larvae of turnip root fly than are roots of common commercial cultivars. Earlier work to obtain representative samples for chemical analysis of resistant and susceptible cultivars from trials grown in Aberdeenshire and Midlothian (*Ann. Rep. 1983*, 51) was vitiated in part by equipment failure. Further trials have been grown in each subsequent year and samples of leaves and roots collected for chemical analysis. In 1983 there were no significant differences between cultivars in contents of reducing sugars, nitrogen, thiocyanate ion and SMCO. HPLC analysis of glucosinolates in 1984 trials confirmed the finding by FRI that Melfort has a low content of progoitrin while Angus has a high content. It also showed that the mean progoitrin content of all cultivars was much lower at the Aberdeenshire site, where the pest is prevalent, than in Midlothian where it is absent. Analysis of other individual glucosinolates by HPLC is now in progress.

(I. K. Munro, H. Bain¹)

Kale population improvement and cultivar production [PU 4(b)]

The kale breeding programme consists of population improvement schemes aimed at investigating the responses to selection for agriculturally important characters. From time to time superior families selected from these populations are multiplied so that their potential as new cultivars may be assessed.

The kale polycross improvement programme started in 1971 was terminated after five generations of half-sib family selection for digestible organic matter yield. Six half-sib families from the final generation, chosen for their dry-matter yield, resistance to clubroot, and contents of digestible organic matter (DOM), S-methyl cysteine sulphoxide (SMCO) and thiocyanate ion (SCN^-) will now be multiplied and assessed further.

In another marrow-stem kale population the primary emphasis has so far been placed on selection for improved clubroot resistance. Significant progress has been measured with the mean disease index of the third generation (12.41) approaching that of the very resistant cabbage, cv. Bohmerwaldkohl (9.38) and being much lower than the mean of the kale control cultivars: Bittern, Canson, Condor, Kestrel and Merlin (47.48). During 1985 84 half-sib families from this newer population were assessed for height, dry-matter yield and DOM, SMCO and SCN^- contents. Heritabilities and genetical correlations between characters are being determined in order to construct a selection index and predict the response to simultaneous selection.

(J. E. Bradshaw)

¹Chemistry Department

Turnip cultivars for the Scottish Uplands [PU 4(d)]

In a procedure aimed at improving yield of the traditional Scottish-type turnip, high yielding lines with white or yellow flesh were selected from the third generation of a polycross. These will be used to produce a fourth generation before the final selections are made. A number of crosses to introduce superior clubroot resistance into cultivars from the experimental Dutch stubble turnip population ECD04 has been made on past occasions. The most advanced breeding material which originates from ECD04 \times cv. Hvit Mainep, is true breeding for resistance but gave a low yield in trials.

(D. J. Gemmell)

Rape cultivar breeding [PU 4(e)]

Rape breeding procedures have been reconsidered with the object of reducing the scale of some of the work while maintaining or increasing efficiency. At present there are technical or operational reasons for deferring the application of some progeny selection procedures until advanced generations of the breeding programme. Of these, the routine screening of advanced breeding lines against clubroot and powdery mildew has resulted in the identification of resistant materials at F_5 which can now be assessed as potential cultivars. The selection from advanced generations of single plants true-breeding for clubroot resistance has produced large numbers of lines which are being evaluated for their other characteristics.

Further restraints on selection occur when analyses are time consuming, and so can be made on only small numbers of plants. For example, only a limited number of breeding lines can be chemically analysed for their SMCO and progoitrin contents. Significant variation in the levels of both compounds was nevertheless demonstrated in some lines, and selection for higher and lower contents has been started.

Very wet conditions in 1985, together with dull weather and low temperatures in May and June, had a pronounced effect on plant growth and yields of replicated trials. A much higher level of premature flowering occurred than in the seven previous years. There was a large increase in the mean dry matter yield over all trials from 4.73 t/ha in 1984 to 6.40 t/ha in 1985. By contrast, in areas such as the south-west of Scotland which normally have adequate rainfall, the additional rain depressed dry matter yields by up to 27% for the same two years.

High-yielding lines in F_3 and F_4 generations exceeded the dry matter yield of the best control, cv. Emerald, by over 12%.

One selection, RS5, was entered to UK National List trials. It was bred from a cross between synthesised *B. napus* and the cultivars Nevin and Samo. Compared to cv. Emerald it has higher fresh weight yields, lower levels of SMCO and progoitrin and similar mildew resistance.

The forage rape cv. Arran is now available commercially in New Zealand. It has high yields of both fresh and dry matter, high digestibility and protein content protected by good resistance to clubroot (New Zealand populations), powdery mildew, *Alternaria* and aphid attack.

Plant spacing experiments with rape [PU 4(e)]

The effect of plant spacing on the performance of cv. Lair and the breeding line, SC57, was studied for a final year, using inter-plant spacings of 5.1, 6.4, 10.2 and 12.7 cm achieved by hand thinning. All other values were as in previous years. The mean dry matter yield was 6.10 t/ha compared with 5.42, 4.11 and 4.25 t/ha in 1984, 1983 and 1982 respectively. The two genotypes showed considerable differences in response to spacing. For Lair the maximum fresh weight yield was found at 5.1 cm, dry matter content at 12.7 cm and dry matter yield at 6.4 cm, while the respective spacings for SC57 were 12.7, 6.4 and 12.7 cm. Plant height was greatest at 6.4 cm for Lair and 12.7 cm for SC57.

No consistent pattern emerged for the characters measured over the five years of this trial. The results indicate that ideal inter-plant spacings will differ between genotypes and between environments (sites and years), making it difficult to decide on an optimum spacing for selection work.

Effects of sowing date on some leafy brassicas [PU 4(e)]

A trial to study the effect of sowing date (17 May, 8 July, 5 August) on the yield and other performance characters of rape, radish and radicle (*Raphanobrassica*) was repeated for a second year. Yield results were invalidated by unexplained seedling damage and death over a large part of the trial. The effects on flowering were similar to those reported in 1984 (*Ann. Rep. 1984*, 57) though flowering was also quite extensive in the first sowing of rape. Samples of all plots were taken for chemical analyses.

(W. H. Macfarlane Smith)

Stock multiplication [PU 4(f)]

Seed multiplications were done wholly in polythene tunnels and an unheated compartmented glasshouse. Cold and wet conditions during most of the growing and seeding period promoted excessive vegetative growth and high levels of fungal infections. These conditions also reduced the activity of blow-flies introduced into tunnels as pollinators. As a consequence, seed yields and quality were very variable.

(I. K. Munro)

Trials of advanced selections [PU 4(f)]

Assessment of breeders' advanced selections of kale, rape and swede was made at a number of sites. In all, 19 trials were sown at Mylnefield and seven other sites in Scotland and the north of England. A higher failure rate than usual was experienced with two trials written-off owing to damage by, respectively, flea-beetle and drifting herbicide, and a third trial abandoned owing to disease problems induced by prolonged heavy rain.

Although rape yields at two sites were affected by late re-sowing or by a high incidence of clubroot, the best yields recorded were higher than in 1984. The results of all harvested rape trials are summarised in Table 1. The selection B17 gave the highest fresh weight yields at all sites but ranked only second for dry matter yield owing to its low dry matter content.

Kale yields were generally lower in 1985 than in 1984 when the same seven selections and five control cultivars had been grown at the same four sites. Yields were obviously depressed by the heavy rainfall, but less so than were those of rape. In both years the lines ranked in the same order for dry matter yield (Table 2). The selection PX80/106 was superior to all other lines and cultivars in dry matter and fresh weight yields.

Swede yields were higher than in 1984 except at Yonderton Farm (Ayrshire). Rotten bulbs were frequent at all sites but mildew did not occur until November and then only at Mylnefield and Trillington Hall (Northumberland). None of the selections was outstanding (Table 3) and their relative yield ranking differed between sites.

(A. J. Redfern)

Table 1. Rape: means from six sites

<i>Some control cultivars</i>	<i>Fresh yield (t/ha)</i>	<i>Dry matter %</i>	<i>Dry matter yield (t/ha)</i>
Hobson	40.83	12.96	5.29
Emerald	43.25	12.94	5.59
Sapphire	28.77	13.17	3.63
Nevin	35.73	13.65	3.45
<i>Means of eight control cultivars</i>	37.58	13.04	4.66
<i>Breeding selections</i>			
SC57/E/18	43.61	11.38	4.87
A5	32.50	11.45	4.51
B2	45.00	11.11	5.00
B17	48.80	11.55	5.53
<i>Selection mean</i>	42.48	11.37	5.00
<i>Grand mean</i>	39.21	12.48	4.77

Table 2. Kale: means from four sites in two years

<i>Control cultivars</i>	<i>Fresh yield (t/ha)</i>	<i>1985 Dry matter %</i>	<i>Dry matter yield (t/ha)</i>	<i>1984 Dry matter yield (t/ha)</i>
Bittern	47.16	14.74	6.88	9.58
Canson	53.22	13.58	7.15	8.32
Condor	66.43	13.07	8.67	9.96
Kestrel	61.86	12.97	7.97	9.15
Merlin	56.13	12.86	7.16	8.84
<i>Control mean</i>	56.96	13.44	7.57	9.17
<i>Best breeding selections</i>				
PX80/69	60.32	13.83	8.28	9.36
PX80/106	69.47	13.13	9.09	10.15
PX80/108	63.19	13.68	8.58	9.87
PX80/114	57.68	14.32	8.19	9.49
<i>Mean of seven selections</i>	63.26	13.48	8.44	9.66
<i>Grand mean</i>	60.63	13.46	8.08	9.46

Table 3. Swede: means from five sites

<i>Control cultivars</i>	<i>Fresh yield (t/ha)</i>	<i>Dry matter %</i>	<i>Dry matter yield (t/ha)</i>	<i>Mildew (Score 1-good 5-bad)</i>
Ruta Øtofte	86.07	10.51	10.25	3.04
Marian	84.20	9.79	9.30	2.48
Bangholm Magres	80.22	10.88	9.90	2.22
Melfort	74.92	11.97	10.27	3.34
Doon Major	91.71	8.96	9.19	4.42
<i>Control mean</i>	83.42	10.42	9.78	3.10
<i>Best breeding selections</i>				
DBOxbx*	88.30	10.36	10.33	2.24
BRicf	87.23	10.54	10.38	2.07
BRibd	84.72	10.65	10.25	2.31
BDgdb	77.51	11.93	10.23	2.52
CHJafda	71.65	11.21	9.07	1.64
WMXdbb	99.65	9.59	10.86	2.39
ARSfca	80.84	11.43	10.51	2.98
ARSfcd	80.50	11.13	10.06	2.96
<i>Means of fifteen selections</i>	82.61	10.55	9.80	2.59
<i>Grand mean</i>	82.81	10.51	9.80	2.71

*performed well in 1984.

Comparative growth of synthetic and traditional rape [PU 4(g)]

The synthesis of *Brassica napus* from *B. oleracea* and *B. campestris* gives rise to a wide range of morphologies depending on the parents used. Some of these are quite different from traditional forage rape. Measurements were made over a 14 week period of fresh weight, dry matter content, dry weight, plant height and leaf area of cv. Hobson, the semi-synthetic selection RS5, and a synthetic line 84411, which is a (kale × kohlrabi) × oriental turnip hybrid. Analysis of the results is in progress and it appears that the yields of Hobson and RS5 are similar while 84411 yields less but has the ability to continue producing fresh green material over a longer period.

(W. H. Macfarlane Smith)

Pollen selection [PU 4(h)]

Gametophytic selection to eliminate unwanted pollen genotypes prior to fertilisation offers considerable benefits to the plant breeder and experiments to develop a suitable procedure for pre-pollination *in vitro* pollen selection have continued.

In one series of experiments pollen was incubated in germination medium for up to 2 hours, centrifuged, rinsed in fresh germination medium, re-centrifuged and tested for viability and germination. During the first hour of incubation pollen imbibed but there was no evidence of germination. Tube growth began during the second hour but even after 2 hours tube lengths seldom exceeded 30 μm . Pollen viability (% grains stained with fluorescein diacetate) showed no significant decrease for the first hour (91-96%) but dropped to 82% after 2 hours. Germination percentage, after 4 hours further incubation in hanging drops at 20°C, dropped from 89% for untreated controls to 73% for pollen centrifuged after 10 minutes' incubation. However, no further reduction was observed after 2 hours' incubation prior to the centrifugation and rinsing treatments. Pollen, incubated in germination medium for 1 h and centrifuged as described above was also used in pollinations to determine the likely maximum seed set. As reported previously (*Ann. Rep. 1984*, 62), incubated pollen failed to germinate or penetrate the intact stigma surface but pollen tubes grew successfully if the stigma was removed prior to pollination. In an experiment, using compatible pollen on four unrelated kale plants, tube numbers from pollinations on cut styles (15 per style) were close to those obtained using fresh untreated pollen (18 per style). However, seed set from pollinations of mature flowers from the same plants using incubated pollen ranged from 0.5 to 2.8 seeds/flower (mean 1.8), which was less than that obtained from unincubated pollen (mean 2.8 seeds/flower). No seed was obtained when buds were pollinated, whether or not the stigma was first removed. The reasons for the reduction in seed set using incubated pollen and the failure of bud pollination are not clear and will be further investigated.

Successful pollen selection requires that the character of interest, or a closely linked character, is expressed in pollen as well as in the sporophyte. It has recently been reported that *Alternaria brassicicola* culture filtrates contain compounds toxic to brassica secondary embryoids. These compounds are present in the methanol soluble fraction obtained from the culture filtrate and can be partially purified by chromatography with LH20 Sephadex. Germination of *Brassica napus*, *B. oleracea* and *B. campestris* pollen was reduced to 20% by the addition of 10µg/ml of the methanol soluble fraction of the culture filtrate and by the same fractions from Sephadex chromatography that killed *B. napus* secondary embryoids.

The toxic components present in the methanol soluble extract were investigated using the thin layer chromatographic (TLC) bioassay developed at SCRI. Following development with acetonitrile, TLC plates were sprayed with *B. napus* pollen in germination medium and incubated overnight. Zones of inhibition of germination were detected at Rf 0.03, Rf 0.33 and Rf 0.53.

It seems likely that the response of pollen to toxins from *A. brassicicola* is similar to that of sporophytic brassica tissue and that the potential for pollen selection for toxin resistance can be assessed.

(J. R. T. Hodgkin)

Pollen irradiation [PU 4(h)]

Progenies obtained from pollinations using pollen X-irradiated at 0, 150, 200, 250 and 500 Gy have been assessed to determine whether there is any evidence for restricted transmission of paternal characters. For the characters tested (*Hr Go Fn Acp-3 S*) there was no evidence of any deviation from the expected transmission except for *Acp-3* where one plant from the 0 Gy treatment lacked the paternal *Acp-3* isozyme although possessing other paternal characters. Some plants from each irradiated pollen treatment were male sterile, most (six) from the 250 Gy. Other abnormalities recorded included thickened and distorted leaves, blind apices and chlorosis. Where possible progeny plants were selfed, and selected F₂ progenies will be grown to confirm the apparently normal transmission of male characters.

(J. R. T. Hodgkin)

Gene expression in synthetic *Brassica napus* [PU 4(i)]

Synthetic *B. napus* plants produced by crossing *B. campestris* and *B. oleracea* are valuable, not only for their immediate use in breeding but also for the study of parental gene action in the new hybrid combinations. Five synthetic hybrid dihaploid plants were raised by ovule culture from a cross in which the parents differed in their character expressions for eight corresponding genes. In common with the *B. oleracea* parent the

progeny plants lacked leaf hairs and were white flowered, although the *B. campestris* parent had hairs on leaf margins and was yellow flowered. However, the progeny did not express the anthocyanin pigmentation which was present on the flower stem and axillary buds of the *B. oleracea* parent. Leaf acid phosphatase isozymes from both parents were expressed in the hybrid but only parts of the esterase isozyme patterns were found. Plants of both parent species had active incompatibility (S) genes but, whereas that from *B. campestris* appeared to be functioning normally in the hybrid, the growth of compatible *B. oleracea* pollen on hybrid stigmas was too poor to determine whether the *B. oleracea* S-gene was active. Thus, for all the genes examined, there was a complex interaction between the two genomes.

Some fertile shoots and self-set seeds have been obtained following induced doubling of chromosome numbers in the hybrids. Triploid plants have also been obtained from backcrosses of *B. campestris* to the hybrids but the reciprocal backcross was unsuccessful.

(J. R. T. Hodgkin)

Heterosis in swede [PU 4(i)]

Heterosis for dry-matter yield in swede is being investigated in order to develop more effective breeding methods for increasing dry-matter yield. The investigation will include the determination of the magnitude of heterosis in replicated yield trials of F₁ hybrids at a number of sites in different seasons. To facilitate the production of this seed in quantity by insect pollination the development of high-yielding inbred lines with strong S-alleles was continued. Genetical analyses of heterosis are being concentrated on two of the most heterotic crosses identified from earlier work.

(J. E. Bradshaw)

Anther culture and micropropagation of marrow-stem kale [PU 4(h)]

In an experiment to obtain haploid tissues for mutagenesis, anthers of nine marrow-stem kale cultivars were cultured. Only two cultivars (Condor and Maris Kestrel) gave pollen-derived embryoids, indicating differential genotypic responses. Plants arising from the embryoids were grown in culture, micropropagated, and 350 rooted plantlets were obtained by shoot regeneration from hypocotyl sections and callus which was produced after several months of micropropagation. As there were obvious differences in ploidy, leaf morphology and colour within the micropropagated clones the initial objective was not pursued. Instead leaf samples were taken for chemical analysis and it is intended to double the chromosome number of the haploid plants so that they may be self-pollinated and their progenies compared.

The production of fertile homozygous plants from anther culture is also an objective for furthering swede and rape breeding. A preliminary experiment to determine suitable conditions gave the greatest embryoid production from anthers of swede plated on to a modified Nitsch and Nitsch medium containing potato extract.

(J. E. Middlefell Williams)

Raspberry callus culture [PU 3(a)]

An experiment to produce callus from red raspberry examined the effect of two sources of explants (petiole and lamina) from five cultivars using three contrasting media. Explant origin did not affect callus induction which was satisfactory for cv. Leo and SCRI seedling 14/106 but only partially successful for cultivars Joy, Glen Moy and the SCRI seedling 3C1. Half of the explants produced callus on two of the media, including one without 2,4-D which promotes callus formation. Very little callus arose on the third medium.

(J. E. Middlefell Williams)

POTATO BREEDING

G. R. MACKAY

SCRI potato breeding operations, especially the harvests, in 1985 were adversely affected by the weather. The lifting of the seed crop at Blythbank took more than five weeks to complete and both the quantities and quality of seed tubers were lower than in previous years. It was not possible to follow usual practice and supply NSDO with 500 kg of all clones completing first year National List Trials, which will interfere with production of stocks for promotion purposes in 1986.

In spite of the difficulties experienced all demands for the now routine overseas trials were met and seed despatched to the various sites in Spain and the Mediterranean basin. Inclement conditions in the Mediterranean in the Spring led to late plantings and delayed harvests in Cyprus and North Africa. A number of clones continued to perform well and were selected for retrieval as potential export cultivars.

The computerisation of our data capture, storage and analyses has proved particularly useful; without these improvements it would have been impossible to meet many of the deadlines such as the dates for National List submissions. Negotiations with An Foras Taluntais, Oak Park, Carlow were completed and the supply of the Data Base Management System (CHIP) to it began. There have been enquiries from other potential customers.

Developments in screening tests for disease and pest resistance continued. The seedling screen for foliage blight resistance was applied successfully to sub-samples of all seedling progenies of the commercial breeding programme for the second year in succession. Preliminary indications from experimental progeny tests for gangrene and tuber blight are promising, so too are investigations into blackleg and *Spongospora* testing.

Increasing co-ordination with other programmes of the work on novel germ-plasm, neo-tuberosum and the diploids continued. A sample of selected tetraploid clones deriving from the diploid and dihaploid breeding programmes was included for the first time in the third clonal year trials of the main programme.

There was an expansion of activity in more novel areas, including the use of tissue culture techniques. Financial constraints and finite resources inevitably mean that such important work can only be supported at the expense of current activities, and priorities are being considered.

Recently released cultivars and clones in national list trials (NLT) [PU 1(a)]

The early maincrop cv. Kirsty (National Listed 1982) was commercially launched by NSDO in 1985 and is being marketed by Tayside Potato Producers Ltd. in association with NSDO. Negotiations between NSDO and the trade are continuing with respect to the launching of cultivars Ailsa and Moira (National Listed 1984). The maincrop cv. Rhona (see p.71) was entered on the National List with a provision that it lacks quality when grown in the UK and it is not suitable for ware production here, but it continues to attract attention overseas. Of the three SCRI clones on which decisions for National Listing were made in 1985 only one, Morag (11305 a 2), (see p.70) was placed on the List.

The early maincrop clones 11328 ab 18 (Shula), 11396 ab 12 (Teena), 11566 ac 7 (Cassie) and 11704 ae 26 (Shelagh) and the first-early clone 11291 3 (Morna), completed NLT in 1985; decisions as to whether they will be entered on the National List are awaited. The early maincrop clones 12276 af 9 and 12290 af 20, and second early clones 12288 af 12, 12721 ae 18 completed first year NLT and are continuing into second and final statutory trials in 1986. The first-early clone 11242 a 1 was withdrawn from first year NLT.

Regional trials of advanced selections [PU 1(a)]

All selections reaching the sixth clonal generation and beyond were grown as usual in trials at a number of sites in order to expose them to a wide range of agricultural conditions and practices, thereby providing data for selection of clones for submission to NLT. Trials were carried out in association with ADAS under maincrop growing conditions at: Arthur Rickwood EHF, Gleadthorpe EHF, Stockbridge House EHS, Terrington EHF and The Murrays farm. The clones were also grown by R. Thompson¹ at Invergowrie with two spacings within drills. This material was also, for the first time, chitted under ambient conditions in Wales, and planted and harvested as first-earlies by the University College of Wales at Trefloyne. In addition, any clones which had shown particular promise as first-earlies were grown in more sophisticated trials by UCW, with two different physiological ages induced, at Trefloyne and Penrice in South Wales and at Cairnside in Wigtownshire and The Murrays farm by SCRI.

On the basis of its performance in these and previous years' trials, and on the results of routine disease and pest resistance tests and assessment of quality characteristics, an early maincrop clone coded 13353 ab 2 was submitted. This high yielding clone produces a bold sample of white skinned, yellow fleshed tubers. It possesses a good spectrum of resistance to fungal pathogens and appears exceptionally

¹Physiology and Crop Production Department

resistant to the common viruses, leafroll and potato virus Y. In addition to its satisfactory performance in the UK, it has done well in trials in the Mediterranean and so may have export potential. Trials and tests by the Potato Processors' association support those of SCRI breeders which suggest that it also has potential as a chipping (french fry) cultivar.

Cooking quality and crisp assessments [PU 1(a)]

Routine cooking quality assessments were again carried out on all material in the third (M1) and later clonal generations. When completed in Spring 1986 some 6000 samples will have been steamed and assessed, principally for after cooking blackening, sloughing and crisp colour. Clones in the fourth clonal year (M2) were also stored at 5°C and tested for crisp colour. Clones which in the previous two years had shown the potential of producing pale crisp colours after such storage were also retested. The most advanced of these, having reached their sixth clonal generation, were included in the regional trials and are potential NLT candidates.

Overseas trials of advanced clones [PU 1(b)]

Following current policy, all clones that had reached the sixth clonal generation in 1984 were trialled in the Mediterranean basin; in Northern Spain (Rioja), in Southern Spain (Valencia), in two trials at Gilat Regional Experiment Station (part of the Volcani Center) in Israel and in Cyprus. The trials included clones which had previously shown promise at these sites (*Ann. Rep. 1984*, 68).

Clones were also trialled in Algeria by arrangement with the Institute de Développement des Cultures Maraichères, Staoueli, and via NSDO and their licencees in Tunisia and in Egypt.

In the 3 years of trials conducted since the SCRI was commissioned to breed for overseas in 1982 a number of clones have been identified as having export potential. A few have been named for example, cultivars Baillie, Ailsa, Rhona and Kirsty and several are currently in UK National List Trials. Several named and coded clones have been included in semi-official and official trials (equivalent in the UK to pre-NLT and NLT) by our collaborators. For example, in Cyprus where cv. Ailsa and five unnamed clones were selected for second stage, official trials in 1985 and 1986; in Algeria where cv. Rhona and clone 12492 ad 6 continued to perform well in official trials and have been requested for 1986; in Spain where of more than 40 entries in the official 'pre-register' trials at Seville and Valencia conducted by Matutano S.A., SCRI clones and cultivars featured prominently.

Cultivar Cassie (11566 ac 7) was one of several clones identified as of continuing interest to our Egyptian collaborators and was included in samples of National List clones supplied by NSDO to them and others

for extension trials overseas. Five clones, including 13353 ab 2 (NLT 1986) and 12492 ad 6 have been reselected for repeat assessment by Dr Susnoschi and another, 12721 ae 14, has been provided in somewhat larger quantity for extension service trials, in Israel. The studies with Dr Nachmias on *Verticillium* and *Alternaria* continue to provide useful evidence of resistance and tolerance amongst SCRI clones to these important diseases. The Tunisian authorities have discontinued trialling 'lignes' (unnamed clones) and will only accept National List clones or cultivars. They are interested in Ailsa and Baillie, which are still undergoing official assessment.

Investigations in the application of novel techniques [PU 1(c)]

There was a re-appraisal of the collaborative work in tissue culture. The production of true-breeding material via anther culture of dihaploids continued but progress was somewhat disappointing. Clones responsive to haploid production from anther culture have been obtained via quarantine and will form part of the basis of further work.

The maintenance in the field of unique clonal material is costly and exposes valuable germplasm to infection by viruses. *In vitro* conservation has been investigated using liquid or agar based media with the addition of growth retardants (such as alar and 4% manitol) and storage at 13°C. It has become clear, however, that different genotypes lasted for different lengths of time before sub-culturing was necessary on the different media. An investigation into such effects was therefore initiated along with a study of *in vitro* tuberisation.

Early generation selection [PU 1(c)]

The results of experiments over the last 4 years into early generation selection have led to a review of the commercial breeding scheme. The inefficiency of selection of individual clones at the seedling stage or in the first clonal year has been confirmed. This practice has therefore been stopped and instead the superior progenies are identified. This was shown to be feasible as the repeatability of the rankings of the samples of the progenies when assessed visually for commercial worth was found to be high even when assessment was of seedlings in the glasshouse. It was shown that for each progeny the mean and variance provided a good prediction of rankings but that the mean alone was satisfactory. Having identified the better progenies, large numbers of clones from them can be grown for assessment.

The computer housed information package (CHIP) [PU 1(c)]

Considerable interest has been expressed in this package by outside bodies and it has been decided to make it available to interested parties. A charge will be made to cover the costs of transferring the source code but the onus for mounting it will be on the prospective user. A User's Manual is also available for the cost of printing, packaging and postage.

Potato cyst nematode (PCN) resistance and tolerance [PU 1(a) and (e)]

PCN is a major pest of potato production and can cause considerable yield losses. Breeding for resistance to *Globodera pallida* and *G. rostochiensis* involves two equally important characteristics, namely resistance *per se* and tolerance of root invasion and damage which can cause substantial yield losses. Field PCN tolerance trials were continued with ADAS and PBI as the final year of a 3 year joint project. The yields of material grown in PCN infested plots were again compared with those in nematicide treated plots at three different sites under ADAS supervision. Yield losses varied from nothing for the most tolerant to 66% for the most intolerant material. It was again evident that no correlation existed between resistance and tolerance, stressing the importance of such trials. Data were also collected on PCN population levels before and after the crop. These data, along with the previous two years' data, are being collated and analysed.

Tobacco rattle virus (TRV) resistance [PU 1(e)]

TRV causing spraing can result in substantial losses by rendering ware potatoes unsaleable. However, until recently, assessment of susceptibility/resistance has relied entirely upon field trials in infested soil—the results of which are extremely variable from year to year depending on a number of environmental factors. A glasshouse test for TRV resistance/susceptibility recently developed at SCRI should allow more repeatable tests to be made on larger numbers of clones. The test was applied to 10 clones with known levels of resistance/susceptibility and 25 clones with unknown reactions. The tubers were assessed on a 1 (susceptible) to 9 (resistant) scale for TRV symptoms. Inspection of the produce of the trial and the data clearly indicated that some apparently resistant (symptom free) tubers were escapes but nevertheless there was good agreement between pot test results and NIAB ratings of the cultivars.

(G. R. Mackay, P. D. S. Caligari, M. F. B. Dale, J. Brown,
C. J. W. Torrance, G. E. L. Swan, J. S. Spence)

Resistance screening [PU 1(e)]

Virus diseases

Potato clones were screened as usual for resistance to potato virus X (PVX) and potato virus Y (PVY) by glasshouse methods, and by field trials for resistance to PVY, potato leafroll virus (PLRV) and the two soil-borne viruses, tobacco rattle virus (TRV) and potato mop-top virus (PMTV).

From a breeding programme to produce parent clones multiplex at their PVY resistance loci, some putatively multiplex clones were identified in progeny tests in which true seedlings were spray-inoculated with PVY. These triplex or quadruplex clones (with three or four resistant alleles at the locus) will yield 100% resistant progenies (i.e. no susceptible segregants) when crossed to a susceptible genotype.

In graft inoculation tests, the new cv. Teena showed major-gene resistance to the common (X₃) and B strains of PVX, the A, C and common (Y^o) strains of PVY and also a veinal necrotic (VN) strain of PVY. Cv. Shelagh also showed resistance to X₃, B, A, Y^o and the VN strain used, cv. Morna to X₃ and B, cv. Shula to X₃ and A, and cv. Cassie to X₃ and B.

In the PLRV field trial, Teena, Cassie and Morna showed resistance equal to that of cv. Pentland Crown, and several clones showed better resistance with no plants infected.

Teena and cv. Croft showed some resistance to PMTV spraing although a few tubers were affected. Shelagh and Morna showed resistance to TRV spraing, with very few tubers affected in a trial with a high level of infection.

The relationship between two genes for resistance to PVX was examined in a segregating progeny. The gene Xⁱ confers resistance to both of the strains X₃ and B, whilst the gene N_b confers resistance to B only. Each clone in the progeny was screened for resistance to each strain separately by sap-inoculation. The segregation ratio suggests that these two genes are at separate, unlinked loci.

(R. M. Solomon)

Fungal diseases

Emphasis continues to be placed on developing tests for detecting the resistance of progenies, as well as improving those for clones. Additional confirmation of the validity of the progeny test for assessing resistance to gangrene (*Phoma exigua* var. *foveata*) has come from a comparison of resistance scores obtained in winter 1985 on 12 progenies tested simultaneously as bulk plots and as individual plots of up to 18 clones per progeny. The rank order of resistance was similar, whether the resistance of the progeny was assessed on individual clones, on a bulk sample from the progeny plot or on a sample containing one tuber from each clone in the progeny plot. The progeny test was used to screen 25 other progenies in 1984-85; 16 were of moderate resistance, four were susceptible and five highly resistant.

Resistance tests have been carried out as usual to late blight, common scab (at three sites), skinspot, gangrene and dry rot. For the first time, resistance to both *Fusarium solani* var. *coeruleum* and *F. sulphureum* has been tested; several clones exhibit large differences in resistance to these two pathogens. Collaborative work with other centres (DANI, DAFS, ASS, NIAB, PBI) concerned with developing a common test for resistance to gangrene has led to joint tests on common stocks of 10 cultivars, using the same isolates of the pathogen. The work is also examining the effect of damage on infection.

With the collaboration of NSCA a site in Banff naturally infested with *Spongospora subterranea* was located for a field trial for resistance to powdery scab. Thirty-nine advanced clones and eight disease standards

were included. Three of the clones were as resistant as the resistant control cultivars King Edward and Ulster Lancer, and seven as susceptible as the susceptible control cultivars Estima and Pentland Crown. The test was severe because of the wet season, and at least half the tubers in the most susceptible clones were infected. The same eight controls were also planted in single tuber plots in four outdoor brick-sided beds at Pentlandfield. The beds were excavated to a depth of about 30 cm, lined with polyethylene film to retain water, and filled with field soil which was artificially infested with the fungus. The rank order of susceptibility of the eight standard cultivars in the two tests was similar, suggesting that on-site screening of clones, or even progenies, should be feasible.

A start has been made on laboratory screening to infection by early blight, *Alternaria solani*, with the assistance of M. W. Tarbuck¹. Spores of three isolates of the pathogen have been produced in culture and successfully inoculated on to detached leaflets.

A severe epidemic of late blight was again established in the field trial at Yonderton Farm, Ayrshire. It was expanded to include sixth year as well as later selections, and only fifth year and dihaploid clones were tested in the glasshouse. The new cv. Teena, with a field score of 6 on the 1-9 scale, was as resistant as the resistant cultivars Record and Cara. Plots of 32 maincrop clones and 10 cultivars adjacent to the field trial were protected with metalaxyl+mancozeb to investigate the effect of foliage infection on yield. Severe infection did not always greatly depress the yield.

Seedlings of 209 progenies from various crossing programmes were assessed for foliage resistance in a seed pan test, and 567 clones were tested for resistance to tuber blight in laboratory tests. Good agreement was observed between the resistance to tuber blight expressed by 10 seedling families in a glasshouse pot test in 1984, and the data from tubers of individual clones of the same progenies grown in the field in 1985 and inoculated after harvest in the laboratory test. This points to the feasibility of carrying out progeny tests for both foliage and tuber blight at the seedling stage.

Investigations towards improving laboratory screening methods to foliage blight have continued. Plants of 18 early and 18 maincrop clones were grown and tested in a glasshouse, in a field trial, and under controlled temperature and daylength in an illuminated cabinet. The laboratory and cabinet tests were done in June and August. The test in June agreed better with field results, but results from the two methods were equally correlated with field results.

The effect of the age of the plant on the expression of major gene resistance in detached leaflets of members of the blight differential series was examined. Challenge with a compatible race always gave a positive reaction (sporulating lesions), but with some differentials an incompatible race gave false positive reactions in young plants and in those which had finished flowering.

¹Sandwich Student

Erwinia

The wet 1985 growing season helped to establish a high level of black-leg in the trials at Pentlandfield. One of the trials was part of a collaborative programme of resistance testing in conjunction with NIAB, DANI, PBI and RES, in which different inoculation methods are being compared on 10 cultivars differing in resistance, and the vigour of growth, appearance of blackleg and the yield are assessed. The trial was duplicated with Scottish seed as well as that supplied from Cumbria by NIAB. Under the conditions of the test one method of inoculation was too severe and another relatively ineffective; the preferred method (vacuum-infiltration of de-sprouted seed tubers with a suspension of *Erwinia carotovora* ssp. *atroseptica*) gave a high correlation between the vigour of growth and the yield. The correlations between vigour and blackleg symptoms, and between blackleg and yield, were considerably lower. A trial of 50 clones was also carried out at Pentlandfield; very few suffered any appreciable yield depression in comparison with uninoculated plots, and of those that did, not all showed symptoms in the foliage. The susceptible control cultivars were however severely affected.

(R. L. Wastie, H. E. Stewart)

Potato breeding material developed from primitive cultivars [PU 6(d)]

Neo-Tuberosum: *Tetraploid breeding material developed from primitive Andigena cultivars.*

Use of Neo-tuberosum parents in the commercial crossing programme recommenced in 1983 (*Ann. Rep. 1983*, 69); 12 further parents were used in 1985, 10 in virus resistance breeding and two for crisping quality. A few hybrid clones from progenies raised for studies of yield and related factors (*Ann. Rep. 1984*, 71) have been subjected to commercial selection: of 35 assessed alongside material at the third clonal year of commercial evaluation (the 'M1' stage) in 1983 five remained under evaluation at the M3 stage in 1985, and a further 18 were entered to the M1 in 1985.

Neo-Tuberosum clones are also being compared with material under commercial selection to evaluate their agronomic properties. Of 179 compared at the M1 stage in 1982, 12 were sufficiently promising to be retained for further assessment as potential cultivars at the M2 stage in 1985. A further 68 were compared at the M1 stage in 1985.

Breeding is in progress within the Neo-Tuberosum population to combine and enhance disease resistances and other properties to provide parents for use in commercial breeding. Seed from crosses involving parents resistant to potato virus Y (PVY) was obtained. As selection against PVY susceptibility by visual means is not yet possible in these seedlings the progenies have been sown for selection on other criteria before investigation of PVY resistance. Small samples from progenies of

blight resistant parents were assessed for such resistance as seedlings; most progenies appeared promising and some very good. A few highly resistant individual seedlings were saved from these tests. The more promising of the progenies assessed from PCN (*G. pallida*) resistance (*Ann. Rep. 1984, 75*) were re-assessed on an individual-clone basis.

(D. R. Glendinning)

Diploid potatoes

The F₁ hybrid progenies of Tuberosum cultivars and selected Phureja/Stenotomum parents frequently show enhanced vigour of growth and high yielding ability. A pilot experiment was planted at the Blythbank farm to investigate this phenomenon. Two different elite PHU/STN parents had been used to pollinate the cultivars Pentland Crown and Cara, giving rise to four progenies which were carried through, without selection, to their second tuber-grown generation in the field in 1985. Each progeny was represented by 25 clones, grown as three tuber plots. The Cara control plot failed to produce a satisfactory yield, so results are only presented for Pentland Crown and its progenies AP184 and AP187.

Table 1

<i>Material</i>	<i>Yield/ plant (kg)</i>	<i>Mean tuber no.</i>	<i>Mean tuber wt (g)</i>
Pentland Crown	2.20	29.2	76.0
AP194	2.68	39.2	74.0
AP187	3.05	37.1	83.0

It can be concluded that the higher mean yield of progeny AP184 is a result of a higher number of tubers of the same size as those of the higher parent (Pentland Crown), and that AP187 is due to a higher number of somewhat larger tubers.

The superior resistance of certain Phureja/Stenotomum clones to potato virus Y, and to leafroll virus, under field conditions at the Cambridge testing site, suggests that useful resistance levels might be obtained by using these clones as parents in the 4x×2x crossing scheme. A high yielding diploid clone, DB152 (31), which had shown high resistance to PVY and PLRV in the field in 1982 and 1984 was crossed with the cultivars Pentland Squire and Désirée. In a previous crossing cycle the PVY-resistant diploid, DB171 (11), had yielded interploidy hybrids in crosses with virus-resistant breeders' lines. Because DB171 (11) has shown evidence that its resistance may be polygenic, test-crosses were carried out with the cultivars Arran Peak and Dr MacIntosh to provide progenies for evaluation in 1986.

(C. P. Carroll)

Potato dihaploids

Dihaploids have been identified which efficiently transfer resistance to important potato pathogens into tetraploid offspring. Work on the use of dihaploids in breeding for increased foliage blight resistance (*Phytophthora infestans*) has been described in previous Annual Reports. In 1985 the testing of tetraploid progenies, obtained by crossing three dihaploids resistant to potato cyst nematode (*G. pallida*) with cultivars, showed that there were differences in the inheritance of resistance from dihaploid parents. Whereas the dihaploid phenotypes had similar, high levels of resistance, one produced a significantly higher proportion of highly resistant offspring than did the other two. This was probably due to their different modes of unreduced gamete formation with the best parent producing 2x gametes by first meiotic division restitution (FDR) and the others by second division restitution (SDR). FDR gametes preserve a larger proportion of the parent's genotype intact than SDR gametes so that dihaploids producing gametes by FDR are valuable for introducing desirable traits into tetraploid potatoes. They are particularly useful for introducing quantitative characters because disruption of the polygene assemblages determining them is minimised.

The response of several dihaploids to changes in the level of fertiliser in the growing medium was observed using pot-grown plants in a glasshouse. Whereas most dihaploids tended to increase foliage growth at the expense of an increase in tuber yield when additional fertiliser was applied one genotype, PDH135, responded in a similar way to the cultivar controls by producing increased tuber yield at the expense of foliage growth. This indicated that, although the dihaploid's yield was substantially below that of cultivars, the partitioning of photosynthate was similar. Such a trait could be useful in breeding for increased tuber yield. An experiment of the North Carolina type 1 was designed to examine the inheritance of yield from this dihaploid and two others. Samples of their tetraploid progenies were planted in three-tuber field plots at The Murrays and Blythbank farms and harvested in the autumn of 1984. PDH135 had a significantly higher general combining ability for yield than the other two with the yields of some individual genotypes similar to those of control cultivars.

(M. J. De, Maine)

NEW POTATO CULTIVARS

MORAG

National List and Plant Variety Rights – 1985

<i>Maturity class</i>	Early maincrop, slightly earlier than cv. Pentland Crown, similar to cv. Majestic.	
<i>Foliage</i>	'Stemmy' erect, medium height, fairly open, branching; leaves open, mid to dark green, 'feathery'; flowers pale red-violet, white tipped petals, small, usually few in number. Berries small and rare.	
<i>Tubers</i>	Round to oval, eyes medium/shallow; skin white flesh pale cream/white.	
<i>Cooking quality</i>	Good. Medium to high dry matter, higher than Pentland Crown; flesh moderately firm, cream/lemon, mild flavour when steamed.	
<i>Processing</i>	Tends to produce darker coloured crisps than cv. Record, similar to Pentland Crown and therefore not considered suitable for crisping.	
<i>Yield</i>	Similar yield potential to Pentland Crown, but tends to produce rather more numerous tubers in the medium ware range.	
<i>Disease resistance*</i> :	Wart	Field immune to the common European race 1
	Late blight – foliage	4
	– tuber	4
	Gangrene	4
	Skin spot	3
	Common scab	7
	Bacterial soft rot	5
	Potato cyst nematode	Quantitatively (= partially) resistant to both <i>Globodera rostochiensis</i> and <i>G. pallida</i>
	Virus X	Susceptible
	B	9
	Y	3
	A	Susceptible
	C	Susceptible
	Leafroll	4

*Numerical values on 1-9 scale, 9 = maximum resistance or hypersensitivity

Summary

A high yielding clone of acceptable table quality, but on the basis of test data with little potential for processing (crisping). Morag's principal value for cultivation and use is its dual resistance to both species of potato cyst nematode. This resistance derives from the wild species *Solanum vernei* and is expressed quantitatively against both species of PCN; unlike that derived from *andigena* in cv. P. Javelin which confers absolute resistance to one pathotype of *G. rostochiensis* but is ineffective against others and *G. pallida*. In SCRI laboratory tests Morag produces substantially fewer cysts than susceptible controls and in field trials has proved as effective in reducing PCN populations as nematicide on some occasions; but in this respect Morag's performance will vary with circumstances (level of infestation, virulence of particular PCN population etc.). In these same trials Morag has also demonstrated above average tolerance to invasion by PCN, suffering less yield loss than contemporaries and existing cultivars in the absence of nematicide.

RHONA

National List* and Plant Variety Rights – 1985

<i>Maturity class</i>	Early maincrop, similar to cv. Pentland Ivory.
<i>Foliage</i>	Medium to tall, erect and open; leaves large – fairly open, grey-green rugose leaflets; flowers – white, small and rare. Berries not observed.
<i>Tubers</i>	Round to oval, skin white, flesh pale cream, eyes shallow to medium depth.
<i>Cooking quality</i>	Moderately firm to mealy, pale cream flesh when steamed with tendency to after cooking blackening under some conditions. Dry matter similar to cv. Pentland Crown.
<i>Processing</i>	Medium dry matter and a darker crisp colour than cv. Record would suggest Rhona is of limited value for processing.
<i>Yield</i>	High yield potential, equal or superior to Pentland Crown, with a tendency to bulk more rapidly than that cultivar; tends to produce moderate numbers of tubers of good size, similar in this respect to Pentland Crown. Has yielded particularly well in SCRI and collaborators' trials in Spain and North Africa.

*See Summary

<i>Disease resistance*</i> : Wart	Field immune to the common European race 1
Bacterial soft rot and Blackleg	8
Late blight – foliage	4
– tuber	6
Gangrene	6
Skin spot	2
Common scab	7
Potato cyst nematode	Susceptible
Virus X	9
B	9
Y	2
A	9
C	Susceptible
Leafroll	4

Summary

In view of Rhona's tendency to after cooking blackening under some conditions, the authorities have National Listed this cultivar with the proviso that it is not suitable for ware production in the UK; however, Rhona's excellent performance in Mediterranean sites such as the early regions of Spain and Algeria support the view that it is of value for cultivation and use for export purposes to such areas, where it has not exhibited this fault. The cultivar's extremely high resistance to soft rot and blackleg is probably a contributory factor to its performance in Mediterranean trials, where planting of cut seed pieces and flood irrigation are commonly practised. However, under extreme conditions, in the Negev desert, Rhona did exhibit symptoms of the physiological disorder 'chocolate spot'—it would therefore seem to be similar in this respect to the cv. Arran Banner and not suitable for sites where this disorder is likely to prove a problem.

In addition to the disease resistances described here, Rhona also appears field immune to PVY (ac) (now PVV) in National List Tests, and was rated 5 (= moderately resistant) to dry rot.

*Numerical values on 1-9 scale, 9 = maximum resistance or hypersensitivity

In vitro genetics of barley [PU 2(d)]

Exploitation of *in vitro* genetic manipulation in crop plants depends on the development of cell and tissue culture systems. Many recent studies have been concentrated on the use of either immature or mature embryos. These explants have therefore been used to quantify the relative importance of genotype, medium and genotype by medium interaction on callus formation and regeneration. For both mature and immature embryos there were significant differences between genotypes, between concentrations of 2,4-dichlorophenoxyacetic acid and also significant genotype by medium interaction. The presence of significant genotype by medium interactions has complicated the interpretation and analysis of tissue culture experiments. However, the interactions have been successfully quantified by using either a joint regression analysis or using a genotype's phenotypic variance over treatments. Such two dimensional assessments of a genotype's performance *in vitro* provide a convenient way of ranking its response to culture. Studies of *in vitro* development in barley, and probably other species, should consider both the mean performance of each genotype and also its response or sensitivity to media constituents.

Reciprocal differences have been reported in numerous tissue culture experiments. Preliminary experiments on callus formation and regeneration from immature embryos have identified large reciprocal differences. Experiments are in progress to establish the underlying mechanism(s) responsible for such differences.

Regeneration from microspores is the only method currently available for the regeneration of green plants from single cells in barley. Considerable effort has therefore been applied to the assessment of anther culture techniques in barley breeding programmes. Barley anther culture involves the induction of microspore derived callus, followed by the regeneration of plants. The segregation ratios in microspore derived lines from an F₁ hybrid heterozygous for a number of major gene loci were examined. There were significant departures from the expected 1:1 ratio for three of the five genes studied. Furthermore, there was evidence of genetic variation between plants derived from the same callus i.e. somaclonal variation. More importantly for barley breeding the mean of the anther culture samples were significantly lower than the mean of the *Hordeum bulbosum* derived haploids for quantitatively varying characters. The problems associated with a prolonged callus phase could be avoided by developing methods allowing the formation of diploid embryoids direct from haploid pollen.

(W. Powell)

Cytogenetical analysis of spring barley lines derived from anther culture [PU 2(d)]

A cytological investigation was instigated into anther culture derivatives from the spring barley cross cv. Golden Promise \times cv. Mazurka. Preliminary chromosome counts of the regenerants from 14 individual calluses allowed the classification of families according to their ploidy level. With the exception of one tetraploid family all the other progenies were diploid. Some aneuploid plants ($2n = 26$ or 27) were also observed in the tetraploid family. As most regenerants were diploid it was essential to establish whether the regenerating structures were from gametophytic tissues. Genetic markers were used for this purpose and all regenerants examined were homozygous for the gene loci studied, and are therefore of gametophytic origin.

Meiosis was examined in progenies derived from 10 of the 14 calluses. Pairing in the tetraploid line was largely a mixture of bivalent and quadrivalent configurations. Translocation heterozygosity was found amongst families from one callus. Progeny from the remaining eight calluses formed seven bivalents. The mean chiasma frequency (13.90) in the *H. bulbosum* derived lines was similar to that of the F_1 hybrid (13.92). Therefore, there is no reason to suspect that there has been any reduction of chiasma frequency induced by the *H. bulbosum* technique. There was, however, evidence in the anther culture families of a reduced mean chiasma frequency.

The cytological study coupled with genetical investigations indicates that caution should be exercised when using anther culture derivatives for genetical analyses. However, disruption of the barley genome during callus culture may facilitate introgression of genetic material following wide crosses.

(W. Powell, E. Borrino)

Cytogenic effects arising from the use of irradiated pollen and ovules [PU 2(d)]

Cytogenetical analysis was continued of progeny from the cross cv. Golden Promise \times S138 in which pollen from S138 was irradiated. M_1 and M_2 generations examined at mitosis and meiosis indicated that the number of translocations was positively correlated with radiation dose. Aneuploidy did not occur; nor were there differences in chiasma frequency and position between the F_1 control and M_1 progeny.

About 40% of the plants with translocations at M_1 were sterile or of low fertility and did not provide sufficient seed to be included in M_2 field trials. Progenies of field-grown M_2 were examined meiotically to provide segregation ratios for translocation heterozygosity and provided no evidence for selection against the translocation heterozygotes. At the

M₂ it was impossible to distinguish cyto-genetically between translocation homozygotes and normal homozygotes.

A sample of M₂ progeny from irradiated ovules had no chromosomal aberrations, despite the high level (70-80 grays) of X-rays used.

(W. Powell, E. Borrino)

In vitro tuberisation of potato [PU 1(c)]

In a factorial experiment to evaluate the feasibility of producing mini-tubers *in vitro*, eight clones were subjected to two concentrations of sucrose (3 and 6%) and three concentrations of benzylamino purine (0, 2 and 4 mg⁻¹). Growth rooms were used to provide contrasting daylength regimes (8, 16 and 24 h). There were significant differences between all the main treatments and the material incubated in short days produced most tubers. The cv. Record consistently produced the highest number of mini-tubers, although limited numbers of tubers were obtained from all the cultivars tested.

Most of the variation in days to tuberisation was due to differences between clones and clones × daylength interaction. Differences between daylength, although statistically significant, accounted for a small proportion of the variation. In general, in the 8 h daylength regime increase in levels of sucrose and benzylamino purine produced more tubers.

(W. Powell)

In vitro storage of potato germplasm [PU 1(c)]

A factorial experiment involving a sub-set of potato clones was initiated to investigate the factors affecting longevity of potato germplasm storage. This allowed comparisons between: type of culture vessel, addition of growth retardants such as abscisic acid and/or the use of compounds with osmotic effects such as mannitol. Kimble tubes which allowed gaseous exchange proved superior to sealed culture vessels. Abscisic acid and 3% sucrose were the most successful combination for the storage of potato clones for 6-9 months. However, significant clone by treatment interaction was detected. High sucrose concentrations induced tuber formation *in vitro* and mini-tubers may be suitable propagules for the storage of potato clones.

(W. Powell)

Monoploid potato plants [PU 1(c)]

A number of plants were sampled from each of two putatively monoploid genotypes supplied by the Max Planck Institute, Cologne. Ploidy levels varied amongst plants from monoploid to tetraploid with the diploid category most frequent.

(E. Borrino)

Cytological screening [PU 1(d)]

Routine cytological screening of material from the diploid potato breeding programme continued. Agronomically improved diploids were assessed for pollen fertility and diploandroid frequency. Ploidy levels from numerous tetraploid \times diploid crosses were determined and the pollen fertility of tetraploid hybrids estimated. Ploidy levels were also ascertained for progenies of interspecific crosses.

(E. Borrino)

Pollen irradiation of potatoes [PU 1(c)]

Mitotic counts on the M_1 and M_2 progenies from pollen irradiation experiments revealed considerable chromosomal instability in the unirradiated progeny (F_1 and F_2) of the cross cv. Pentland Ivory \times cv. Cara. Aneuploidy was present at a low level in the F_1 . However, in the F_2 generation approximately half of the plants exhibited aneuploidy, with chromosome numbers from 47 to 50. The relatively small sample of M_2 progeny examined displayed a similar range of aneuploidy.

The extent and nature of the chromosomal instability in cultivated potato is of central importance to the exploitation of somaclonal variation in potato improvement. The present studies demonstrate the need to establish the cytological status of genotypes prior to their use in studies on the production of somaclonal variation.

(W. Powell, E. Borrino)

SOFT FRUIT BREEDING

D. L. JENNINGS

The cold and wet weather of the 1985 season prevented a full assessment of selections for fruit quality and gave inadequate vegetative growth in some black currant material. However, good performance in difficult conditions gives confidence, and high hopes are held for some of our leading raspberry selections.

Collaboration with EMRS in raspberry breeding was active with the exchange of parent material showing resistance to diseases or pests for further assessment in a different environment, and the inter-crossing of material selected in the two programmes, notably material chosen for high yield potential or good fruit colour. A consignment of a further 58 black currant selections resistant to gall mite completed the transfer of EMRS germplasm to the SCRI. Collaboration and exchange of germplasm with Australia and New Zealand was also promoted by my visit to Australia and by a three-month visit by the New Zealand *Rubus* breeder, Mr Harvey Hall.

The strawberry breeding programme is no longer active but it is gratifying that four selections from the former programme were recommended for commercial assessment following their good performance in trials.

Provide improved cultivars of raspberry and study relevant characters

[PU 13(a)]

The new stage 1 trials planted at Brogdale and SCRI in 1984 established well and grew vigorously in 1985, but they did not produce sufficient fruit for assessment. Four less advanced selections (7815A12, 7815B8, 795B10, 8044C9), cropped well at SCRI and were rated highly for fruit quality and plant habit. It was decided to enter them into a new NFT in 1986.

Resistance to fungal pathogens

A further survey of resistance to *Leptosphaeria coniothyrium* was made in hybrids derived from *Rubus pileatus*. The results were similar to those found previously (*Ann. Rep.* 1983, 85) and showed wide segregation for resistance in the backcross generations. In these generations the mean resistance of the segregates carrying the dominant gene *H*, which confers cane hairiness, was 15% higher than that of the *h* segregates. Some of the apparently resistance segregates were propagated for further assessment.

The year was notable for the high incidence of grey mould (*Botrytis cinerea*) in most fruit samples. Twenty-six advanced selections were assessed for resistance to the disease by studying grey mould development in a conducive environment on samples of their fruit obtained from the field. The mean incidence of mould 4 days after picking was 63%, but the selections 789E5, 789C7 and 7133R40 and cv. Glen Prosen had only 48, 42, 37 and 37% respectively. This was the third year that the resistance shown by 789E5 and 789C7 has been high. The resistance of Glen Prosen and 7133R40 is thought to be associated with fruit firmness, but the reason for the good results for the other selections is not known.

(D. L. Jennings, R. J. McNicol, E. Brydon)

In a series of three experiments the amount of post-harvest grey mould which developed on fruit samples during incubation at a high humidity was substantially increased either by inoculating the fruit with conidia of *B. cinerea* or by subjecting them to small pricks with a needle. Differences between genotypes were large in spite of these treatments. This indicates that the resistance of the fruit's epidermis to minor wounds probably contributed to the delay in development of grey mould, and suggests ways in which the efficiency of screening for resistance might be improved.

(H. Hall¹, R. J. McNicol)

Resistance to viruses

The study of the inheritance of immunity from raspberry vein chlorosis virus (*Ann. Rep. 1984*, 86) was completed by a study of segregation for immunity in a selfed progeny of the black raspberry cv. Cumberland, and in a cross between Cumberland and cv. Delight, an infectible red raspberry. Immune and graft-infectible segregates occurred in both families. For red raspberries, it was concluded that immunity is a highly heritable character but that it is not determined by a single major gene. The range in the severity of symptoms expressed in the infectible segregates of immune parents suggested either that sensitivity to infection is under separate genetic control, or that immunity and sensitivity are opposite expressions of a character which varies continuously rather than discontinuously. The data for black raspberry were insufficient to decide whether the genetic mechanism was the same.

Cv. Haida is the only red raspberry cultivar discovered which is apparently immune from a resistance-breaking isolate (RB) of raspberry bushy dwarf virus (RBDV). To study the inheritance of this immunity, and the possible role of gene *Bu* which confers immunity from the type isolate (RBDV-S), segregates from a selfed progeny of Haida were multiplied vegetatively and one plant of each segregate was graft-inoculated with RBDV-S and another with RBDV-RB. Preliminary results suggest that

¹ DSIR, New Zealand

immunity from RBDV-RB is conferred by gene *Bu* acting with other unidentified genes.

(D. L. Jennings, A. T. Jones¹, M. J. Mitchell¹)

Bud suppression

The problem of bud suppression (BS), in which buds at sub-terminal levels of the cane fail to produce fruiting laterals, was studied by one of us (DLJ) during study leave in Victoria, Australia. The incidence of BS in some cultivars, e.g. Glen Clova, is considerably less than in others, e.g. Meeker. A difference in the dormancy cycle of the cultivars is a likely explanation, and exposure to wind is known to aggravate the problem. The dormancy cycle of these two cultivars at SCRI was therefore compared throughout the 1984-85 winter by cutting canes from the field on six dates and forcing them into growth in the glasshouse. For canes cut on 29 November it was found that the proportion of buds that commenced growth was similar for the two cultivars, but whereas the proportion for Glen Clova improved progressively in the samples cut later, the proportion for Meeker was lower for samples cut on 17 December and 14 January and then improved gradually for samples cut on 11 February, 25 February and 11 March. This suggested that Glen Clova has a lower chilling requirement than Meeker, but that the latter responded differently to exposure to winter weather.

(D. L. Jennings, E. Brydon, R. J. McNicol)

Provide improved cultivars of black currant and study relevant characters

[PU 13(b)]

The adverse weather affected the EMRS gall mite resistant hybrids planted in winter 1983/84 (*Ann. Rep. 1984*, 87) and spring 1985 so badly that they had to be cut to ground level, thereby delaying fruiting for one year. One of these progenies (*(R. nigrum* × *R. grossularia)* × *R. glutinosum*) was notable for its combination of good plant quality attributes, including erect habit, branch strength and leaf spot resistance.

A gall mite infestation plot was established to screen 15 EMRS progenies for resistance to gall mite and reversion virus.

Regional trials and commercial assessments

A Brogdale-EHS trial which contained the three most advanced late flowering, frost-hardy SCRI hybrids (*Ann. Rep. 1984*, 87) was terminated after the sixth crop was harvested in 1984. The total yields (1979-84) of seven SCRI hybrids was significantly higher than cv. Baldwin, but only one (SCRI P8/12/7) gave a significantly higher yield than cv. Ben Lomond. The total yields of five others, including SCRI P9/8/7 and P8/5/24, did not differ significantly from that of Ben Lomond.

¹Virology Department

In another trial, planted in 1980/81, a frost-hardy, early flowering hybrid, SCRI F6/3/39 [Ben Lomond \times (*R. nigrum* \times *R. dikuscha*)] cropped heavily and ripened 5 days earlier than Ben Lomond. The NFT Panel recommended that a virus-tested stock of it should be prepared for propagation. Two cv. Ben Sarek \times Ben Lomond hybrids – P10/18/116 and P10/18/121 – planted in 1983, tolerated a radiation frost at about full flower stage to crop at 12.1 and 13.7 t/ha respectively.

At Luddington EHS, two -3.0°C air frosts during the blossoming season severely affected the yields of Baldwin, SCRI 243/7 and two of its hybrids. Again, as at Brogdale, SCRI F6/3/39, P10/18/116 and P10/18/121 – all in their second year of cropping – were clearly more hardy and productive.

In a machine-harvesting trial in Norfolk, SCRI F6/3/39 cropped very heavily (30 t/ha) in 1984, its first year of cropping, but only a third of this was harvested by a straddle harvester, the remainder being lost about equally between fruit dropped on the ground and fruit retained on the bush. Ben Lomond and cv. Ben Nevis gave only a third to a half of the yield of SCRI F6/3/39, but higher proportions of their yields (75-85%) were harvested.

The total yield of F6/3/39 machine harvested in 1985 was less than half (11.8 t/ha) that of 1984, but only 20% of it dropped to the ground. SCRI P8/12/7 and P9/8/7 dropped 15-21% of 10-12 t/ha crops. In Baldwin 47% of a 2.8 t/ha crop was not harvested, most of it being retained on the bushes.

In an unusually wet season, trial results and commercial assessments of productive SCRI hybrids emphasised the need for improvements in plant quality, especially branch strength, for machine harvesting in the first and second years of cropping.

(M. M. Anderson, C. J. Lynch¹)

Season of flowering

Late flowering genotypes avoid spring frosts. Median dates of first open flowers (FOF) of SCRI P8/12/7 and SCRI P9/8/7 over a period of 6 years at Brogdale were on average 3 weeks later than the median date of Baldwin, 16 days later than that of Ben Lomond and 8 days later than that of cv. Ben More.

Compared with the flowering time of Baldwin, the very late flowering of P9/8/7 reduces the probability of frost injury at grape stage by around 60%, at FOF by about 80% and at full flower (FF) by nearly 90%. Nevertheless, on average, flowers of SCRI P9/8/7 would be exposed to at least one occurrence of freezing temperature after grape stage in 4 years out of 10 at Brogdale. This probability would be halved if the cultivar flowered 1 week later.

¹Beecham Foods, Brentford

Factors affecting season of flowering and yield

Season of bud break is genetically determined by a cultivar's winter chilling requirement, and flowering dates are modified by the temperatures encountered after the chilling requirement has been satisfied. A study of the relationships over 9 years between yield and temperature during the flowering and pre-flowering periods of the frost-susceptible Baldwin and the frost-hardy Ben Lomond at Brogdale EHS showed that 1. yields of Baldwin but not Ben Lomond were positively correlated with dates of three stages of flower development, with temperature minima from grape to FOF and daily maximum and minimum temperatures during the blossoming period; 2. yields and dates of flowering of both Baldwin and Ben Lomond were negatively correlated with daily maximum and minimum temperatures in February and February-March; 3. flowering dates of Baldwin but not Ben Lomond were positively correlated with daily temperature minimum from grape to FOF and temperature maximum and minimum for FOF to FF. Furthermore, in 7 frost-free years between 1960-84, Baldwin yields were positively correlated with daily temperature maximum and temperature minimum in January and negatively correlated with daily temperature minimum in February; they were also positively correlated with degree days above 10° and 14°C, from FOF to FF. Yields (1979-94) of SCRI P8/12/7 and P9/8/7 were positively correlated with temperature maximum in January and temperature minimum in January.

These results show that Baldwin was much more sensitive to temperature variation than Ben Lomond. The correlations between Baldwin yields and dates of the flowering stages were associated with the effects of low February-March (but not February alone) temperatures. These delayed flowering and gave the flower buds and flowers both a lower probability of being killed by frosts and the benefit of higher temperatures during pollination and fertilisation, thereby improving fruit set and yield. Baldwin but not Ben Lomond showed significant positive correlations between yield and the mean air minimum temperatures between grape and FOF and between FOF and EF.

The positive correlations between yield and maximum and minimum temperatures in January suggest that warm winter temperatures favour the development of flower buds initiated the previous autumn.

(M. M. Anderson, J. Taylor)

Juicy quality

Over a period of 5 years (1980-84) principal components analyses of six simple aspects of juice quality—total pigment concentration (E515 at pH 1.0), % soluble solids (%SS), titratable acidity (TA), juice pH ascorbic acid content and juice yield per 100 g fruit, the latter two adjusted to standard specific gravity (AAsg and Jysg)—have consistently shown the same broad pattern, with minor differences associated with differences in type of season. The first component, which on average accounted for

30% of the variation, has been concerned with the effects of dilution, where a high Jysg and high %SS is associated with low AAsg and low E515 values (except in 1983). The second component, which on average accounted for 22% of the variation, has described an association where high E515 and AAsg values predominate and are related to low or average Jysg and pH values. The third component has been concerned with acidity.

Mean annual E515 values were positively correlated ($r=0.85$) and mean AAsg values negatively correlated ($r=-0.93$) with degree days above 6°C in July.

Juice colour

In 1985, the pigment concentration (E515 at pH 1.0) of duplicated juice samples of 25 cultivars of diverse origin from the NFT, Brogdale, Kent was compared using Kent-grown Baldwin as a standard (100). Values ranged from 70 for the mean of two cultivars in the cv. Boskoop Giant group to 100 for two cultivars in the cv. French Black group. Mean relative values of the two Swedish cultivars Triton and Titania, the Canadian cv. Consort and two East Malling selections were 104, 108, 122, 178 and 195 respectively. Thus the total pigment concentration of modern hybrids was nearly twice that of the standard UK cultivar Baldwin.

Juice flavour

In general, in anthocyanin-pigmented fruits there is a correlation between juice colour and flavour, probably because the same precursors are required to synthesize anthocyanins and components of flavour. Unfortunately, in some highly pigmented black currant juices the flavour ratings fall well below that of Baldwin, which is the standard for juice processing in the UK. This is why we attach such importance to SCRI 243/7 (*Ann. Rep. 1982, 93*) as a donor of an outstanding combination of juice quality components: high pigment concentration, high ascorbic acid content and good flavour. However, this selection is spring frost susceptible, lacks winter hardiness and is ill-adapted to UK commercial growing because of its weak branches. These undesirable characteristics have been inherited by some of its hybrids.

Acylated anthocyanins

Fruit samples of 20 European and five Nordic cultivars from the NFT, Brogdale were evaluated for their acylated anthocyanin content, using Ben Lomond as a standard (100) for comparison. All the European and three of the Nordic cultivars contained quantities of acylated anthocyanins rated from 0 to 20. The Swedish cultivar Janslunda was rated 84, suggesting that Ben Lomond probably inherited most if not all of its acylated anthocyanins from this source. Unfortunately, a fruit sample of

cv. Magnus, one of the other grandparents of Ben Lomond, was not available for analysis. The Finnish cv. Gerby was rated 56.

In addition, 130 SCRI selections were evaluated. SCRI 238/36/12 (cv. Goliath × Öjebyn) op, a sister seedling of Ben More, was rated 75, slightly lower than Ben Lomond, and SCRI P9/11/16 (238/36/12 × Ben Lomond) was rated highest of all the samples with 140.

Gamma-linolenic acid in black currant seeds

Gamma-linolenic acid is now recognised as an important constituent of the human diet. The total lipid content of black currant seeds by weight is 30.5% in European cultivars. The two best-known dietary sources of gamma-linolenic acid are the seeds of *Oenothera* spp. and *Ribes* spp., notably black currant seed oil, which contains concentrations of gamma-linolenic acid of up to 19% of the total lipid content. Hence, industrial residues from juice or jam production, hitherto considered to be waste by-products, are a possible rich commercial source of the oil. A recent patent protects *Ribes* seeds as purveyors of the physiologically active n-6 essential fatty acid fractions.

Seed samples of cultivars and SCRI hybrids were submitted to Nestle Products Technical Assistance Co. Ltd., Switzerland for analyses and comparison with standard European cultivars.

(M. M. Anderson, J. Taylor)

Cold tolerance

Investigations were continued to explain the high incidence of flower drop in some black currant cultivars under cold conditions. Histological observations of the effect of low temperatures (above freezing) on pollen tube growth and the longevity of the stigma and style of several genotypes showed that pollen tubes grew at temperatures as low as 5°C, but though their growth was slower at low temperatures the longevity of the style was prolonged. At 5°C and 12°C respectively fertilization of the ovules occurred 8 and 6 days after pollination and the stigmas and styles remained receptive to pollen growth for 17 and 9 days after pollination.

Pollen tubes grew normally in the styles after pollinated flowers had been subjected to cold temperature shocks of 0°C for 1.5 hr or 5°C for 19 hrs. Thus, in the cultivars examined, the results so far have eliminated the effect of cold on pollen-tube growth as a cause of flower drop, but they have not identified the cause.

(R. J. McNicol)

Provide improved cultivars of blackberries and other *Rubus* fruit

[PU 13(c)]

The cool weather of 1985 caused most blackberries to ripen too late in Scotland, but calculation of the heat units (accumulated degrees above 6°C) received between flowering and ripening showed that some

segregates from a family related to cv. Ashton Cross required only 470 to 500 units and would therefore be early enough for Scotland in a more typical season. Our most advanced thornless selection, 78102E10, ripened before Ashton Cross. This selection produces good yields of large fruit and is considered to be of cultivar potential.

An attempt was made to transfer gene *Sf*, for spinelessness, from tetraploid blackberries to tetraploid raspberries and other tetraploid blackberries using pollen irradiation to limit the transfer of germplasm from the blackberry donor parent. A high proportion of pyrenes containing seeds (i.e. sank in water) was obtained when the pollen received a radiation dose of 1000 Gy prior to crossing. This seed will be germinated in 1986.

Purple raspberries (F₁ hybrids of diploid red and black raspberries) have fruit which may have a commercial potential for some market outlets, especially where flavour and intense fruit colour are important. Improved forms have been bred with spinelessness by first transferring this characteristic from red raspberry to black raspberry parents by back-crossing. One selection, which combines spinelessness and good fruit size, has been propagated for commercial assessment and has been given favourable reports. Similar hybrids and a plant of black raspberry at the tetraploid level fruited for the first time in 1985, and were notable for the regularity of their drupelet set and apparently good fertility. Their fruit size was appreciably larger than that of corresponding diploids, and it may therefore be more useful to breed at the tetraploid level with this material.

(D. L. Jennings, R. J. McNicol, E. Brydon)

Identify strawberry genotypes adapted to the Scottish environment

[PU 13(d)]

Four advanced SCRI strawberry selections continued to crop well and both the NFT Scottish Soft Fruit Panel and the NFT Strawberry Panel recommended that they should be propagated for commercial trials on growers' farms. DK60 will be tested for early production in areas of Hampshire and S.W. England, EW30 for fresh market sales because of its excellent fruit quality and very high yields, and GU76 and WC64 for commercial processing. Barrenness problems in ET115A cause it to crop unreliably and it has been withdrawn from trial.

Cv. Tantalion, released in 1977, is slowly gaining acceptance, particularly where its yield and moderately high field resistance to red core are important. In 1984 the Leatherhead Food Research Association ranked samples of this SCRI-bred strawberry third and first for strawberry jam made from frozen and sulphited fruit respectively. Of the other cultivars released at that time, Troubadour, a late cultivar, is also proving commercially valuable for processing, dessert and 'pick-your-own.'

(R. J. McNicol)

MYCOLOGY AND BACTERIOLOGY DEPARTMENT

R. A. FOX

The increasing incidence of severe die-back involving root and crown death in raspberry, reported both within the UK and mainland Europe, has undoubtedly been affected by recent unusually wet summers. The distribution of patches of dead canes within sites also supports the hypothesis of an association with high soil moisture. More disturbing than the number of reports is preliminary, but as yet indirect, evidence that the pathogens concerned may be distributed with planting stock in a manner analagous to the way in which crown gall and leafy gall of raspberry, and red core root disease of strawberry, were once distributed.

Reports from many sources worldwide indicate poor reproducibility of tests of potato R-genes and compatible virulence factors in races of *Phytophthora infestans*. Results indicated last year and now reported suggest that the supposedly simple 'either/or' reaction of compatible/non-compatible may be substantially influenced by the environment and by the physiological state of either host or pathogen. The importance of resolving inconsistencies and ensuring reproducibility of results is essential to ensure that breeders achieve their objectives of excluding R-genes from their lines and new cultivars. Our findings, and those elsewhere, make it clear that the A2 mating type of *P. infestans* is now widely distributed in Europe and north Africa.

Continuing work on host/pathogen relationships in red core root disease of strawberry, as part of an investigation into the genetics of pathogenicity in *Phytophthora* spp., have also thrown doubts on hitherto accepted concepts of host and pathogen race relationships.

Snow rot of winter barley [PU 8(a)]

Snow rot has become a potential limiting factor to the continued increase in the area of the Scottish barley crop sown with winter cultivars. A collaborative programme with ESCA to determine optimum fungicide treatments to control snow rot was continued at sites near Blairgowrie and Kinross where winter barley had been severely affected in the previous season. Plots were sown in early or in late September at both sites. Symptoms of snow rot and the proportion of plants infected by *Typhula incarnata* by March were greater in the early compared with the late sowings. Applications of triadimenol sprays generally reduced the proportion of plants killed and increased grain yields compared with the

untreated controls. Benodanil applied at 1 kg/ha product also provided good control but was not as effective at the 0.5 kg/ha rate. Both chemicals controlled the disease better when sprayed in December than in November. Treating seeds with a dust of triadimenol and fuberidazole did not give adequate control although results improved when it was followed by benodanil sprays.

Seeds of cv. Igrí were sown in a trial at Invergowrie and the soil inoculated at the same time with either *Fusarium nivale* or *T. incarnata* alone and both together. There were no effects on plant establishment or autumn growth but in spring both pathogens were associated with lower percentage survival and their effects were additive where both were present (the percentage survival following application of no inoculum, *F. nivale* alone, *T. incarnata* alone and both together were 88.0, 71.5, 72.8 and 58.3 respectively, S.E.D.=8.21). Application of triadimenol in December was associated with improved plant growth in the spring and greater numbers of ears/m² at harvest.

An inoculation method in a growth cabinet at 2-5°C was developed in which either dry sclerotia of *T. incarnata* or conidial suspensions of *F. nivale* were applied to pot-grown barley seedlings and the plants compressed to the soil surface with wet cotton wool. The efficiency of triadimenol to control symptoms caused by both fungi was confirmed; benodanil was effective against only *T. incarnata* and carbendazim controlled only *F. nivale*. Using combinations of the inocula and fungicides, *T. incarnata* was shown to be a more aggressive pathogen than *F. nivale* alone and there was a synergistic relationship between them, particularly in the presence of fungicides. Tolerance of *F. nivale* to triadimenol in agar was common in a collection of isolates from the field but resistance to carbendazim was less frequent. No resistance of *T. incarnata* to any fungicides were found.

(D. A. Perry)

Cause and control of cavity spot carrots [PU 14(f)]

Cavity spot remains the major disease problem for carrot growers despite recent progress in understanding its cause and the ability to control it. Isolations from cavity spot lesions in east Scotland and East Anglia continued and confirmed that *Pythium violae* was the main *Pythium* spp. associated with symptoms in both areas. Applications of metalaxyl+mancozeb (Fubol) and oxadixyl+mancozeb (Recoil) at 12.5 kg/ha product 6 weeks after sowing in east Scotland reduced the percentage of affected roots from 39 in the untreated plots to 8.5 and 10.0 respectively.

When 12 carrot cultivars grown in pots and sampled at three harvest dates were inoculated with discs of agar culture of *Pythium* spp., highly significant differences between the cultivars in susceptibility to infection and lesion enlargement were evident, with a trend for all cultivars to

become increasingly susceptible with time; Chantenay type cultivars were consistently more susceptible to attack and developed the largest lesions. Inoculation experiments showed that *P. violae* infected carrot roots within 3 h of inoculation at 20°C.

The spectrum of antifungal compounds occurring in lesions induced by *P. violae* was similar to those produced following lesions caused by physical and chemical stimuli indicating similarities in biochemical reactions during lesion development. The phytoalexin, 6-methoxymellein, was not released until c. 36 h after the periderm was damaged, suggesting that tissue collapse observed in the early stages of lesion development was not due to the phytotoxicity of the chemical although it may be responsible for darkening the lesion following tissue collapse.

(M. R. Groom¹ and D. A. Perry)

Epidemiology and aetiology of *Botrytis* on field bean [PU 4(c)]

Effects of leaf age on infection by B. fabae, increase in lesion size and sporulation

Chocolate spot disease often becomes worse as bean plants mature or at the onset of senescence.

When plants were grown out of doors and inoculated with conidia of *B. fabae* the oldest leaves, although they had not started to become yellow, developed more lesions than younger ones, and established chocolate spot lesions on young leaves increased in size at only half the rate of those on the oldest. A week after inoculation a higher proportion of lesions on old leaves bore conidia than on young leaves but leaf age had no effect on numbers of conidia per mm² lesion area.

(J. G. Harrison)

Wind dispersal of conidia

Wind-dispersed conidia of *B. fabae* and *B. cinerea* spread chocolate spot disease both within a crop and from one field to another.

Increasing numbers of conidia were blown from sporulating *B. fabae* and *B. cinerea* as windspeed increased up to 10 m sec⁻¹. Proportionally more conidia were blown at intermediate windspeeds from *B. fabae* than from *B. cinerea* and from partially dried than from fresh cultures of both species. At higher windspeeds there were no differences. Release of spores at a constant windspeed was sustained over a prolonged period. Patterns of release from the two species differed at a constant windspeed. An increase in the number of *B. cinerea* conidia released per unit time, always followed a mechanical shock to the mycelium but release of *B. fabae* spores was often unaffected. Most conidia of both species were released as clumps. A higher proportion of *B. cinerea* than *B. fabae* conidia were clumped, partly because the mean number of spores per clump was greater. Clumps fell faster through air than did individual conidia.

¹Research Assistant

The humidity of air in a bean crop was more favourable to development of *Botrytis* than that above a crop. Low windspeeds measured within crops may restrict dispersal of conidia resulting in the uneven distribution of chocolate spots observed in early July.

(J. G. Harrison, R. Lowe)

Bacteria within conidia of B. fabae

Some conidia on cultures of *B. fabae* grown on agar contained numerous motile bacteria. Their identity and potential role in disease control is being investigated.

(J. G. Harrison)

Control of midge blight in raspberry [PU 9(a)]

In 1984, the cultivars Glen Clova and Malling Jewel were sprayed five times at fortnightly intervals from mid July to September with the insecticide fenitrothion, the fungicide benomyl, or with both chemicals. Canes were cut in February 1985 and scraped to detect vascular stripe lesions (*Leptosphaeria coniothyrium*) and patch lesions (*Fusarium* spp.).

After the dry weather in 1984 the stripe lesions were less common than in a similar experiment in 1983. Fenitrothion alone or in combination with benomyl reduced the incidence of stripe lesions in Glen Clova from c. 14% in control plots to 6 and 3% respectively and similar reductions were found in Malling Jewel.

Fenitrothion either alone or in combination with benomyl, reduced the incidence of patch lesions from >70% in controls to c. 6%. Benomyl alone had no effect on the number of canes with patch lesions.

As in 1983 (*Ann. Rep. 1984*, 124), *L. coniothyrium* clearly is implicated in the midge blight complex and the results suggest that fungicides alone are likely to be ineffective despite the importance of fungi in the complex.

(B. Williamson, A. Dolan)

Effects of inoculation of raspberry flowers with *Botrytis cinerea* on grey mould [PU 9(a)]

The styles of raspberry flowers inoculated in 1984 with dry conidia of *B. cinerea* became infected symptomlessly. Fruits developing from them, either in the glasshouse or in the field, never rotted before maturity but after picking rotted twice as fast as those from non-inoculated flowers (*Ann. Rep. 1984*, 119). In 1985, eight genotypes were similarly inoculated in a glasshouse, infection of their styles followed histologically, and the ripe fruits subjected to rot tests. In seven genotypes, conidia again germinated in the stigmatic fluid, colonised the styles slowly and entered the carpels. In Carnival, a cultivar susceptible to grey mould, germination

of most conidia was inhibited and growth of the few hyphae that developed was severely restricted suggesting that there must be other, as yet undetected, pathways for drupelet infection.

Fruits from inoculated flowers again rotted twice as quickly as those from non-inoculated flowers. Cultivar ranking for rot resistance depended on whether or not they had been inoculated. In non-inoculated controls, selection SCRI 1B/11 was most resistant followed in order by Malling Jewel, Delight, Haida, Boyne, SCRI 61/11, Carnival and Glen Moy. When flowers were inoculated, 1B/11 was again the most resistant but Delight the most susceptible.

In the hot, dry summer of 1984, endophytic mycelium of *B. cinerea* was not seen within carpels of flowers inoculated in the field, although stylar infections were common and the fungus sporulated on the stigmas (*Ann. Rep. 1984*, 119). Accordingly, the effect of temperature on stylar infection in Malling Jewel was examined in 1985 in environment cabinets on inoculated and non-inoculated emasculated flowers (petals, sepals and stamens removed before pollen was shed). At 13°C the fungus grew quickly in the first 7 days, and 28 days after inoculation hyphae were detected within maturing carpels. At 22°C, hyphae never grew more than half-way down the styles and infection of carpels was not detected.

In the exceptionally wet summer of 1985, some of the immature fruits that developed from flowers of the cultivars Glen Clova, Glen Isla, Malling Jewel and Malling Orion inoculated in the field were destroyed by *B. cinerea*. Of 680 styles from 136 flowers examined, those from inoculated flowers were usually infected by *B. cinerea* and hyphae had usually grown into the carpels, but there were also hyphae of *Cladosporium* spp. in some styles. In contrast, the styles from non-inoculated flowers were also colonised by *Cladosporium* spp. whereas *B. cinerea* was relatively rare and neither fungus had grown more than half-way down the styles.

When stored at 20°C, the surviving ripe fruits from uninoculated flowers took 3 days to rot whereas those from inoculated flowers rotted within 1 day. Fruits of Malling Jewel from inoculated flowers were the most rot resistant whereas Glen Clova was the most resistant of the non-inoculated controls.

The role of floral parts and pollen as food bases for *B. cinerea* were examined by comparing the rot resistance of fruits derived from entire flowers with fruits stimulated to develop by a hormone solution from non-pollinated emasculated flowers (*Ann. Rep. 1984*, 120). In further studies, flowers of Malling Jewel, Haida, Carnival and SCRI 61/11 were left entire or emasculated and inoculated with dry conidia of *B. cinerea* c. 3 days after the petal opening stage, except in one treatment in which conidia were applied after the fruits had been picked. All ripe fruits were picked and incubated in high humidity at c. 20°C.

The presence of pollen did not affect the rate of rotting but fruits from inoculated entire flowers rotted most rapidly. Fruits inoculated after picking rotted faster than those from emasculated inoculated flowers. These results again suggested that direct penetration of the fruit epidermis is involved in the onset of grey mould, particularly since Carnival was again the most susceptible to rot and the most resistant to stylar infection.

(B. Williamson, R. J. McNicol¹, A. Dolan)

Root-rot and die-back of raspberry [PU 9(a)]

Isolates of *Phytophthora megasperma* var *megasperma* recovered from raspberry plants affected by severe die-back and root rotting, proved to be pathogenic to red raspberry in inoculation tests (*Ann. Rep. 1984*, 124).

Samples from affected sites in South Wales, Herefordshire, Gloucestershire, Essex, Scotland, Eire and West Germany have yielded many more isolates of *Phytophthora* spp, including *P. cactorum*, *P. syringae* and *P. megasperma* var *megasperma*. The last named was the most common species and it occurred in two distinct forms. One form was fast-growing; it produced abundant, thick-walled, large oospores (c. 45-50 μm diameter) on various media, it had antheridia that were mostly paragynous, its zoospores were large (15 \times 12 μm) and all isolates were non-pathogenic to raspberry. Isolates of the other form grew slowly; they produced only a few, small oospores (c. 35 μm in diameter), most antheridia were amphigynous but paragyny was wholly absent in three isolates from Germany that otherwise were similar to the British isolates; all zoospores were c. 12 \times 9 μm and all isolates were highly pathogenic to raspberry.

P. cactorum and an unidentified isolate that closely resembled *P. cambivora* caused slight root rotting on raspberry, but *P. syringae* and other unidentified isolates were non-pathogenic.

All red and black raspberry genotypes inoculated with the pathogenic form of *P. megasperma* var *megasperma* were susceptible, although some North American cultivars selected for resistance to root rot in the USA (e.g. Latham) were less susceptible than all British cultivars tested; the hybrid Tayberry and its blackberry parent, cv. Aurora, were immune.

Various features of inoculated plants were measured including plant height, fresh weight of stems and root systems, volume of root systems, numbers of leaves yellowed and wilted and the length of the lesion produced on the stems of inoculated plants; the last two offer most promise as measures for screening for resistance.

(J. M. Duncan, D. M. Kennedy)

¹Soft Fruit Breeding Department

Downy mildew (*Peronospora rubi*) of *Rubus cane fruits* [PU 9(d)]

P. rubi was found on wild blackberry leaves collected in Warwickshire and in Grampian Region. The leaves had small irregular dark-purple lesions bounded by the veins and the fungus sporulated sparsely on the underside of the lesion. S. M. Francis¹, reports that the fungus has been recorded in the UK only four times; twice on wild blackberry, once on cultivated blackberry and once on red raspberry.

Although rare in the UK, the disease is of significance for *Rubus* breeders and plant health authorities because in New Zealand it causes serious yield losses in Boysenberry (there named 'dryberry disease' and attributed to *P. sparsa*) and also affects Youngberry and blackberry cv. Aurora. The lesions found in the UK are similar to those found on blackberry in New Zealand. Tayberry and Tummelberry are derivatives of cv. Aurora but the resistance of these hybrid berries to downy mildew is unknown.

(H. K. Hall², B. Williamson, J. McMunro³)

Pathogenicity of Phytophthora fragariae [PU 14(e)]

When zoospores of *Phytophthora fragariae* from isolates 169 (race B66-3) and 171 (race B66-11A) were mixed in different proportions and inoculated onto strawberry clone SCRI 52AC18, the cultivars Climax, Saladin and Cambridge Favourite, only isolates that were highly pathogenic to each of the first three of these hosts were re-isolated from them (*Ann. Rep. 1984*, 130). Subsequently, one isolate obtained from inoculated Saladin was found to be non-pathogenic to it and other inoculation experiments have given anomalous results.

Cambridge Favourite is susceptible to cultures derived from both isolates 169 and 171 but in one experiment only the 169 type was commonly recovered from plants inoculated with mixtures of zoospores of both pathotypes. On two occasions both types were obtained when single zoospores isolates were made from a single isolate obtained from one infected root. In another experiment, using as inocula zoospore mixtures of two other isolates, again one each of race B66-3 and B66-11A, the predominant isolates recovered were, in contrast to previous results, similar to isolate 171 (race B66-11A). In both sets of experiments single isolates were obtained from which some single zoospore isolates proved to be race B66-3 and others B66-11A, demonstrating that both virulences appeared to be combined in this culture also. The presence of different virulences in one root may result from mixed hyphae or from heterokaryosis and has already been observed for isolates from Saladin and Cambridge Favourite in the field (*Ann. Rep. 1984*, 130). Indeed the

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virulence of one hyphal tip culture from an isolate from field grown Saladin which was previously unknown (B66-11D) produced high levels of disease on five cultivars not previously attacked severely by any isolate. Other hyphal tip cultures from the same isolate have given even more anomalous results, for example, one isolate which originally had the virulence pattern of B66-11D responded as B66-11B when retested as did five single zoospores taken from it and another, classed originally as B66-11B, gave a B66-3 reaction on retesting while a third B66-11B hyphal tip isolate yielded zoospores that gave B66-3 and B66-11B reactions. These and other results support the view that virulence is a less stable characteristic than previously thought. The occurrence of different strains with perhaps variable virulences in one plant or root could provide a basis for the emergence of new virulence combinations. Surprisingly, no such variation has been seen among single oospore isolates, all these being identical in virulence to their parents. When oospores were used as inoculum in virulence testing they usually gave similar results as zoospore inocula although higher numbers were usually required to obtain the same level of infection and not all replicates of each cultivar necessarily became infected, perhaps due to low levels of germination of oospores. Host genotypes that were only slightly infected at high zoospore concentrations of a given isolate were usually uninfected when oospore inoculum of the same isolate was used.

(D. M. Kennedy, J. M. Duncan)

Pathogenicity of *Phytophthora infestans* [PU 14(e)]

Virulence tests on isolates of the potato late blight fungus *P. infestans* sometimes do not give consistent results. Extensive tests have been done with a mass transfer isolate and first and second generation zoospore isolates derived from it to determine if the inconsistency is due to genetic variability of the pathogen or to some other cause.

Micropropagated plants of the R-gene differentials were grown in soil-less compost for 1-2 months in a growth chamber. Detached leaflets were inoculated with two droplets of zoospore suspension (0.015 ml/droplet), one on either side of the midrib, and then held in a controlled environment for a week before being assessed for infection. The mass transfer isolate was race 1, 3, 4, 7, 8, 10, 11 and it remained so in repeated tests. All first generation single-zoospore isolates derived from it, and second generation zoospore isolates derived from the first series, were of the same race.

The results varied at zoospore concentrations below 7,000/ml and some of the differential genotypes were not always infected at low inoculum levels (e.g. <100 zoospores/droplet). Necrotic flecks, characteristic of incompatible reactions, were more pronounced with higher zoospore numbers and at very high numbers they sometimes merged to

give a limited necrotic lesion on which the fungus sporulated lightly. The differential host containing R-8 gave variable reactions depending on the age of the plant; it gave negative results if the leaflets had been growing for less than 1 month in the growth cabinet whereas leaflets from older plants always gave positive results. These observations suggest that inoculum concentration and the age and physiological status of the plant are variables that may affect the consistency of the results of virulence tests.

All isolates collected from various sites in the UK in 1984 and 1985 and tested at SCRI belonged to race 1, 3, 4, 7, 8, 10 and 11. No isolate possessed the virulence factor for resistance gene R-2 including those obtained from the foliage of cv. Pentland Dell which contains R-gene 2. All isolates were of the A2 mating type whereas all but one isolate obtained from early potatoes imported from Egypt and Spain were of the A2 type. Interestingly, these 'imported' isolates had the same complex virulence as the British isolates and as did one A1 and one A2 mating type isolates from Germany.

(J. M. Duncan, A. M. Campbell)

The A2 mating type of *P. infestans*, detected in potatoes grown in Scotland in 1983 (*Ann. Rep. 1984*, 115), was also identified in samples of blight from crops grown in south-west England and east Scotland (from LARS and ESCA respectively) and from tomato (also from ESCA) grown in east Scotland. All A2 mating types had been collected from 1981 onwards, the earliest from England being contemporary with the first A2 isolates recorded outside Mexico and identified in Switzerland. Isolates collected between 1967 and 1981 at SCRI Pentlandfield were all of the A1 mating type as were most of the isolates made since then including all but two isolates from samples received through DAFS and ESCA from 84 potato crops grown in Scotland in 1985. The A2 mating type was also obtained in 1985 from tomato.

(J. F. Malcolmson)

The membrane technique used previously to produce self-fertilized oospores on A1 mating type isolates has also been used successfully with A2 mating type isolates from the UK in which oospore numbers were usually higher than with A1 types. Some A2 isolates produced occasional oospores on agar without membrane stimulus or an opposite mating type being present. Liquid V-8 medium gives satisfactory yields of oospores from crosses of A1 and A2 mating types and allows for easy extraction and washing of the oospores.

In examining alternatives to liquid nitrogen storage, isolates were grown on rough rye agar plates which were then covered with 10% glycerol and sealed before being put in deep freeze at -40°C ; the fungus was usually recovered successfully after 3 weeks.

(J. M. Duncan, A. M. Campbell)

The contribution of tuber-borne and soil-borne inoculum to the incidence of fungi on potato roots [PU 13a, 14f]

Examination of potato plants grown traditionally from seed tubers, cv. Maris Piper, in 1982 (*Ann. Rep. 1982*, 108) showed that the spectrum of fungal colonisers on the roots was influenced more by the tuber-borne microflora than that of the soil in plots with different cropping histories. When the same plots were planted with micropropagated (MP) plants in 1983 (*Ann. Rep. 1983*, 103) differences in plot history were partly reflected in the patterns of colonisation but they were also partly obscured by early colonisation of the root surface (rhizoplane) by cellulose and lignin-degrading fungi established in the peat pots (Jiffy 7) used for the initial stage of raising MP plants in the glasshouse. Many of these fungi produce anti-fungal and anti-bacterial compounds and are notable antagonists of other microorganisms. In 1984, MP plants raised initially in Universal Compost (UC) and seed tubers selected for their apparent high health status, again all Maris Piper, were planted in a site where potatoes had not been grown for 16 years. The results demonstrated that some potato pathogens were effectively soil-borne, others strictly tuber-borne but that tubers also bore microorganisms antagonistic to some potato pathogens (*Ann. Rep. 1984*, 108). Again, the results were somewhat obscured by antagonistic fungi derived from the peat used in the compost.

In 1985 a 'clean' site was again used; MP plants were raised in UC, peat or perlite and half the number raised in peat and perlite were initially planted over 'introduced' tubers selected from a 'dirty' stock of Maris Piper. More tubers of that stock and some from an apparently high health stock were also planted in the field, half the number being first surface sterilised in sodium hypochlorite to give a total of nine planted treatments.

Polyscytalum pustulans (skin spot) was most common on roots of plants grown from 'dirty' tubers and had become established from 'introduced' tubers more often on roots of MP plants raised in perlite (no antagonists) than on those raised in peat. Surface sterilisation of tubers substantially reduced root colonisation and the tuber-borne nature of the pathogen was clearly evidenced because it was found on only one of 4,320 roots tested from the three micropropagation-only treatments. Tubers were also the principal source of *Rhizoctonia solani* (black scurf and stem canker) and the numbers of roots colonised was reduced by half following surface sterilisation. In the absence of antagonists there were greater numbers of infected roots following the introduction of *R. solani* on a tuber into perlite than into peat. Similarly, tubers were the main source of *Colletotrichum coccodes* (black dot) and, in accord with previous findings, root colonisation progressively increased during the growing season. The increase was greatest in the absence of antagonists

in perlite, fourteenfold between August and September but only sixfold and threefold in UC and peat respectively over the same period.

Verticillium dahliae (verticillium wilt) was soil- rather than tuber-borne and its numbers were reduced in both peat and perlite by antagonists from the introduced tubers. Two other *Verticillium* spp, *V. tricorpus* and *V. nubilum* were relatively rare; both were tuber-borne and both tended to be suppressed as the season progressed but not in the absence of antagonists in perlite-raised MP plants. Numbers of the common root coloniser *Cylindrocarpon destructans* increased with time and they were unaffected by any of the planted treatments. *Trichoderma viride* is a potent antagonist of *R. solani*, *V. dahliae*, *C. coccodes* and *Fusarium oxysporum* but its numbers were high only where peat had been used and it tended to be suppressed by an unknown tuber-borne component. *Phoma leveillei* occurred only on the roots of MP plants showing that it too was soil-borne and was suppressed by a tuber-borne factor. In the absence of antagonists from peat, *F. oxysporum* derived from soil multiplied and spread rapidly over roots. *Fusarium tabacinum*, not studied in previous years, was both soil- and tuber-borne; in The Netherlands it is thought to be a numerically important component of the rhizoplane of potato.

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

Develop control measures by studying the biology of fungal diseases of brassica forage crops [PU 10(a)]

Genetic control of resistance to Plasmodiophora brassicae in Brassica napus
The genetic control of resistance to clubroot has been studied using *Brassica napus* cultivars in glasshouse seedling tests. Because the rate of disease development may vary between tests, previous results were checked with 25 cultivars that represented all the resistance groups so far identified. They were inoculated with six isolates derived from single resting spores and four populations of the pathogen. The structure of resistance groups was similar and the twelve groups previously identified were also recognised.

Preliminary genetic studies which followed two generations of selfing and crossing showed that some of the swede cultivars are very heterogeneous and inbred lines from cultivars are therefore being produced in the Forage Brassica Breeding Department for use in genetic analyses of resistance.

Components of pathogenicity in P. brassicae

Most populations of *P. brassicae* have been shown to be mixtures of pathotypes and the pathogenicity of a population which infected five *B. campestris* European Clubroot Differential (ECD) hosts is being studied. Sub-populations have been reinoculated onto each of the *B. campestris* hosts up to nine times in succession and so far have shown little change in pathogenicity.

The effect of temperature on resting spore production in two populations (Pb 8305 and Pb 8307) was investigated using the susceptible swede cv. Doon Major grown at 15 and 20°C. At 20°C, both populations gave clubs with viable resting spores between 3 and 6 weeks after inoculation, whereas at 15°C few viable resting spores were produced until 7 weeks after inoculation. Population Pb 8307 produced a lower total FW clubs than did Pb 8305 at both temperatures, but it produced more viable resting spores per unit fresh club weight.

(C. J. Williamson)

Screening for resistance to brassica powdery mildew

Erysiphe cruciferarum [PU 4(k)]

Six-week old seedlings of swede and forage rape cultivars and advanced lines, and 78 swede gene bank accessions were examined for resistance to a local population of *E. cruciferarum* by spray-inoculating them with a spore suspension. Twelve cultivars from the swede gene bank showed a level of resistance similar to that of cv. Marian and were selected for further assessment. Spore production, assessed by infra-red reflectance analysis and a visual assessment on mature glasshouse grown plants confirmed the superior resistance of inbred lines from cv. Bangholm Dima and Marian compared with lines from the cultivars Acme, Ne Plus Ultra and Bangholm Wilby.

(C. J. Williamson)

Investigation of pollen-stigma interactions in brassicas [PU 4(j)]

Brassica phytoalexins

Phytoalexins are an important component of plant disease resistance mechanisms and play a role in limiting growth of potential pathogens. It is possible that phytoalexin-like compounds may also limit the growth of pollen germ tubes in incompatible pollen/stigma interactions. Because phytoalexins have not yet been reported in *Brassica* spp., we have examined their production in brassica leaves. When silica gel TCL plates were sprayed with a spore suspension of *Cladosporium cucumerinum*, extracts of healthy leaves of *Brassica* spp. were shown to contain two preformed anti-fungal compounds. Inhibitory compounds were detected at the same R_f in extracts of leaves from *B. napus*, *B. oleracea*, *B. campestris*, and *Raphanus sativus* suggesting that the same compounds occurred in all of the species tested. Leaf extracts from plants inoculated with either *Alternaria brassicicola* or *Xanthomonas campestris*, or injected with a solution of a heavy metal, contained an additional antifungal compound characteristic of a phytoalexin. This compound was further purified by TCL and HPLC, but it has not yet been characterised. These inhibitors were not detectable, using the TLC bioassay against *C. cucumerinum*, when plates were incubated at 25°C but were detected

at 15 and 20°C. Work is continuing to determine whether these antifungal compounds are related to the pollen germination inhibitors detected in stigma extracts.

(K. Sikkema¹, G. D. Lyon, T. Hodgkin²)

Studies on the epidemiology and etiology of blackleg and bacterial soft rot of potato

Blackleg etiology and epidemiology [PU 13(a)]

The epidemiology of *Erwinia carotovora* pv *carotovora* (Ecc) and *E. carotovora* pv *atroseptica* (Eca) on potatoes in Scotland was studied on plants grown from healthy tubers of cv. Maris Bard inoculated by vacuum infiltration with either Ecc or Eca or with both together. Latent infection of the stems was detected but only after the mother tubers had rotted and infection was detected in fewer stems in September than earlier in the season.

The yield of tubers from plants grown from Maris Bard seed vacuum inoculated with Eca was only 73% of that from plants grown from uninoculated tubers. Haulm weight was significantly reduced ($P < 0.05$) but numbers of stems per plant and mean stem height were unaffected. Thus in addition to direct losses caused by blackleg, cryptic stem infection derived from contaminated seed can also reduce yield.

(M. C. M. Pérombelon, L. J. Hyman)

Effect of soil calcium content on blackleg and tuber rot [PU 13(a)]

Increasing soil calcium level from 2830 to 6100 ppm by the addition of CaSO₄ (gypsum) significantly reduced blackleg incidence in June and July but not in August in plots of cv. Maris Bard grown from seed inoculated with Eca by vacuum infiltration. The effect of calcium may have been to delay multiplication of the pathogen and rotting of the mother tubers. Healthy mother tubers from the calcium-amended plots in June and July were more resistant to rotting by Eca *in vitro* than those from the control plots and daughter tubers were also more resistant to rotting in the laboratory than those from non-amended plots.

(R. A. Bain³, M. C. M. Pérombelon)

Effect of climate on blackleg development [PU 13(a)]

Because blackleg is the most important seed-borne problem on Scottish seed potatoes exported to the Mediterranean region, studies on its epidemiology were initiated in Israel in 1982 and in Spain in 1984 in collaboration with local pathologists. In Israel, blackleg incidence

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increased with increasing level of seed inoculation with Eca confirming previous results and the increase was greatest in the most susceptible of four cultivars used. The minimum mean number of bacteria per tuber required for the disease to develop was similar in Scotland and Israel for the cultivars Maris Bard and Spunta but for Désirée and Pentland Crown it was higher and lower respectively in Scotland compared with Israel. The threshold seed contamination level was least for Spunta, intermediate for Maris Bard and Désirée and highest for Pentland Crown; in both countries Spunta and Maris Bard were most susceptible, Pentland Crown the most resistant and Désirée intermediate.

(R. A. Bain¹, M. C. M. Pérombelon)

Crops grown in Valencia, Spain from Scottish seed often fail because of extensive blanking caused by early decay of cut seed pieces in flood irrigated fields. Seed of 22 British and foreign cultivars grown in Scotland and inoculated with Eca were planted in Valencia. Disease incidence was highest in the cultivars Pentland Crown, Kingston, Baillie, Kirsty, Rhona, Maris Piper and Pentland Squire.

(M. C. M. Pérombelon, J. Carbonell², M. Milagros-Lopez³)

Tuber contamination by erwinias during mechanical grading: survival and control of the bacteria [PU 13(b)]

Examination of seed stocks before and immediately after grading in commercial stores showed that the percentage of tubers with peeler (c. 1 mm deep) and severe (c. 2 mm deep) wounds increased from <3% to between 12 and 41%. Tuber contamination by erwinias increased proportionately although the extent varied with the numbers of rotting tubers in different stocks. Because Eca, the blackleg pathogen, is the predominant bacterium in naturally rotting tubers in stores, stocks containing some rotting tubers may become heavily contaminated when graded. When Ecc and Eca were inoculated onto intact tuber skin and into different types of wounds and incubated under different environments, both survived >4 weeks in the peeler and severe wounds but <2 weeks at 70% r.h. and for >4 weeks at c. 100% r.h. at both 5 and 15°C. Because the relative humidity within a stock of potatoes in store is c. 100%, survival of erwinias in wounds is probably greater in peeler and severe wounds than in scuff wounds or on the tuber surface.

(M. C. M. Pérombelon)

Because bacteria on the tuber surface and in fresh wounds are accessible to bactericides they may be controlled by spraying. Surface

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coverage was estimated at >90% using a fluorescent dye when tubers were sprayed at 3 l/t immediately after grading by two low volume 'team' sprayers opposed on either side of the roller table. Naturally contaminated tubers were sprayed with 0, 2.3, 3.0 and 3.8 l water per tonne and incubated in sealed paper potato sacks at 15°C for 5 days. Numbers of erwinias in the lenticels of tubers treated with 3.0 and 3.8 l increased significantly ($P < 0.05$) compared with other treatments. Spraying tubers, wounded and inoculated with an antibiotic resistant Ecc strain, with 1.3% 8-hydroxyquinoline solution at 3 l/t controlled contamination on the surface and in scuff wounds but only partly in peeler and severe wounds, but lenticel contamination increased when non-inoculated tubers were sprayed and then stored at 15°C for 5 days.

(M. C. M. Pérombelon, C. E. Quinn¹, D. Ruthven¹)

Pathogenicity of soft rot bacteria [PU 13(b)]

Stems of pot grown plants, cv. Bintje, were stab inoculated with strains of Ecc, Eca and *E. chrysanthemi* (Echr) and kept at c. 100% r.h. and 15, 30 and 35°C in growth cabinets. Only one of seven Ecc and one of eight Echr strains caused a stem rot at 18°C; none of six Eca strains were pathogenic at 30 and 35°C. Pathogenicity varied; some Ecc and Echr strains were highly pathogenic at both 30 and 35°C, others at only one or the other temperature, while others were weakly pathogenic at both temperatures.

Ecc, Eca and Echr were inoculated in pairs in different combinations into tubers held in wet sand and into stems of plants of cv. Bintje in pots kept at c. 100% r.h. and 15, 30 and 35°C. When rotting progressed, Eca was dominant at 15°C; Ecc at 15°C when inoculated with Echr and at 30°C when inoculated with Eca, Echr at 35°C when inoculated with Eca but when inoculated with Ecc their numbers were equal.

(M. C. M. Pérombelon, L. J. Hyman)

Ecc, Eca and Echr alone and in different combinations were also inoculated into seed tubers planted in the spring and autumn growing seasons in Israel. In spring, Ecc rotted seed tubers early causing blanking but not blackleg, while Eca caused both blanking and blackleg when alone and in combination with Ecc or Echr. Eca was consistently isolated from blackleg stems although the other bacteria were often present when they had been inoculated to the seed tubers. Echr failed to cause blackleg, perhaps because temperatures in April and May were below average. As in previous years, little disease developed in the autumn sown crop.

(M. C. M. Pérombelon, R. A. Bain²)

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Tuber decay in temperate climates is caused usually by erwinias and to some extent by pectolytic *Clostridium* spp, but *Bacillus polymyxa* and *Pseudomonas marginalis* tend to predominate in hot climates in unrefrigerated stores. Tubers, cv. Désirée, were inoculated and then incubated anaerobically. At 35°C *B. polymyxa* caused most rotting, *P. marginalis* and Ecc were intermediate and similar respectively and *Clostridium* spp. caused least rotting. At 30°C, rotting by *B. polymyxa*, *P. marginalis* and Ecc was similar and greater than that of *Clostridium* spp. but at 15°C only *Clostridium* spp and Ecc rotted tubers, more so than they did at 30 and 35°C.

(G. S. Shekhawat¹, M. C. M. Pérombelon)

Cultivar resistance to tuber soft rot [PU 13(b)]

As found previously, the ranking order for resistance to rotting of eight different cultivars, differed when assessed by three methods: infectivity-titration; point-inoculation; and inoculation by vacuum infiltration. There is insufficient evidence from field experience to indicate which technique might best be used by breeders for screening for resistance.

(R. A. Bain², M. C. M. Pérombelon)

Genetics of Erwinia spp [PU 15(c)]

Several molecular genetical techniques have been developed for Ecc and Eca to analyse the genetic basis of extracellular enzyme production and pathogenicity. A recent method involves introducing a multicopy plasmid that encodes the lamda receptor protein of *E. coli* K12 to various species via a broad host-range conjugation system; it allows bacteriophage lamda adsorption to *Erwinia* spp. including Ecc, Eca, Echr, *E. amylovora*, *E. cypripedii*, *E. nigrifluens*, *E. quercina* and *E. rhapontici*, and other enteric species. Infection of Ecc SCRI 193 with several lamda transposon vectors has demonstrated that this system can be used for generalized transposon mutagenesis. Several extracellular enzyme and secretory mutants of SCRI 193, isolated by lamda::Tn5 mutagenesis, are now being studied. Furthermore, this system has been applied to Eca SCRI 1043 and used to isolate a range of auxotrophic mutants and it is being used to try to isolate Tn5-induced non-pathogenic mutants of SCRI 1043 which would allow the mapping, cloning and characterisation of Eca pathogenicity determinants. The system also allows transposon mutagenesis to be extended to erwinias which are genetically uncharacterised and it should prove to be a valuable genetical tool.

(J. G. Hinton³, G. Salmond³, M. C. M. Pérombelon)

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The chemistry of resistance of potato to Erwinia spp. [PU 15(b)]

Factors affecting sensitivity of bacteria to rishitin

Research has continued on the effect of water soluble components of potato tissue on the sensitivity of *Erwinia* spp. to rishitin. Compared to bacteria suspended in water, cells suspended in sugars or divalent cations were more resistant, in carboxylic acids more susceptible, and in amino acids similarly sensitive to rishitin. Experiments are continuing to determine whether differences in the concentration of these compounds could affect the sensitivity of bacteria to rishitin *in planta*.

Experiments have continued on the phytoalexin elicitor activity of culture filtrates of *Erwinia* spp. using the soybean phytoalexin elicitor assay. Although purified polygalacturonic acid lyase (PL) is known to elicit phytoalexins, the elicitor activity of crude culture filtrates from several isolates of *E. carotovora* was not proportional to PL activity. However, the optimum calcium concentration for PL activity in culture filtrates was shown to vary between isolates. This apparent anomaly can be explained by assuming that isozymes of PL have different calcium concentration optima and that different isolates have varying ratios of PL isozymes. For example, isolate 206 of *Erwinia carotovora* pv *carotovora* showed an optimum calcium requirement of 0.2mM with 'peaks' at 1, 1.3, 1.6 and 1.8mM. Other isolates showed no distinct maximum at 0.2mM but a broader optimum from 0.2 to 1.0mM. There was therefore no single concentration of Ca^{++} which was optimal for all isolates. There were no differences unique to any of the *Erwinia* spp. and all variation could be accounted for as isolate to isolate variation. Whether variation in the ratio of PL isozymes between isolates affects phytoalexin elicitor activity is not known.

(G. D. Lyon)

Development of clostridia on potato in the field and in storage

[PU 13(b)]

The spores of obligately anaerobic pectolytic clostridia involved in the soft rot complex of potatoes are widely distributed in all arable soils and their numbers on the mother tuber, daughter tubers and roots of growing potatoes cv. Maris Piper were monitored throughout the growing season and compared with the numbers in the surrounding soil for the third successive year. Soil populations averaged 1×10^4 colony forming units (cfu)/g and were similar to those found on the roots and daughter tubers until roots began to senesce at the beginning of October when populations rose to 5×10^4 cfu/g, confirming previous findings that anaerobic microsites occur around plant tissue. The numbers on mother tubers were always higher than in the surrounding soil and reached a maximum of 1×10^5 cfu/g in July when rotting commenced. All these results were obtained from tubersphere soils from healthy tubers.

Bacteria present in soft rot lesions on mother and daughter tubers were examined by plating on selective media to determine the relative proportions of *Erwinia carotovora pv carotovora* (Ecc), *E. carotovora pv atroseptica* (Eca) and clostridia (C1). The onset of rotting of the mother tubers occurred early in the prevailing wet soil conditions and initially Eca predominated but later Ecc and C1 were also frequent. Some daughter tubers began to rot by the end of October and lesions at harvest contained predominantly Eca and C1. However, after storage for 1 month the dominant form was Ecc accompanied by C1. Rotted tissue of tubers of the cultivars Bintje and Maris Piper stored for 1 month was macerated and dilution series made in an anaerobic bench. The numbers of pectolytic clostridia were compared with those of erwinias obtained from using similar techniques in air. In the eight tubers examined, both occurred in high numbers ($1 \times 10^7 - 1 \times 10^9$ cfu/g tissue DW) and although the proportion varied, neither consistently outnumbered the other suggesting that both bacteria may be equally active within soft rot lesions.

(D. A. Perry and N. A. Williams)

Pectolytic enzymes of Clostridium spp. [PU 13(b)]

In continued studies to characterise the pectolytic enzymes of six isolates of clostridia from soils and plants, the bacteria were cultured in pectin and in sodium polypectate liquid media with and without the addition of 2 mM CaCl_2 . All isolates grew well on pectin regardless of the Ca content but did not grow on polypectate unless Ca was present. Supernatants from both pectin and polypectate cultures contained lyase enzymes but no polygalacturonase. Tests on the lyase preparations showed optimal activity between pH 8.8-9.3, some with two peaks, and none were active at pH 5-6 suggesting that they were all pectate lyases and not pectin lyases. However, activity of two extracts from the six isolates was not promoted by the addition of calcium. The results indicated the presence of a complex of pectate lyase isozymes in the isolates.

(D. A. Perry and N. A. Williams)

ZOOLOGY

D. L. TRUDGILL

Again, the unsuspected cause of unthrifty crop growth, this time in swede and kale, was found to be damage by ectoparasitic nematodes. Marked differences between kale cultivars in their tolerance of this damage were also identified. In potato, the importance of differences between cultivars in their tolerance of damage by potato cyst nematodes is now widely accepted and a more simple method of screening breeders' clones has been developed. As a result a wide range of tolerance has been revealed with some exceptionally tolerant genotypes being identified. Experiments with plants made by grafting a tolerant and an intolerant cultivar have shown that the root-stock makes a major contribution to tolerance.

Fungal parasites of nematodes are increasingly being recognised as effective, natural biocontrol agents. In Scotland, a large proportion of the eggs of the cereal cyst nematode were found to be parasitised by two species of fungi, and nematode trapping fungi have been shown to be widespread in arable soils. Laboratory experiments demonstrated that trapping fungi may be selective in the genera of nematodes that they capture and earlier work indicates that this specificity may be related to differences in the nature of the insoluble carbohydrates associated with nematode cuticles. Carbohydrates, as glycoproteins, have been shown to be associated with nematode sense organs and their presence seems to be necessary for normal behaviour. Evidence is also increasing for carbohydrates having a major role in the specific retention of virus particles within the feeding apparatus of vector nematodes.

A new project on resistance in swede to turnip root fly is making good progress and has already demonstrated two different mechanisms in the resistant SCRI cultivars Angus and Melfort. Studies on potato leafroll virus (PLRV) have continued and confirmed that the aphid *Macrosiphum euphorbiae* may be a more important vector than previously recognised. The weather in early summer was also shown to have a marked effect on the spread of PLRV and late applications of granular insecticides as sidebands were shown to give effective control of aphids and virus. A satisfactory alternative to DDT for the control of clay-coloured weevil has at last been demonstrated; the only snag is that the product is applied at night for best effect.

The epidemiology and control of potato leafroll virus (PLRV)

[PU 13(f,g) 14(c)]

The incidence of potato leaf roll in Scottish seed potato crops has decreased since the epidemics in the mid-1970s because the conditions which favour virus spread can now be predicted in time for control measures to be applied. Our previous work has emphasised the need to protect young crops in seasons following mild winters when aphid infestations start before roging.

In 1984 an experiment compared PLRV spread by the two most abundant potato aphids, *Myzus persicae* and *Macrosiphum euphorbiae*. Plants infected with PLRV were grown in the centre of plots of Super Elite grade cv. Maris Piper and infested with reared aphids in mid-June, or 2 weeks later when wild aphids were starting to arrive. The PLRV infector plants were removed in early July and tubers sampled at harvest from 50 plants in the centre of each plot. Growing these tubers in 1985 showed that in plots infested with *M. euphorbiae* the infections were more widely distributed. Disturbance during sampling for aphids tended to increase the degree of PLRV spread, particularly around the infector plants. Surprisingly, plots infested with aphids in mid-June had slightly less PLRV than those infested 2 weeks later, possibly because these artificial infestations provided food for predators before other plants were naturally colonised by aphids.

Bench-mark trials for assessing annual variations in the spread of potato leafroll virus (PLRV) [PU 14(c)]

A model is being developed to predict the rate of spread of PLRV, and a block of cv. Maris Piper at SCRI and at Monkton, Ayrshire, supervised by G. N. Foster¹, were used to monitor the natural rate of increase of PLRV in 1984. When the plots were roged in early July potato aphids were still scarce, and populations remained quite low at SCRI whereas at Monkton larger populations developed. Samples of tubers harvested in 1984 and grown in 1985 showed that the incidence of PLRV in untreated plots had increased by 2.9 times at SCRI and 2.5 times at Monkton. The granular insecticide thiofanox applied at 5.6g a.i./100 m of row at planting to plots in each block, controlled aphids and virus spread at SCRI and decreased virus spread by 90% at Monkton. The results show that PLRV spread more in 1984 than in 1983 even though there was little difference in the numbers of aphids before roging; however June 1984 was warm and dry, whereas June 1983 was cold and wet. The results also show that, even after a cold winter, the incidence of PLRV can still increase when conditions before roging are favourable for virus acquisition and aphid movement.

¹Biological Sciences Division, WSAC

Control of aphid vectors of potato viruses [PU 13(g)]

Granular systemic insecticides applied at planting have provided consistent protection from potato leafroll virus (PLRV) for potato crops in Scotland. However, routine treatments with insecticides will probably lead to increases in aphid resistance and ways are being sought for delaying the time of treatment until early June when a better assessment of the risk of PLRV spread can be made.

One possible way of delaying treatment is to apply insecticide granules as side-bands to the growing crop. In 1984 control of aphids and PLRV was tested in an experiment using a prototype side-banding machine in an irrigated ware crop of cv. Maris Piper, each plot of which had been 'seeded' with eight PLRV-infected plants. Aphids were equally well controlled throughout the season either by aldicarb applied at 4.3 g a.i./100 m of row at planting in mid-April, or by a similar rate of treatment applied by side-banding at the beginning of June. Bioassays showed that excised leaves from side-band treated plots were less insecticidal in early June than those from plots treated at planting, however from mid-June until late July leaves from side-banded plots were more toxic. Yields from both treatments and the control were not significantly different.

Samples of tubers from around the PLRV infector plants, and bulk samples from the whole experiment were grown in 1985 to assess the extent of PLRV spread. The results showed that both aldicarb treatments had been equally effective, greatly decreasing the incidence of virus both in plots from which the PLRV infectors had been rogued and in plots where the infectors were left (Table 1). However, in the untreated plots roguing the PLRV infectors in early July decreased the incidence of PLRV but was less effective than the aldicarb treatments.

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

Table 1. Tuber yield and % tubers infected with PLRV from plants neighbouring infectors ('units') and from 'bulk' samples

<i>Treatment</i>	<i>Yield (t/ha)</i>	<i>PLRV infectors</i>			
		<i>Rogued</i>		<i>Not rogued</i>	
		<i>Units</i> ¹	<i>Bulk</i> ²	<i>Units</i> ¹	<i>Bulk</i> ²
Aldicarb at planting	67.2	3.1	1.3	3.5	0.9
Aldicarb side-banded	60.3	2.5	1.3	1.4	1.5
Untreated control	62.6	16.7	14.1	35.8	3.9

¹768 tubers/treatment

²800 tubers/treatment

Screening for resistance to potato cyst nematodes (PCN) [PU 1(e)]

A problem of assessing clones with partial resistance to *Globodera pallida* (white species of PCN) is that the PCN multiplication rates vary, sometimes greatly, between tests. Because of this variation we have suggested that a small number of clones with different degrees of resistance are included in pot screening tests to act as standards against which the unknown clones are compared. As part of a collaborative study into the use of such standards the resistance of 11 clones were compared at six centres in Britain. Despite differences in environment and populations of PCN all the centres ranked the clones in a similar order of resistance, confirming the potential value of internal, standard clones for assessing categories of resistance.

(M. S. Phillips, D. L. Trudgill, L. A. Farrer)

Screening for tolerance of damage by potato cyst nematodes (PCN)

[PU 1(e), 13(h)]

Growing resistant potato cultivars is an effective means of reducing populations of PCN. However, resistant cultivars are not immune from nematode damage and it has recently become evident that clones with resistance to *Globodera pallida* differ greatly in their tolerance of this damage. This was demonstrated in a recent trial at a site heavily infested with *G. pallida* which tested a range of genotypes with resistance derived from *Solanum vernei*. Applying a nematicide at planting increased the yield of the least tolerant clone (12380) from 8.0 to 55.9 t/ha whereas that of the most tolerant clone (12243) was unaffected at 57.9 and 57.2 t/ha in the untreated and treated plots respectively.

It is therefore necessary when breeding cultivars resistant to *G. pallida*, to screen clones for their tolerance of damage, and traditionally this is done in large, replicated trials at heavily infested sites which compare yield increases following treatments with and without nematicides. However, a new approach has been tested for 2 years, involving the growing of widely spaced single plants in untreated soil at a heavily infested site, and the results show that when 10 plants of each clone are grown in a replicated design there is a very close agreement with the results obtained by the previous method. Both tolerant and intolerant clones are readily identified by the new technique which, because it uses much less labour and land and fewer tubers, will enable more clones to be tested earlier in the breeding programme.

(T. J. W. Alphey, M. S. Phillips, D. L. Trudgill)

The physiological basis for tolerance of potato cyst nematodes (PCN)

[PU 13(h), 14(e)]

The potato cv. Cara is consistently more tolerant of damage by both species of PCN (*Globodera pallida* and *G. rostochiensis*) than cv. Pent-

land Dell. For example, in a recent trial at a site heavily infested (76 eggs/g soil) with *G. pallida* treatment with the nematicide aldicarb increased the yield of Cara from 48.5 to 54.1 t/ha whereas the yield of Pentland Dell was increased from 18.6 to 48.8 t/ha.

The reasons for this difference in tolerance were largely unknown, though an experiment with grafted plants grown in pots (*Ann. Rep. 1983*, 140) indicated that it was largely due to the root-stock. A further experiment with plants grafted between Cara and Pentland Dell, in field plots infested with different population densities of *G. rostochiensis*, showed that both the root-stock and the scion contributed to the greater tolerance of Cara. Top growth was decreased more in the heavily infested plots (179 eggs/g soil) for plants with Pentland Dell stocks or scions than for those with Cara. Also, plants with Pentland Dell scions became senescent much earlier than those with Cara. However, when part of the experiment was harvested on 30 August the most tolerant combination was a Pentland Dell scion on a Cara root stock, and the greater growth of plants with Cara scions was not reflected in their tuber yields (Table 2). At a later harvest on 18 September the tuber yields of plants with Cara scions had increased whereas those with Pentland Dell had not, and the combination of Cara on Cara was now the most tolerant. The overall results showed that Cara scions conferred vigorous top and root growth and late maturity on the grafted plants and, provided harvest was sufficiently delayed, this extra vigour was reflected in larger tuber yields and a high level of tolerance of damage by *G. rostochiensis*. Cara root-stocks also conferred increased vigour and tolerance on the grafted plants, increasing the yields and tolerance of plants with Pentland Dell scions. In contrast, scions or root stocks of Pentland Dell decreased the vigour and tolerance of the grafted plants as compared with their Cara equivalents.

(D. L. Trudgill)

The occurrence of glycoproteins on juvenile heads of potato cyst nematodes (PCN) [PU 13(i), PU 15 (a,d)]

Alternatives to expensive and highly toxic nematicides for the control of PCN are being sought through an increased understanding of nematode behaviour and host/parasite relationships. One such area of research concerns how nematodes find and recognise their hosts, concentrating on the role of carbohydrate polymers associated with the sense organs on the heads of juvenile nematodes.

These studies have revealed that naturally hatched juveniles have carbohydrates in association with their heads and especially with the amphidial sense organs which can be labelled with the lectin CON A among others. However, this carbohydrate labelling was much reduced in juveniles artificially freed from their eggs. Juveniles from surface-sterilised eggs hatched in sterile potato root diffusate also became

Table 2. Fresh weight of tops and tubers of plants made from reciprocal grafts between cv. Cara and cv. Pentland Dell in field plots lightly and heavily infested with *G. rostochiensis*.

Harvest date	Infestation	$\frac{\text{Cara}}{\text{Cara}}$		$\frac{\text{Cara}}{\text{Pentland Dell}}$		$\frac{\text{Pentland Dell}}{\text{Cara}}$		$\frac{\text{Pentland Dell}}{\text{Pentland Dell}}$	
		Top weight (kg/plant)							
30 August	Light	1.08	0.70	0.12	0.10				
	Heavy	1.14	0.36	0.11	0.02				
18 September	Light	1.10	0.72	0.06	0.05				
	Heavy	1.30	0.43	0.04	0.01				
<i>Tuber yield (t/ha)</i>									
30 August	Light	27.9	21.3	28.9	21.6				
	Heavy	20.1	14.5	23.0	10.6				
18 September	Light	35.0	26.8	35.1	20.6				
	Heavy	33.8	21.0	24.4	12.5				

extensively labelled with CON A indicating that substances labelled are not contaminants. Treatments of naturally hatched juveniles with the enzymes β -glucosidase, β -galactosidase, α -mannosidase, trypsin and lipase did not diminish the amounts of carbohydrate labelling. However, treatment with Pronase E, a non-specific protein-degrading enzyme, reduced labelling on the head and amphids, indicating that the substances being labelled are partly or wholly glycoproteins. Brief treatments with sodium hypochlorite, a general oxidising agent, also removed labelling, and treated juveniles though still active lost their ability to find and/or penetrate host roots.

(J. M. S. Forrest)

Changes in potato roots induced by potato cyst nematodes (PCN)

[PU 15(b)]

Several sources of resistance are being used in breeding potatoes resistant to PCN, but the nature of the resistance mechanisms involved is unknown. As part of a study into resistance mechanisms a sterile medium was devised on which rooted sprouts could be grown and infested with surface-sterilised PCN juveniles. Longitudinal sections through infested roots of non-resistant cultivars showed that the developing females induced modified cells called syncytia and which contained fine tubes originating from the point at which the nematode stylet had pierced the cell wall. These 'feeding tubes' are thought to enable nematodes to extract soluble nutrients from the syncytia without ingesting cytoplasm and cell organelles and so killing the host cells.

(J. M. S. Forrest)

Natural plant products as nematicides [PU 14(d)]

A natural plant product for controlling nematodes may have advantages over a synthetic as fewer environmental problems are likely to be caused, it may be more readily available, and it may be less costly to produce. Studies on the nematicidal activity of a natural plant product were continued. Observations on agar plates showed that the virus vector nematodes *Xiphinema diversicaudatum* and *Longidorus elongatus* were repelled from a point of application of the product and eventually became moribund. However, the nematodes were not killed immediately by low doses and could recover mobility when transferred into clean tap water. In pot studies the treatment of soil in one half of a split-pot of soil with the product prevented *X. diversicaudatum* from migrating into that half and attacking the plant roots present. After 18 days most of the nematodes in both the treated and untreated halves had been killed. The natural plant product therefore appears to act both as a nematode repellent and a nematicide.

(T. J. W. Alphey, W. M. Robertson, G. D. Lyon¹)

¹Mycology and Bacteriology Department

Characterisation of resistance in swede to turnip root fly (TRF)

[PU 10(b), 14(c), 15(d)]

In Scotland TRF (*Delia floralis*) causes severe damage to swede and turnip in some years, but is often difficult or uneconomic to control using insecticides. The SCRI cultivars Angus and Melfort are resistant to TRF but the basis of this is not understood, and the mechanisms of resistance are therefore being studied to develop efficient plant breeding screens for new swede genotypes. The aim is to produce rapid bioassays or chemical screens to replace laborious field trials.

Field trials in 1985 monitored the oviposition period and inter-cultivar preferences of TRF. On resistant swede cultivars less than half as many eggs were laid than on a susceptible control cultivar Doon Major, and pupal numbers were decreased even more (Table 3). In glasshouse tests on young plants inoculated with 50 eggs per pot, small but repeatable differences between resistant and susceptible cultivars were observed in pupal numbers present, as both antixenosis (behavioural avoidance) and antibiosis (adverse effects on larval feeding and development) are operating, although the former appears to be a more important component of the resistance.

(A. N. E. Birch)

Effect of controlling nematode by aldicarb on the yield of kale and swede

[PU 10(c)]

Fodder brassicas are an important crop in eastern Scotland and results from previous trials have shown that plant-parasitic nematodes can reduce their yield. In 1985 the effect of the nematicide aldicarb on 12 kale and 20 swede cultivars was tested at a site which had previously been a grass ley and which contained a high density of plant-parasitic nematodes.

Treatment with aldicarb decreased the numbers of *Tylenchrohynchus dubius* (initially 260/200 g soil) *Helicotylenchus digonicus* (37/200 g) and *Longidorus elongatus* (20/200 g), and increased the overall mean fresh weight of the kale and swede at harvest by 28.8% and 14.8% respectively. All plots were treated twice with chlorpyrifos to control of insects and these increases are attributed to control of nematodes therefore alone. There were large differences in the yield response of the kale cultivars to the application of aldicarb e.g. the yield of cv. Bittern was increased by 63.8% compared with 13.3% for cv. Canson (Table 4). Aldicarb treatment also increased the overall mean percentage dry matter content of the kale from 12.4 to 12.9%. Samples taken in mid-June showed that the mean weight of kale in the aldicarb treated plots was twice that in the untreated controls, indicating that most of the damage occurred in the early stages of growth.

(B. Boag, A. J. Redfern¹, J. E. Bradshaw¹)

¹Forage Brassica Breeding Department

Table 3. Number of eggs laid and pupae formed by TRF on susceptible (S) and resistant (R) swede cultivars.

<i>Cultivar</i>	<i>Field oviposition</i> (Mean egg number/ plant at peak)	<i>Field pupae</i> (Mean pupae/root at harvest)	<i>Glasshouse inoculation</i> (Mean pupae/root in pot tests)
Doon Major (S)	86	23	11
Angus (R)	39	6	7
Melfort (R)	48	4	8

Table 4. Effect of aldicarb on the yield and dry matter of kale cultivars

<i>Cultivar</i>	<i>Mean fresh weight</i> (t/ha)		<i>% dry matter</i>	
	<i>Untreated</i>	<i>Aldicarb</i>	<i>Untreated</i>	<i>Aldicarb</i>
Bittern	35.0	57.3	13.5	13.5
Canson	50.0	56.7	12.5	13.0
Condor	56.7	74.0	12.3	12.9
Kestrel	57.3	72.7	11.9	12.3
Merlin	46.0	62.7	11.8	12.1
Mean of seven new accessions	59.3	72.7	12.4	13.0
Overall mean	55.0	69.1	12.4	12.9

Specificity of nematode vectors of plant viruses [PU 15(e)]

Uncertainty exists regarding the degree of specificity between nematode vectors and the viruses they transmit. A question frequently asked is the extent of the danger posed by the importation of plants infected with nematode transmitted viruses. As part of the study of this problem, transmission by an English population of *Longidorus attenuatus* of five isolates of tomato black ring virus (TBRV) from England, one isolate from Scotland, and three* from the the Federal German Republic was examined in the laboratory.

All the English isolates were transmitted with a much greater frequency than the the three isolates from Germany; the proportion of individual *L. attenuatus* transmitting the English isolates varied from 20 to 70% whereas only 3 to 5% transmitted the German isolates. Also, 57% of individual *L. attenuatus* from a naturally infected English population transmitted TBRV but only 10% of a naturally infected population from Germany* transmitted virus. The TBRV isolate from Scotland and a pseudo-recombinant isolate made from the Scottish and the German isolate were not transmitted by *L. attenuatus* but were transmitted by a poulation of *L. elongatus* from Scotland. These results indicated that the introduction of planting material infected with English or German isolates of TBRV to an area where *L. attenuatus* is endemic could result in the virus becoming established, but local strains of virus seem to be partially adapted to local populations of nematodes.

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

Structure and functioning of virus vector nematodes [PU 15(e)]

Knowledge of the structure and functioning of the feeding apparatus in virus vector nematodes provides a basis for understanding feeding behaviour, and the mechanisms of virus retention and transmission. The action of the oesophagael pump is particularly important as it is involved in both virus acquisition and transmission. Therefore, the operation of the pump chamber in the oesophagael bulb of *Longidorus elongatus* has been computer-modelled.

The results indicated that during normal pumping the three-rayed lumen would open to the shape of a triangle (apex angle 60°); however the model showed that in special circumstances e.g. when cleaning the food canal after withdrawal of the spear from the feeding site or when passing the cast pump can still open efficiently up to an apex angle of 90°. Beyond an apex angle of 90° the action of the radial muscles becomes increasingly less efficient. Comparison with two-rayed adult mutant emphasised the efficiency of the normal triradiate lumen; to be equally effective the bi-radiate form required a larger pump and proportionally greater contraction of the radial muscles.

*Held under DAFS licence

The oesophageal bulb is surrounded by three bands of peripheral muscles which are thought to stretch during the contraction of the radial muscles and to act as springs closing the pump chamber when the radial muscles relax. Changes in the volume to surface ratio of the bulb during pumping are accommodated by three longitudinal grooves in the outer walls. Muscles linking the opposite sides of the grooves may also aid in closing the pump chamber.

(W. M. Robertson, P. B. Topham¹, P. Smith¹)

A possible role of carbohydrates in the retention of nematode-transmitted viruses [PU 15 (a)]

Understanding why viruses can be transmitted by particular species of populations of nematodes could provide a basis for novel methods of control. Current work aims to locate and identify the molecules which enable the outer surface of the virus to bind the lining of the food canal at the sites of retention in the nematodes.

In *Xiphinema diversicaudatum*, a vector of two viruses, patches of carbohydrates have been found on the food canal wall at the site of virus retention in the mouth-spear, and particles of arabis mosaic virus (AMV) retained within the spear were surrounded by a cloud of carbohydrate staining material. In *X. diversicaudatum* carrying strawberry latent ring-spot virus (SLRV) particles were found associated only with those parts of the food canal wall where the lining stained for carbohydrates. No carbohydrate was found surrounding particles of SLRV.

Paratrichodorus pachydermus is a vector of tobacco rattle virus and the lining of the wall of the oesophagus, which is a specific site of retention for TRV, also stained for carbohydrates. Unlike *X. diversicaudatum*, where the carbohydrate was distributed in patches, the staining in *P. pachydermus* was continuous over the whole of the lining and nematodes carrying particles of TRV revealed no other extraneous carbohydrate-staining material.

(W. M. Robertson, C. E. Henry)

Fungal parasites of cyst nematode eggs [PU 14(c)]

Some populations of cyst nematodes appear to be prevented from increasing to damaging levels by the action of fungal parasites. In eastern Scotland, about 50% of the arable land is infested with cereal cyst nematode (CCN) (*Heterodera avenae*) but severe damage is unusual even in fields where cereals have been grown continuously.

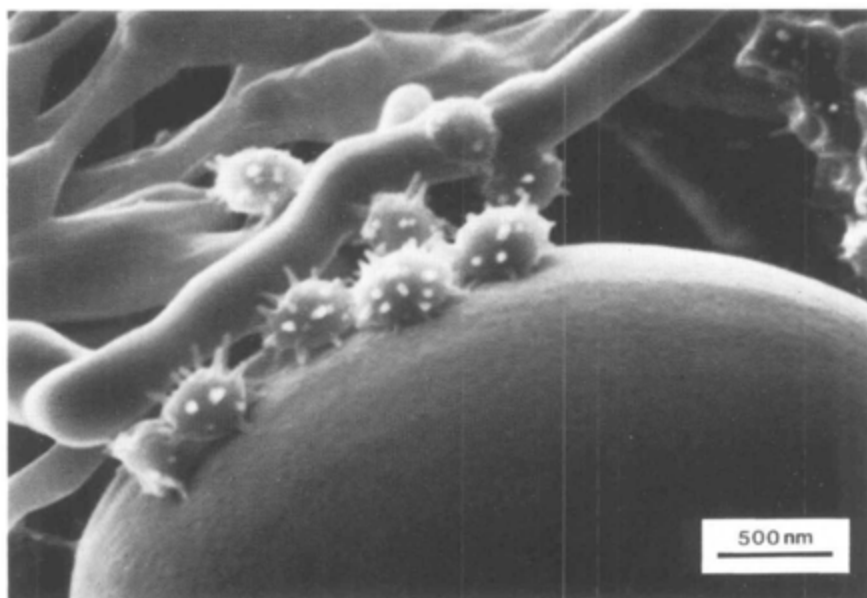
In order to study the role of parasites of eggs in controlling CCN, two agar media were developed for isolating and identifying fungi associated with dead eggs (Fig. 1). The first was used to estimate the percentage of

¹Data Processing Department

infected eggs and the second to determine the identity and frequency of occurrence of the different fungi. Using these media a high level of egg parasitism was found in all populations of CCN examined. A *Verticillium* spp., closely related to but distinct from *V. clamydosporium*, was most abundant with between 6 and 68% of eggs being infected. All the populations examined were also infected with *Paecilomyces carneus*, with between 4 and 17% of eggs being infected. Spores of a third fungus (*Nematophthora gynphila*), which attacks the developing females, were also found in some soils. It seems probable that these fungi are of major importance in controlling CCN in Scotland, and preventing damaging populations developing in many fields growing cereals continuously.

(L. V. Lopez Llorca¹, J. M. Duncan², B. Boag)

Figure 1



Scanning electron micrograph of part of egg of nematode *Heterodera avenae* and the parasitic fungus *Paecilomyces carneus*. The frozen hydrated specimen was etched and coated with gold.

¹Research Student

²Mycology and Bacteriology Department

Nematophagous fungi associated with migratory plant-parasitic nematodes

[PU 14(c)]

No work has been previously undertaken on the role of fungi in the natural control of migratory ectoparasitic nematodes. A survey showed that nematophagous fungi are present in the majority of 57 fields examined in the Carse of Gowrie with species belonging to the genera *Arthrobotrys* and *Monacrosporium* being most abundant. Laboratory studies with *A. dasguptae* shows that it is markedly specific; the detachable adhesive knobs of the fungi did not adhere to most virus vector species belonging to the genera *Longidorus*, *Xiphinema*, *Paratrichodorus* or *Trichodorus*, but have a strong affinity for the ectoparasitic nematodes *Rotylenchus* and *Helicotylenchus*. The adhesive knobs also attach to a lesser extent to the two species of potato cyst nematode and to the free-living third stage larvae of the sheep parasites *Ostertagia circumcincta* and *Trichostrongylus colubriformis*.

(B. Boag, L. F. Ainsworth)

A technique for measuring live nematodes [PU 14(c)]

Many species of plant parasitic nematodes have to be killed before the measurements required for their identification can be made. As part of the work on virus transmission and nematode ecology a technique for measuring live nematodes has been developed. The principle of the technique relies on the image of the nematode being 'frozen' on a VDU screen and using two-way mirror to reflect the image on to the surface of a digitising platen. The image of the nematode can then be measured on the platen and nematode identified using the computer aided technique described previously (*Ann. Rep. 1984*, 142).

(B. Boag, P. Smith¹)

European Plant Parasitic Nematode Survey (EPPNS) [PU 13(c)]

The SCRI is the instigator and coordinator of a survey, in Europe, of plant parasitic nematodes, including the virus vector nematodes. The project, funded by the European Science Foundation and involving 14 participating countries, has as objectives the establishment of a data base for ecological studies and the creation of computer based maps showing the distribution of individual nematode species.

The collection and processing of all distribution data is now complete. During the year national atlases for France, Norway, Sweden, Finland, Poland and Yugoslavia showing the distribution of 36 species of Longidoridae and Trichodoridae have been published. To date, 11 national atlases have been published, illustrating the national distribution patterns of 63 nematode species. Computer subroutines to process data

¹Data Processing Department

from these countries have been added to the IMENS program making it more powerful and flexible; this program is now available for mapping distributions of other organisms by workers in other disciplines. All national distribution data have been converted to 50 km UTM grid references and used to create a single partitioned data file, which has been used in co-operative work with W. Berry¹ to map nematode distributions in Europe on a continental basis. For this purpose a new computer generated outline basemap of Europe has been produced and individual maps showing the distributions of the 63 longidorid and trichodorid species have been plotted in preparation of a European Atlas.

(T. J. W. Alpey, C. E. Taylor)

Nematode species associations

EPPNS data is valuable as a data resource and has been used to study the associations between species, and to compare the associations in Great Britain and Belgium. The two countries have similar soil types, vegetations and agricultural practices and may be expected to have similar nematode distributions.

Distribution data for Great Britain (4066 records) and Belgium (2015 records) were analysed for species associations by several techniques. Twenty-nine species of Trichodoridae and Longidoridae occurring in one or both countries were used, with particular attention to the eight which were frequent in both countries. Comparison of species associations between the countries showed *Xiphinema diversicaudatum*, *Longidorus goodeyi* and *L. leptcephalus* were similar but not *L. elongatus* and *L. caespiticola*. Associations between trichodorids were broadly similar except for *Trichodorus viruliferus* and *Paratrichodorus teres* which showed different affinities in the two countries. Analyses confirmed highly significant associations between species which were generally higher in Great Britain than in Belgium.

(T. J. W. Alpey, B. Boag, Pauline B. Topham²)

Biogeographical classification

In co-operative work Spanish nematode distribution data initiated during the EPPNS were analysed to determine whether the nematofauna could be classified biogeographically.

From the Spanish data it was possible to identify within the criconematid and longidorid nematofauna species groups with similar distribution patterns and also areas typified by a distinct fauna. Eight main faunistic groups were distinguished and classified according to their geographical position and include five areal groupings which were related to altitude within Spain. The varying frequency of nematodes

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²Data Processing Department

from the different European faunistic groups within areal groupings was used to define four distinct distribution patterns in which (i) northern species were predominant, (ii) southern species were predominant, (iii) mediterranean and central European species were predominant and (iv) areas of high faunistic diversity were present, characterised by a wide range of environmental factors. This classification has been tested in further research in Spain and has been valuable in suggesting lines of approach to study the ecology and distribution of this important group of potential plant pests.

(T. J. W. Alpey, P. B. Topham¹)

Mechanisms controlling nematode development [PU 14(c)]

Almost nothing is known about the control of moulting and development in plant parasitic nematodes. The relationship between feeding, growth and moulting in *Goodeyus ulmi*, a nematode that can be cultured on fungi, was therefore studied in relation to changes in ultrastructure and to the secretion of hormones by nerves. These studies showed that *G. ulmi* required 108 day° above a threshold temperature for development of 1.3°C for its complete life-cycle. More detailed studies showed that at 20°C juveniles in the fourth stage fed for 29 h before commencing to moult but that they would still moult after feeding for 23 h. Immediately prior to moulting there was an intensive build-up of mitochondria, golgi bodies and glycogen granules in muscle cells underlying the hypodermis, along with the appearance of extensive membrane structures in the lateral cords. Cytochemical and immunocytochemical investigations showed that the classical neurotransmitters acetylcholine, serotonin and γ amino butyric acid were present at specific sites in the nervous system. In addition neuropeptides such as adrenocorticotrophic hormone and FMRF-amide, which might be involved in the control of development, have also been found.

(L. Leach², P. Gahan², D. L. Trudgill)

Temperature requirements for development of the northern root-knot nematode, *Meloidogyne hapla* [PU 14(c)]

The northern root-knot nematode, *M. hapla*, is not found in Scotland but it is a damaging pest of annual and perennial crops in many European countries. It is readily transported in infested planting stocks and a study was therefore conducted to determine whether it could become established in Scotland and other north European Countries such as Finland. The development of populations of *M. hapla* from Sweden and The Netherlands was measured at four temperatures and the temperature requirements for a complete life-cycle were found to be c. 560 day°

¹Data Processing Department

²King's College, London University

above a temperature threshold of c. 8.0°C. However, maximum multiplication required more than 1,120 day° above the threshold temperature. In Scotland the average accumulated soil temperature above 8°C reaches 560 day° by mid-August but it never exceeds 800 day° in one year. These results therefore indicate that *M. hapla* could become established in Scotland but that it would be unable to attain its maximum rate of multiplication.

(A. Lahtinen¹, D. L. Trudgill)

Control strategies for insects and mite pests of cane fruit [PU 9(b)]

Raspberry Cane Midge

Raspberry cane midge (*Resseliella theobaldi*), which caused severe damage to cv. Glen Clova in the mid 1970s, has been controlled for several years by dinoseb applied to manage cane vigour. However, the pest remains a problem in raspberry plantations where primocanes are allowed to develop normally. Recent work has concentrated on predicting the emergence period of overwintered midges in order to optimise the timing of insecticides applied to control eggs and larvae on the canes. In a glasshouse experiment temperatures were recorded continuously beneath cane midge cocoons in pots of soil. Most midges emerged over a 3 week period with 50% of the total population emerging when 220 day° had accumulated above a temperature threshold of 8°C. On average, males emerged 1.5 days before females.

Recent work at RES has shown that the females of several species of midge produce sex-pheromones which can be used to catch males and monitor emergence. To test if *R. theobaldi* produces a sex-pheromone, groups of virgin males or females were confined in small ventilated vials and used as 'lures' in water traps or sticky traps. The traps were put on to the soil surface between stools in a plantation of Glen Clova and in tubs of Glen Clova, infested with *R. theobaldi*, in a glasshouse. Two traps, each containing two virgin females, caught 24 males and no females during an 8 day trial in the glasshouse. An empty control trap caught no males or females. The field traps were set up in late July towards the end of the emergence period for adults developing from first generation larvae. In two exposure periods of 7 days small numbers of male *R. theobaldi* were caught by traps baited with virgin females but not by traps containing virgin males or left empty.

Clay-coloured weevil

The Food and Environment Protection Act (1985), which brings pesticide regulations under statutory control, has serious implications for pest control in 'minor' crops. The area of raspberry grown in the UK is too small to justify pesticide manufacturers doing the trials needed for

¹Plant Quarantine Services, Helsinki, Finland

approval and label recommendations. Clay-coloured weevil damage to raspberry is a locally important problem for which there has been no recommended pesticide since the withdrawal of DDT. In a field trial two sprays of azinphos-methyl (0.28 kg a.i./ha)+demeton-S-methyl sulphone (0.08 kg a.i./ha) (azinphos-methyl mixture) or fenitrothion (0.55 l a.i./ha) in May reduced weevil numbers but not as much as DDT, used as an experimental standard, applied at 1.0 l/ha. Azinphos-methyl mixture was almost as effective as DDT when it was applied at night when weevils were on the canes. A similar improvement in efficacy of the azinphosmethyl mixture when applied at night was noted the previous year (*Ann. Rep. 1984*, 146).

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

PHYSIOLOGY AND CROP PRODUCTION

P. D. WAISTER

The supply of nitrogen to the potato crop is critical in determining rates of growth and development, and is a factor that can be largely, though not wholly, controlled by the grower. Research on this topic at SCRI is concentrated on understanding the consequences of differing levels and forms of nitrogen within the plant, while a complementary programme at MISR investigates the factors affecting uptake from the soil.

This year's work has confirmed that the net effect of nitrogen supply on growth in a crop is mainly mediated by its influence on canopy development and hence light interception, rather than on efficiency of utilisation of light energy. Studies with ^{14}C have clarified the role of nitrogen in assimilate partitioning between haulm and tubers, and have demonstrated that nitrogen stress leads to storage of carbohydrate as starch, with remobilisation later in the season. Monitoring of nitrate reductase showed that, even with every high and frequent application of nitrogen to the soil, there was a decline in enzyme activity between 80 and 100 days after planting, coinciding with the onset of depletion of leaf protein.

Size grade distribution of tubers reflects another aspect of assimilate partitioning. Examination of the components of variability in commercial crops has not so far indicated that cultural manipulations will give the required control of uniformity. A model of size grade distribution that relates mean tuber size to a dispersion coefficient has shown that the inherent variability in size distribution is little affected by time of harvest, tuber number per unit area, or by cultivar within the limited range so far examined.

British agriculture is well supplied with safe and effective herbicides to deal with most of the important weed problems, but the multiplicity of products and of weed/crop combinations calls for efficient information retrieval systems for herbicides. A new SCRI data-base, HERBREX, has replaced HORTIHERB, and covers fruit, ornamentals, vegetables and most arable crops. It has been enthusiastically received by the advisory services, and is now being made available to commercial organisations on subscription. Efforts are being made to combine information on weed seedbanks with this data-base to give still better guidance on weed control strategies.

After this extremely wet season it was a pleasure to see a start made on the construction of two large movable rain shelters, which will greatly facilitate research on the effects of water supply on crop growth and quality.

POTATO

Potato: light interception and growth [PU 5(a)]

Different levels of N applied to potatoes at planting time give rise to differences in crop maturity and final yield. Differences in harvestable dry matter can be due to alterations in the timing of partitioning of dry matter within the crop, interception of sunlight, and the effectiveness of use of the light energy.

An experiment to examine the response of the crop to a range of levels of N showed that the higher applications extended the duration of rapid canopy expansion and so led to the attainment of denser canopies than did low N levels. Greater interception of light produced more dry matter but this was associated with a delay in maturity of the crop, so that curves of progress of yields from each higher application level exceeded yields from the lower levels at later dates. The most appropriate level of N application therefore depended upon the harvest date.

(D. K. L. McKerron, R. A. Jefferies)

Potato: growth cracking [PU 5 (a)]

In experiments designed to observe the natural incidence of growth cracking in tubers and to relate this to weather conditions, tubers of two susceptible cultivars, Guardian and Record, were lifted three times per week throughout the tuber bulking period and the incidence and severity of cracking were scored.

In 1984, the incidence of cracking in Guardian was low (2%) and could not be related to any particular weather pattern. However in Record the incidence of cracking was associated with re-wetting of the soil by rain at the end of August after a prolonged dry period during which a soil moisture deficit of 100 mm had accumulated. The highest incidence of cracking recorded was 35% of tubers lifted. The weather conditions associated with the occurrence of cracking were similar to those which induced cracking in Record in 1983 (*Ann. Rep. 1983*, 147).

In 1985, a wet season during which soil moisture deficits never exceeded 20 mm, the incidence of cracking in Record was low (1%). However, there was substantial cracking (up to 17% of the tubers lifted) in Guardian, associated with re-wetting of soil in mid-July, after a 20 mm soil moisture deficit had developed.

(D. K. L. MacKerron, R. A. Jefferies)

Potato: effect of second growth on the quality of tubers as seed [PU 5(a)]

The growing seasons of 1983 and 1984 were characterised by prolonged dry periods with high temperatures from June through to the end of August each year. Second growth was common in potato crops, particularly cv. Record which formed many secondary tubers. Seed quality in crops of Record harvested in 1983 and 1984 was compared in tubers which either, (a) were unsprouted prior to harvest (normal), (b) had formed stress-sprouts prior to harvest, (c) had formed secondary chain tubers prior to harvest (primary), (d) were secondary chain tubers.

Normal, stress-sprouted, and primary tubers made substantial sprout growth during storage, while there was little sprout growth from secondary tubers. Plants derived from the several seed tuber types differed in terms of emergence, number of emerged stems, and tuber number. Tuber yield was affected by seed type in one year but not in the other.

(R. A. Jefferies, D. K. L. MacKerron)

Potato: tolerance of potato to flooding before harvest [PU 5(a)]

Weather conditions in summer and autumn 1985 were so wet that the harvesting of many potato crops was delayed. In some fields there was standing water in the furrows and this flooding persisted, in some areas for many days and even for weeks. Under such conditions potato tubers will rot. An investigation was made to establish the duration of flooding which could be tolerated without causing tubers to rot – immediately or during subsequent storage – or to lose their viability as seed.

A low level of rotting (5% of tubers) was found from all durations of flooding up to and including 72 hours. Among tubers flooded for 120 hours 60-90% rotted. The frequency of rotting was not influenced by temperature when tubers were stored at 2.5 and 10°C. All tubers that survived 3 months storage without rotting were found to be viable.

(D. K. L. Mackerron, R. A. Jefferies)

Potato: effect of high temperature on pre-emergence growth [PU 5(a)]

Recent studies have shown that the rates of sprout development and of sprout extension growth are temperature dependent and that the time taken from planting to emergence can be estimated if the soil temperature and the condition of the seed tuber are known. That work was done at temperatures ranging between 2.5 and 15°C. A further investigation examined pre-emergence growth at temperatures up to 27.5°C. Such conditions are not met in UK agriculture but may be experienced by seed sent overseas. Growth rates reached their maximum at temperatures close to 25°C.

(D. K. L. MacKerron)

Potato: influence of soil compaction and soil temperature on tuber number

[PU 5(a)]

Tuber size grade distribution is dependent on tuber yield and tuber number. The effect of soil compaction and soil temperature on tuber number was examined in a field experiment with three levels of compaction and three levels of temperature.

Differences in the degree of soil compaction, in comparison with the normal tilth, were obtained by rotavating prior to planting to produce a fine tilth, or by rolling the ground with a cylindrical roller after planting. Soil strength at a depth of 10 mm was 305, 576 and 749 kPa for fine, normal and compact treatments respectively. Differences in soil temperature were achieved by laying mulches of perlite or clear perforated polythene after 50% emergence to produce cool and warm soils respectively, relative to the ambient treatment. Soil temperature differed by a maximum of 5°C between the cool and the warm treatments.

Compaction reduced final tuber number by 10-13% as a result of decrease in the number of emerged stems. The number of tubers produced per stem was not affected. Increasing soil temperature advanced tuber initiation, and reduced final tuber number which in the warm treatment was 79% of that in the cool, because of the lower number of tubers produced per stem.

Tuber yield at the final harvest was not affected by either the compaction or the temperature treatments.

(D. K. L. MacKerron, R. A. Jefferies)

Potato: leaf development and growth [PU 5(a)]

Experiments to quantify the effect of environment (primarily temperature) on the development and expansion of leaves were completed. Most work was done on cv. Maris Piper, an early maincrop cultivar, and comparisons were made with the first early cultivars Maris Bard and Guardian. Both rates of initiation of leaf primordia (prior to planting) and of appearance of leaves (after emergence) were linearly dependent on temperature. However, the duration of expansion of individual leaves, although influenced by temperature in a similar manner, was also affected by the nutritional status of the plant. Leaves appearing higher up the stem took longer to expand than earlier formed leaves lower down. The magnitude of this effect was dependent on the amount of fertiliser applied.

(W. W. Kirk, B. Marshall)

Potato: influence of N on assimilate partitioning [PU 5(b)]

Carbohydrate partitioning was examined under conditions of both N deficiency and N excess in the field. Plants grown in the absence of applied N showed marked changes in carbohydrate partitioning which

were apparent from early stages of growth and continued following the onset of tuberisation. Nitrogen stress raised the starch and sucrose concentrations of leaves and stems while sucrose concentrations remained remarkably constant. The stem functioned as a considerable store for carbohydrates in N-stressed plants, these reserves being mobilised to the tubers during the later stages of crop growth. Carbohydrate reserves remained at low concentrations throughout the growth of the high-N crop. The fraction of assimilated ^{14}C transported to tubers in the low-N plants was twice that of the high-N, during the 24 hr period following labelling. The results suggest that N stress alters the balance of photosynthetic allocation between storage sinks and growth sinks, the latter being limited by N deficiency. The early onset of tuberisation, frequently reported for N-deficient plants, may be related to the increased accumulation of carbohydrates in the haulm.

(K. J. Oparka)

Potato: phloem unloading in the tuber [PU 5(b)]

Pathways of phloem unloading were examined in developing potato tubers. Abundant plasmodesmata connected sieve elements with phloem parenchyma and phloem tissues with storage parenchyma. The enzyme ATPase, said to play a role in phloem loading, was localised cytochemically. No evidence was found for ATPase that was unique to the sieve element-companion cell complex, the plasmalemmae of all cells in the tuber showing an identical enzyme reaction. The results suggest that unloading of sucrose in the tuber could occur symplastically and passively along a downhill sucrose concentration gradient.

(K. J. Oparka)

Potato: influence of sink removal on tuber number [PU 5(b)]

Previous work (*Ann. Rep. 1984*, 157) showed that particular sites on a potato stem were more likely to form large tubers than others. The hypothesis that removal of these dominant sites would increase tuber number was tested in the following ways: (a) the tips of primary stolons were excised prior to tuber initiation (b) entire stolons were excised at their bases (thus removing potential branch sites on the primary stolon) prior to initiation (c) terminal tubers were removed immediately following initiation.

Excision of stolon tips (Fig. 1) greatly increased the number of tubers initiated, the new tubers arising from branch sites on the primary stolon and also from tips of secondary stolons. However, a new sink hierarchy quickly re-established and few of the newly-formed tubers attained a size of 30 mm. Complete removal of stolons stimulated tuber production on secondary stolons, but final tuber number was only $\frac{1}{3}$ that of the untreated control. Removal of tubers post initiation also stimulated tuber

production on branches, and in this case also few of the tubers reached seed grade. In each of the above treatments the final size-grade distributions, expressed as a percentage of the final weight in each size class, were remarkably similar.

(K. J. Oparka)

Figure 1



Removal of stolon tip induces formation of new tubers on branches of the primary stolon.

Potato: reserve mobilisation in sprouting tubers [PU 5(c)]

Sprout growth is dependent upon the mobilisation of mother tuber reserves. An understanding of the factors which control this process is important if targets for the improvement of sprout growth are to be defined. Enzyme activities have been analysed in sprouting tubers of cv. Maris Piper in relation to the rates of starch and protein depletion. Despite substantial rates of depletion there were no consistent and substantial increases in the extractable activities of total amylase, starch phosphorylase, invertase, protease and aminopeptidase. The control of reserve mobilisation does not appear to depend upon those factors which stimulate enzyme synthesis.

(H. V. Davies, H. A. Ross)

Potato: tuber size distribution [PU 5(d)]

Evaluation of the truncated normal distribution as a quantitative descriptor of the distribution of individual tuber weights continued. To date, experiments over a range of cultivars and treatments—in particular, treatments that affect the number of daughter tubers produced—have shown that the spread in tuber sizes is directly related to the average tuber weight; viz, if two tuber samples have the same number of tubers but one has twice the weight of the other, then the spread of tuber sizes will be twice as broad in the higher yielding sample than in the lower yielding sample. The value of that relationship is that from a knowledge of the daughter tuber number produced, which is determined early in the growth of the crop, the tuber size distribution can be predicted given an estimate of the total tuber yield.

(B. Marshall)

Potato: nitrate reductase activity [PU 5(e)]

In combination with water, nitrogen has a marked influence on the growth and development of the potato crop. The nitrogen nutrition of the plant is under examination to determine the way in which nitrate absorbed from the soil solution is used to drive the physiological processes that affect the functional longevity of the plant.

The activity of nitrate reductase (NR), the enzyme considered to catalyse the rate limiting step in nitrate assimilation, has been examined in a range of field-grown crops with varied nitrogen nutrition. In one experiment nitrogen at four different levels was supplied to the crop at 14 day intervals throughout the season; the highest total N applied was 1000 kg/ha, which has been used previously when determining the potential yield. Potential enzyme activity, (measured by the *in vivo* method with nitrate supply non-limiting) has been determined using the youngest mature leaves from the top of the plant. On a gram fresh weight basis maximum activity increased with increasing rates of nitrogen application. An increase in activity during the first part of the season coincided with a decrease in the nitrate-nitrogen content of the leaf, total petiole sap and xylem sap. Irrespective of the quantity of nitrogen supplied (up to 1000 kg/ha in some instances, applied over the season at 14 day intervals) NR activity declined between 80 and 100 days after planting. The decline in NR coincided with the onset of protein depletion in the leaf and was not prevented by maintaining high concentrations of either leaf or xylem sap nitrate. The decline in NR activity may well signal the onset of senescence. Although nitrate reduction in the root has not yet been examined in detail, petiole xylem sap does contain free amino acids. Under conditions of high nitrate supply the ratio of nitrate-N: amino acid-N is between four and eight. The ratio falls below unity under conditions of low nitrate supply.

(H. V. Davies, H. A. Ross, R. Thompson)

Potato: nitrogen contents in crops as influenced by the application level of N

[PU 5(e)]

A study done in 1984 (*Ann. Rep. 1984*, 155) showed that concentrations of xylem sap nitrate fell sharply from mid-season suggesting that the supply of nitrate to the plants had declined. Measurements of growth (SCRI) and of tissue concentrations of N (MISR) in the same experiment have been combined to calculate the total N content of the crop and of its component parts. These calculations have shown that the crops take up nitrogen throughout the whole season at rates which depend on the initial level of application, and even when no nitrogen has been applied. For all levels of application examined, between 0 and 240 kg/ha, the total amount of N incorporated into plant material exceeded the amount applied at planting time, and there are indications that the rate of uptake in all treatments declined to a common rate after the net uptake matched any initial application.

(D. K. L. MacKerron, P. Millard¹)

Potato: subcellular localisation of calcium in the potato tuber [PU 5(e)]

Though physiological disorders of the potato tuber such as chocolate spot may be associated with calcium deficiencies, the cellular distribution of calcium in the tuber is unknown. Calcium was localised in the tuber using a modified antimonate precipitation procedure. In storage parenchyma of the medulla and cortex, Ca-containing precipitates were abundant in vacuoles, on the tonoplast and to only a limited extent in cell walls. While the method employed has been reported to retain >90% tissue Ca, the potential for loss of apoplastic Ca during fixation is the subject of further investigation. Phloem tissues showed a high concentration of precipitates, mainly in companion cells and phloem parenchyma. Xylem parenchyma elements were rich in vacuolar Ca and within vessel elements deposits were localised on the surface of secondary wall thickenings. A number of fluorochromes, found to be sensitive to regions of cell wall degradation in the tuber, are being evaluated as possible probes for detection of the initial changes associated with the development of chocolate spot symptoms.

(K. J. Oparka, H. V. Davies)

Potato: factors influencing processing quality [PU 5(f)]

To avoid unacceptable browning of the product, the reducing sugar content of potato tubers destined for crisp manufacture must be below a certain limit. In 1984, to produce crops of varying degrees of suitability, cv. Record was grown at different locations in eastern Scotland and in Lincolnshire under a range of commercial practices, and tubers were

¹MISR

harvested six times at 3 week intervals until October. Changes in reducing sugars and sucrose levels were observed throughout the growing season and after 2 months storage at 10°C, in order that the time-course of the development of the levels of reducing sugars could be established. However, in spite of site and cultural differences all materials had reducing sugar levels acceptable for crisping purposes, both at harvest and after storage.

(D. L. Richardson, H. V. Davies)

Potato: genotype response to competition [PU 7(a)]

In 1984 60 M4 clones from the SCRI breeding programme were examined for responsiveness to competition. A number of these clones together with some newer ones were grown in a similar experiment in 1985.

There was again a wide range in responsiveness to spacing in terms of number of tubers per stem, weight of tubers per stem, and average tuber weight. About thirty clones were common to both years, and the correlation between their performance in 1984 and 1985 for each of the above parameters was measured. The best correlations were for change in weight of tubers per stem per unit change in stem density ($r=0.63$), and for average tuber weight at an interpolated density of 20 stems/m² ($r=0.71$). Correlation between total yield in both years were poor at wide spacing but better at close.

(R. Thompson, H. Taylor)

Potato: control of tuber size in cv. Kirsty [PU 7(a)]

There is increasing polarisation in tuber size specifications for seed and ware. The seed grower is encouraged to produce tubers of 35-45 mm or less, while the ware grower receives a premium for large tubers over 60 mm. Size is manipulated mainly by varying stem density, but genotypes respond differently to this manipulation.

The behaviour of the new SCRI maincrop cultivar Kirsty was examined over a wide range of planting rates giving from 5-60 stems/m², and at four harvest dates from early August to early November. The plateau of the yield/density curve was reached at about 17 stems/m² irrespective of harvest date. The maximum yield of 35-45 mm tubers was obtained from a stem population of 55/m², harvested on 4 November, and the highest yield of tubers greater than 60 mm came from a density of 10/m², harvested on 4 November. An average of six stems per plant was obtained from the 68 g sets used, so these planting densities correspond to seed rates of 6.2 and 1.1 t/ha respectively.

Detailed analysis of size grade distributions using the relationships described previously (PU 5(d) p.126), showed that the relative uniformity of the crops was unaffected by either planting rate or harvest date.

(R. Thompson, H. Taylor, B. Marshall)

Potato: effects of nitrogen levels on tuber number [PU 7(a)]

'Measured maximum yield' (MM) plots, in which crops are grown in compost well supplied with nutrients and water, have regularly produced more tubers per unit area than similarly treated plots of field soil.

Cv. Maris Piper was grown in MM and normal soil plots and given N at three levels through the trickle irrigation system at about 10 day intervals, and by the end of the growing season the totals of N applied were 100, 400 and 1000 kg/ha. Control plots were irrigated but received no applied N.

Averaged across nitrogen treatments, the MM plots produced 112 tubers/m² compared with 88/m² in the field soil plots. Differences in tuber numbers between N treatments were small, and these results suggest that the higher tuber numbers in MM plots cannot be attributed to more generous nitrogen nutrition.

(R. Thompson, H. Taylor)

Potato: source of tuber size variability in commercial crops [PU 7(a)]

This year, the PMB sponsored an investigation of the variability of tuber size in farm crops together with components of that variability. The main factors thought likely to influence size-grade distribution were regularity of spacing in the row, seed size and condition, the time of emergence relative to neighbours, and stem and tuber numbers per plant.

Preliminary analysis suggests that though crops differed in the relative magnitudes of the variation attributable to each component, there is an important and possibly over-riding variation arising from the hierarchy of tuber sizes per stem or per plant (see PU 5(b) p.124).

(T. D. Heilbronn, D. K. L. MacKerron, P. D. Waister)

PROTEIN SEED CROPS

Grain legumes: cultivar evaluation [PU 7(b)]

The wet weather had a predictably adverse effect on both maturity and ease of harvesting of the dried pea trials. Average percentage seed moisture contents of the eight cultivars examined fell from 66% on 12 August to 28% on 17 September, when it was decided to harvest the crops. In the process of hand harvesting for threshing, between 0.2 t/ha (for Helka) and 0.4 t/ha (for Heron) of the seeds was shed from the pods. There was no significant difference between harvested yields which averaged 2.5 t/ha when dried to 14% moisture content. This low yield was the result of shedding, and also of fungal infection.

About 40 cultivars and breeding lines of field bean from several sources were grown in part to provide information for a joint EEC project designed to compare different breeding systems, and in part to identify material more suited to the northern environment than are the cultivars presently available. Some of the lines were derived from the

SCRI/PBI breeding programme. The somewhat protracted season made it easier to distinguish differences in maturity than in the past few years.

Table 1. Yield (t/ha) and maturity of selected field bean lines

(- = days earlier + = days later)

<i>cv.</i>	<i>Maturity</i>	<i>yield (t/ha)</i>
Ukko	- 22	3.7
*ETS 56/7/1	- 19	4.6
*Syn I/II	- 14	4.3
Maris Bead	0	4.9
VSB 688	+ 10	5.8

* = SCRI/PBI line

Although VSB 688 gave the highest yield, its late maturity probably rules it out for northern conditions.

(R. Thompson, H. Taylor)

VEGETABLE CROPS

Predicting the maturity of calabrese [PU 7(c)]

A multiple linear regression model was developed that predicts the date by which half the calabrese heads in a crop are mature. A total of 122 crops of *cv.* Corvet, sown throughout the season in each of 4 years, together with meteorological records, provided the basic data set for the model. It was found that daily observations of air temperature (maximum and minimum) explained 74% of the variation in the duration from sowing to maturity, and solar radiation an additional 18 per cent. The model can predict maturity with an accuracy of ± 7 days for nine out of ten crops, and within the year the precision can be improved to ± 5 days. The application of the model for scheduling successive sowings and for forecasting supply is being examined.

(B. Marshall, R. Thompson)

FRUIT CROPS

Raspberry: pilot survey of yield components in commercial plantations

[PU 6(b)]

Considerable differences occur between the yields of raspberries recorded in experimental plantations and those obtained by growers. To quantify these differences, identify causes and test techniques for recording yield components a pilot survey was made in 1985.

After discussions with ESCA advisers, seven representative commercial plantations were chosen in Perthshire, Angus and Fife. The four main

components of yield, cane population, lateral number, fruit number and mean berry weight were recorded and potential yield calculated. Large variations were found between farms, particularly in cane population, potential yield and harvested crop. Cane population ranged from 27,000 to 72,000 /ha and potential yield from 17 to 30 t/ha.

In an unusually wet season when young cane growth was excessive and pickers scarce, growers managed to harvest between 16 and 78% of the potential yield. A study of hand pickings in 1980 (*Ann. Rep. 1981*, 51) showed that careful and closely supervised hand pickers could gather 80% of the potential yield, so the grower who picked 78% was near to the feasible maximum.

(M. R. Cormack, D. T. Mason)

Raspberry: mechanical harvesting [PU 6(c)]

Plots of cultivars Malling Jewel, Glen Prosen, and SCRI selections 33R40 and 14/106 were harvested either by a Littau machine or by hand in 1984 and all were harvested by hand in 1985. Like 1983, the 1984 picking season was very dry and, as recorded previously, (*Ann. Rep. 1984*, 163), there were no detrimental residual effects of machine harvesting. All four cultivars cropped at about 10 t/ha.

In a plantation of 14/106 established in 1983, appropriate plots were treated with dinoseb-in-oil to suppress all young cane growth in 1985. This treatment rendered these plots 'part-biennial' in that the fruiting canes had developed during the 1984 season as annual canes, but were bearing fruit in 1985 without competition from young canes. Six of these plots were picked by Littau machine and six by hand and data from each were compared with those from hand picked annual plots. The numbers of canes in the annual and part-biennial plots were similar, but ripe fruit yield in the hand picked part-biennial plots was 56% higher than in the annual which bore 6.6 t/ha, and in the machine picked part-biennial, 29% higher. From the part-biennial plots the machine picked 83% of the ripe fruit picked by hand. Of the total fruit picked by machine, 93% was ripe, 2% under-ripe and 5% either mummified or affected by mould. The part-biennial plots will be vegetative only in 1986, producing young canes in the absence of competition from fruiting canes and will bear the first truly biennial crop of the experiment in 1987.

(M. R. Cormack)

Raspberry: quality of machine harvested fruit [PU 6(c)]

Attempts to improve the proportion of fresh market quality fruit picked by the Littau machine (Fig. 2), by shortening the harvest interval and reducing the vigour of shake, met with only limited success. Plots of cv. Malling Jewel harvested at 1 day intervals with a shaking frequency of 2.2 Hz yielded fruit with slightly higher acid and lower sugar content

than that harvested at 4 day intervals and 3.5 Hz, indicating differences in maturity of the produce. However, the proportion of whole fruit in the two treatments was virtually the same, and amounted to only 25% in this very wet picking season.

(M. R. Cormack, D. T. Mason)

Figure 2



The Littau raspberry harvester.

Raspberry: cane vigour control [PU 6(d)]

Over the last 3 years the SCRI cultivars Glen Moy and Glen Prosen have consistently failed to give adequate replacement cane when vigour has been controlled by removal of first-flush canes in May. Preliminary investigations suggest that poor replacement cane growth is not due to a shortage of basal cane buds but many remain dormant.

Two potential alternatives to dinoseb-in-oil were evaluated for cane vigour control, but proved unsuitable due to slow and inadequate desiccation.

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

Raspberry: National Fruit Trials [PU 6(d)]

The First Stage Trial planted in 1980 produced its final crop in 1985. The late cv. Joy, and the early cv. Glen Moy had the highest yields at 18 and 17 t/ha respectively. Of three SCRI selections which have progressed to

Multicentre Trials, 7133R40 and 7331/7 yielded over 14 t/ha and 7515C5 over 12 t/ha, similar to cv. Glen Clova. Cv. Malling Jewel cropped at 10 t/ha.

In a year in which moisture was plentiful, fruit size was generally good.

Joy tends to produce fewer canes but the other main yield components lateral number, berry number and berry size more than compensate for this, giving the cultivar its high yield potential.

A second trial was planted in 1984 and bore its first small crop in 1985.

(M. R. Cormack)

Black currant: abscission of bud scales [PU 6(b)]

In studies of bud necrosis and flower initiation, it is necessary to dissect large numbers of dormant axillary buds. Mechanical dissection to remove the bud scales is slow and often results in damage to the floral apices, so a faster, more reliable method was sought. Investigations were made into the use of ethylene to activate the abscission zones located at the base of each scale. The minimum concentration of ethylene required to achieve significant levels of abscission within 3 days was $0.5 \mu\text{l l}^{-1}$. There were differences in response between scales, the outer and innermost scales requiring higher concentrations.

Applications of either 10^{-4}M IAA or 10^{-4}M NAA auxin in a lanolin paste reduced the effect of ethylene.

Ethylene induced abscission only in bud scales and left the floral apices unaffected.

(P. A. Gill, J. N. Burdon¹, R. Sexton¹)

Black currant: flower development [PU 6(b)]

Flower development in the cultivars Baldwin and Ben Lomond was followed by observation of dissected buds by light and scanning electron microscopy. Floral buds were examined from SCRI and Luddington EHS. Flowers were initiated within axillary buds, mainly on 1 year old shoots, during early July in the season prior to fruiting. Two types of inflorescence were distinguished, a primary raceme originating from the main vegetative meristem, and one or two secondary racemes formed in the axils of the innermost leaves of the bud. Initiation of the basal flowers occurred first, so that the terminal flower was the smallest and last formed. By the onset of dormancy, the anthers of each flower were well-developed and partly covered by sepals. During February, differentiation of all flowers was completed. In both cultivars axillary buds from Luddington EHS contained more flowers than those from SCRI because of greater numbers of flowers on the primary raceme, and more secondary racemes.

(P. A. Gill, G. H. Duncan²)

¹Department of Biological Science, University of Stirling

²Virology Department

Strawberry: yield trials of SCRI selections [PU 6(d)]

A trial of advanced selections from the discontinued SCRI Auchincruive breeding programme was planted in spring 1983 and the second main crop harvested in 1985. Five selections have been included in further trials in the NFT system. Of these, 69GU76 yielded 18 t/ha and 71WC64 and 69EW30 yielded over 15 t/ha of sound fruit. The fourth selection, 69DK60 yielded about 9 t/ha, rather less than in 1984, but was distinctly earlier than cv. Cambridge Vigour. The relatively low yield of 69DK60 was due mainly to low crown numbers per plant which were not compensated for by higher truss and fruit numbers, as in 1984 the heaviest crop, over 22 t/ha of well formed, bright, attractive fruit, was produced by the selection 76AD11. This selection starts to ripen with cv. Cambridge Favourite, which cropped at 18 t/ha in matted rows, but has a longer picking season.

(M. R. Cormack)

Blackberry and hybrid berry observations [PU 6(d)]

The cropping of a range of blackberry and hybrid berry cultivars is being observed in an area of single row plots.

Two blackberry cultivars, Ashton Cross and Bedford Giant consistently bear heavy yields of good quality fruit. In the dry year of 1984, Bedford Giant cropped at 20 t/ha and Ashton Cross at 19 t/ha. In 1985 when the exceptionally wet weather caused a lot more fruit to rot, Bedford Giant bore 11 t/ha and Ashton Cross 13 t/ha. The season exacerbated the problem of maintaining good fungicidal protection of a crop which ripens over such a long period, but fruit size was generally greater in 1985 than in 1984. Tayberry appeared to be less affected by weather conditions, yielding 10 t/ha in 1984 and 9 t/ha in 1985. Berry weight in each year was about 7 g.

Experiments to examine the effect of biennial cropping of Ashton Cross and Tayberry and to test the suitability of a range of types for mechanical harvesting were planted in 1985.

(M. R. Cormack)

Windbreaks for fruit crops [PU 6(d)]

A range of tree species and varieties are under observation for their suitability as natural windbreaks.

In a mature break planted in 1971, *Populus x generosa* has proved the fastest growing and has now reached a height of 14.5 m. It grew by an average of 0.76 m per year during the 2 dry years of 1983 and 1984. In the same period *Cupressocyparis leylandii* grew by 0.43 m per year and the cricket bat willow, *Salix alba coerulea*, by 0.48 m. *Populus trichocarpa* × *tacamahaca* clone 32 has proved the most vigorous of a row of 15 varieties of poplar planted in 1979. During 1983 and 1984 it increased in height by over 1 m per year.

(M. R. Cormack)

Prediction and control of weeds in crop rotations [PU 14(a)]

The compilation of data on weed seedbanks in arable soils, together with the development of techniques for identifying and forecasting likely weed problems from seed populations, will permit the use of more cost-effective weed control strategies.

Soil samples from 100 swede fields throughout Scotland have had their weed seed populations extracted and identified. The results are being analysed to ascertain the extent to which the occurrence of particular weed species and associations is related to soil, husbandry and geographical factors.

(H. M. Lawson, G. Wright)

Weed seed separation and identification [PU 14(a)]

The efficiency of identification by image analysis of seeds of each of 40 weed species was found to be unaffected by the orientation of the seeds. Amendment of the image to remove features such as hairs and awns improved identification of several species but impaired that of others. In some genera (e.g. *Polygonum*) accuracy of identification at the generic level was much better than at species level. Magnification improved recognition of several species, but reduced the number of seeds which could be included in the field of view at any one time. Modifications to lighting improved the accuracy of measurement of most seed shapes.

(H. M. Lawson, P. Smith¹, G. Wright)

The HERBREX data-base [PU 14(a)]

The HORTIHERB herbicide information data-base was extended to include vegetables and the majority of arable crops. The new version, re-named HERBREX, was put on-line in June 1985 and is widely used by advisers in ADAS, SAC and more recently DANI. Agreement has been reached with the BCPC for financial support for the annual maintenance and updating of the file and for its extension to include cereals and grassland. HERBREX is now being made available to commercial organisations on subscription and arrangements have been made to utilise data from the file in the BCPC Pesticide Databank and in BCPC publications. SCRI is also cooperating with SAC in the development of advisory packages using the herbicides and weed data contained in HERBREX.

The data-base is being used in association with the weed seedbank and image analysis projects reported above, so that prediction of weed associations can be used as an aid in determining weed control strategy.

(H. M. Lawson, G. Wright)

¹Data Processing Department

Herbicide evaluation [PU 14(b)]

The evaluation of crop tolerance to new herbicides, and to accidental contamination by chemicals applied to preceding or adjacent crops, provides data to support or oppose label submissions by chemical companies to the MAFF Pesticide Registration and Surveillance Department.

None of the herbicides evaluated for crop tolerance in 1984 for use on potato had any adverse effect on chitting behaviour of daughter tubers over the winter. Injury to the growing potato crop by residual herbicides evaluated in 1985 was minimal despite the very wet season. However, a swede herbicide which had shown excellent crop safety over the previous 3 years (benazolin + clopyralid) caused severe crop injury in 1985. Two potential post-emergence herbicides (carbetamide and pyridate) appeared safe to swede over a wide range of application rates. Napropamide applied as a winter surface treatment to established strawberry and raspberry proved to have a high margin of safety, while trifluralin at comparable rates of application was less well tolerated. Potential soil residue problems with these treatments are being monitored. Pyridate applied as a late winter foliar herbicide in established strawberry had no adverse effects on crop growth or yield.

Investigations into the effects of accidental contamination of potato crops with clopyralid have shown that very low doses applied to growing crops may distort and delay foliage development by daughter tubers in the following growing season. The relationship between dose, timing and subsequent malformation are being assessed so that the risk to seed potato crops can be quantified.

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

CHEMISTRY

M. J. ALLISON

During the year, routine chemical determinations included SMCO in brassica (1,500 samples), thiocyanates in brassica (408 samples), digestibility of brassica (1,278) samples, total glucosinolates of brassica (170 samples separated on HPLC), reducing sugars in brassica (122 samples), micromalted samples of barley (690 samples), diastase in barley (500 samples), alpha amylase of barley malt (20 samples), nitrogen in barley and brassica (758 and 226 samples, respectively), anthocyanins in black currant (170 samples separated on HPLC), protein separations in barley (80 samples separated by RP-HPLC), total glycoalkaloid content of potato by the dye binding method (20 samples) and the ELISA test (100 samples).

The development was started of a chemometric system for metabolic profiling analysis, which is essentially a computer-aided analysis of complex data generated in the form of multiple chromatographic peaks. The system consists of a capillary GC and an HPLC each linked to a BBC microcomputer with attendant software so that resolution data can be transferred to a microcomputer and the chromatograms can be displayed if needed. The next step is to link the microcomputer-held data through to EMAS with appropriate software so that GENSTAT programs, for example, could be used for data analysis. These systems will allow investigations of complex data sets, as instanced by identifying those peak patterns that relate to disease resistance from among the large number of chromatographic peaks observed for plant volatiles.

It was established this year that reversed phase HPLC separations of storage proteins in European barleys is superior to that achieved by SDS polyacrylamide electrophoresis, and that, consequently, RP-HPLC was a more effective aid than electrophoresis in the identification of European barley cultivars. It was observed that European two-rowed cultivars classified into groups indistinguishable by SDS PAGE, could be separated within these groups by RP-HPLC. This HPLC method can also be used for an efficient separation of the water- and salt- soluble proteins in barley and, since the proteins are easily collected, it is possible to identify the nutritionally-important proteins in the chromatogram.

In addition, high resolution of all the brassica glucosinolates was achieved on HPLC after a prior desulphonation step. The results for forage rape provided confirmatory evidence that the indole glucosinolates

are not the main goitrogenic factors in rape, but progoitrin which is present in large amounts is likely to be the main goitrogen in rape leaves and stems. Comparison of glucosinolates in swede bulbs are in progress to test whether the high turnip root fly resistance of the cultivars Angus and Melfort can be attributed to glucosinolate levels or not. Considerable effort was expended on the refurbishment of our milling energy measurement system. Pedigree studies established that a main aspect of high malting quality of current cultivars depended on a low milling energy and that this character was selected from the central European old malting cultivar, Kneifel.

Further work on the ELISA test for the rapid estimation of total potato glycoalkaloid content increased our confidence in this test, especially in its ability to process a large number of samples quickly.

The individual anthocyanins of black currant cultivars from different geographical regions were separated on HPLC in an attempt to trace the origin of acylated anthocyanins. Black currant cultivars with good juice quality usually have two acylated anthocyanin peaks and this is of interest concerning the relationship of acylated anthocyanins to overall pigment quality.

With the increased sophistication of treatments of near infra-red data now possible, it becomes increasingly important to ensure the validity of the manual data for any proposed analysis and that the samples selected for calibration evenly cover the range normally encountered. Despite knowledge of these restrictions, calibration samples are still offered either with imprecise measurements of the given attribute or, more often, a population of samples with glaring 'holes' in the distribution. It is still the hope, however, that we can use near infra-red analysis to help cope with some of the heavy routine chemistry workload in addition to the current quality parameters estimated by NIR.

Use of the ELISA system as a rapid screening method for potato glycoalkaloids [PU 1(f)]

In potato breeding, it is sometimes necessary to use species other than *Solanum tuberosum* in order to introduce disease-resistant or other genes which are needed in a new cultivar. Thus the potential cultivar may inherit undesirable traits such as unacceptably high levels of glycoalkaloids (TGA) in the tubers or, in some cases, new alkaloids in addition to solanine and chaconine (alkaloids present in *S. tuberosum*) may be introduced particularly when some of the more exotic *Solanum* sp. are exploited using the recent breeding methods.

Further measurements of TGA in our laboratory made on SCRI breeding material have increased our confidence in the ELISA test developed at FRI, as a fast screening method for glycoalkaloids. Values for TGA estimated by ELISA and by the statutory dye binding method

correlated well ($r=0.87$) for 10 samples evenly spread over a narrow range (7–23 mg TGA per 100 g fresh weight). A main advantage of the ELISA test is that a large number of samples can be processed quickly with reasonable accuracy.

(H. Bain)

Reversed-phase HPLC separations of storage proteins in barley [PU 2(c)]

The extensive polymorphism for the storage proteins in barley has proved useful in breeding work as an aid to cultivar identification, and in monitoring crosses etc. This year it was established that reversed phase HPLC of the C and B hordeins of European barleys gave a superior resolution to that achieved by SDS polyacrylamide electrophoresis. As a consequence RP-HPLC proved to be a more powerful aid to cultivar identification than SDS PAGE.

Good separations of water- and salt-soluble proteins of barley were also achieved on an RP-HPLC system. This system was used to recognise changes in the soluble proteins due to mutation. A comparison of the barley cv. Glacier and its high amylose mutant revealed three differences in the soluble protein peaks. Since the HPLC fractions are readily collected, it is possible to identify the nutritionally important proteins in a soluble protein chromatograph.

(M. J. Allison, D. W. Griffiths)

Development of malting quality tests [PU 2(f)]

Because of the very wet weather in 1985 during the period of barley grain ripening, the development of a reliable test for preharvest sprouting was given a top priority. A recent test which relies on fluorescence detection after degradation of fluorescein dibutyrate (FDB) to fluorescein by pregermination enzymes, proved to be a sensitive reliable test. Harvested grains are halved longitudinally and then stained by FDB in the Carlsberg Malt analyser system of thermoplastic blocks viewed for fluorescence under UV light. Preliminary studies indicate that this is a sensitive test, which is also more reliable than some other current pregermination tests.

Pedigree analysis was used to trace the origin of low milling energy endosperms in barley. It was established that low milling energy was probably selected as a main aspect of malting quality inherited from the central European malting barley cultivar, Kneifel. Many of the modern cultivars with high malting quality and low milling energy, e.g. Triumph Keg and Ark Royal also have Kneifel in their ancestry. For this reason considerable effort was expended this year on refurbishing the Comparamill. As the Calan version had become too unreliable, a new Comparamill was built in collaboration with the Engineering and Maintenance Division. Rogarth Electronics were hired to provide control and measurement systems with improved designs for two mills. The

further improvements in design plus a greater concentration on quality control in the electronic system should result in a reliable Comparamill capable of rapid measurements of milling energy as a rapid screen for this aspect of malting quality in early generations of breeding material.

(K. Taylor, I. A. Cowe)

Studies on toxic constituents in brassicas [PU 4(l)]

The number of brassic leaf samples analysed for both S-methyl-cysteine sulphoxide (SMCO) and total buffer-soluble amino-acids, increased considerably over the totals for the previous year. The samples included not only routine breeding material from kale and rape breeding programmes, but also 250 single kale plants produced by anther culture. Although considerable variation for SMCO was found among these somaclonal plants (0.25 to 2% SMCO), very low levels were not observed. Some of the observed variations may have been due to physiological variation in the plant and possibly differences in ploidy.

HPLC was used to compare the relative amounts of all the glucosinolates present in seeds, roots, stems and leaves of various forage rape cultivars and selections. Preliminary results indicate that a lowered progoitrin content may be associated with an increased amount of but-3-enyl glucosinolate, so that estimates of total glucosinolate would not be a reliable method of selecting for low progoitrin content. However further studies are required to confirm this and to determine the effect of growth stage on glucosinolate content.

(D. W. Griffiths)

Applications of NIR analysis [PU 16(a)]

Throughout the year work continued in collaboration with the Data Processing Department and G. Weatherall¹ on the development of IRSYSTEM (analysis methods) with the aim of reducing the costs of running analytical packages for NIR on EMAS. At the same time a number of collaborative experiments were initiated to test the suitability of using principal component analysis for near infra-red data.

In preparation for a workshop on NIR techniques held at SCRI, spectra for two sets of kale samples analysed for SMCO levels were distributed to other UK institutes which have monochromator systems for NIR calibration analysis. The results indicated that the wide variation in tissue type and proportion in brassica plants made calibration analysis for SMCO difficult. Thus it seems that NIR cannot at present be used for the rapid estimation of SMCO.

Calibration analysis for the various sugars in potato tubers were carried out in collaboration with the Physiology and Crop Protection

¹ARCUS

Department. From these experiments it seems that satisfactory screening systems for glucose would be possible, but that calibration estimates for fructose, sucrose and total sugars were less satisfactory. Further analysis indicated that the values obtained for the calibration population were insufficiently accurate for the derivation of NIR regression models and further work is needed on fresh samples.

In other collaborative exercises, the suitability of principal components analysis as the basis of regression models was tested on two hundred tobacco samples with data supplied by W. F. McClure¹. The regression models were based on the spectra of components derived from principal components. Further work on the use of principal components included collaborative work with B. Osborne² and T. Fearn³ on the spectra of wheat flour components. Work with the other laboratories includes development of an NIR method for predicting mite infestation (number of mites) in samples of pig feed, with R. Wilkin³.

During the year, mildew infection levels in brassica estimated by NIR was added to our routine NIR estimations of chemical constituents.

(I. A. Cowe, D. C. Cuthbertson)

¹University of North Carolina

²Flour Milling and Baking Research Association

³MAFF Laboratories, Slough

DATA PROCESSING

P. B. TOPHAM

The DP staff at Pentlandfield moved to Mylnefield during the year. User support there has since been provided by telephone and regular visits from the former Pentlandfield staff, taking a substantial amount of their time and energy and reducing their collaborative involvement in programming and statistical projects.

The increase in the number of microcomputers and the wider spread of equipment throughout both sites have increased the burden of support for hardware maintenance, for the use of local and mainframe computer facilities and GENSTAT and statistical support. Graph plotting also requires considerable involvement by DP staff, as many scientists are occasional users of graphics.

Text processing has become a major area in which scientists require DP support, since increasingly departmental micros are being used for drafting reports and papers. In the absence of any compatibility with the typists' machines, this trend and the call on DP time is likely to continue. The seriousness of the barriers between different systems is often not appreciated and strenuous efforts will have to be made to reduce the number of text processing software packages and versions of the same software. The wider outlook is confused: the AFRC Computing Centre has standardised on hardware; the ERCC also, but on a software solution, on a limited set of text processing packages. This would integrate well with our general scientific computing but would require both communications and different equipment to be supplied to the typists. In the short term, each scientist has to make his own decision as to whether his speed on the keyboard is enough to justify his personal use of text processing for any particular purpose, given the level of support which the DP Department can provide.

In preparation for registration under the Data Protection Act 1984 R. J. Clark was appointed Data Protection Co-ordinator. He has carried out a survey of all members of staff and their activities which fall under the provisions of the Act.

A software release policy was formulated, by which software developed for local use will be released where benefit can be obtained by ourselves and the recipients, providing that we have the resources to support the transfer. CHIP is the first substantial software product to be prepared for release under this policy.

Computing service: hardware and facilities

The DEC PDP11/10 at Mylnefield was replaced by two CAMTEC Packet Assemblers/Disassemblers (PADS). As more staff moved to Mylnefield the 16 ports there were insufficient and as equipment aged maintenance was less easy and more expensive. Up to 32 ports are now available most of which are now allocated to user departments and dispersed throughout the site. At Pentlandfield computing ports have been distributed throughout the building following rewiring. A Philips GP300 high quality printer was added to the Mylnefield configuration and can be accessed directly from any micro or through the EMAS main-frame service.

Many of the Apples were bought over 5 years ago and are showing their age by an increased frequency of maintenance call-outs. They continue to be heavily used even though additional microcomputers have been purchased. These comprise five Apricots, three model F1s and two of the larger Xis, with 10 megabyte hard disk, one of which will be used for a database project involving dBase III. Three BBC micros with Juki printers were bought by various departments at Mylnefield and are used as terminals as well as increasing the text processing facilities available to scientists. Two BBC microcomputers were purchased by the Chemistry Department to collect data from a high pressure liquid chromatograph and a capillary gas chromatograph. More Epson HX20 portable microcomputers were purchased by departments for data collection in field and laboratory. The support needed to keep all this equipment functioning and to train and support users is taking up an increasing proportion of staff time.

The quantity and portability of computer equipment has led to other problems; various small items have disappeared and one microcomputer was stolen and later recovered by the police. Security measures, including the prominent marking of the Institute's name on equipment, were introduced following discussions with the Crime Prevention Department of Tayside Police.

Usage of the ERCC facilities continued to increase (Table 1) and our status as a regular and substantial outside user of their services was marked by the negotiation of a discount, which also applies to similar users.

Considerable support was given to HERBEX, the information system for herbicides, following its sponsorship by BCPC. Users in ADAS, SAC and the AFRC Institutes have been assisted to establish easy access routes via British Telecom Packet Switch Stream (PSS).

Communication with the AGRENET system has been maintained mainly for the benefit of users of the DNA sequencing programs available on the AFRCCC Vax, and members of the Virology Department have two processes there for such work.

Table 1. Computer usage 1985

<i>Department or Division</i>	<i>Users</i>	<i>Logons</i>	<i>%</i>	<i>Graphs*</i>	<i>%</i>
Cereal Breeding	5	450	6.3	0	0.0
Chemistry	5	497	7.0	42	3.6
Data Processing	10	1526	21.4	143	12.3
Estate	1	4	0.1	0	0.0
Forage Brassica Breeding	5	216	3.0	88	7.6
Information Services	3	314	4.4	12	1.0
Mycology and Bacteriology	10	363	5.1	80	6.9
Physiology and Crop Production	19	1777	24.9	716	61.6
Potato Breeding	13	1196	16.7	45	3.9
Soft Fruit Breeding	3	129	1.8	0	0.0
Virology	4	76	1.1	0	0.0
Zoology	11	599	8.4	36	3.1
Total	89	7147	100.2	1162	100.0

*Excludes graphs plotted for Pentlandfield

Statistics

The association between pairs of species can be expressed by various functions of the 2×2 tables of presence/absence data, and there is little agreement among ecologists as to which is the most appropriate. A study is being made of some theoretical aspects of the measurement of association between nematode species including the effect of additional doubly-negative samples, the effect of simulated sampling variation by 'boot-strapping' techniques and the effect of pooling samples from a number of habitats in which the association is not necessarily similar in relation to several of the most widely used measures of association.

The spatial distribution of nematode species within the soil continued to be studied with B. Boag¹. A preliminary investigation of the techniques of geostatistics suggested that an approach on these lines, originally developed to estimate the grade and extent of ore bodies in a mining context, might be informative. It is not yet known whether the results will be consistent over sites for individual species nor what functions will best describe the relationship between sample variance and distance (the semi-variogram).

An assessment of the biplot as a means of describing interactions between potato clones and nematode populations was made with M. S. Phillips¹. On all data sets examined the biplot clearly highlighted

¹Zoology Department

comparisons between populations of *Globodera rostochiensis* and *G. pallida*, and in general it was found to provide a helpful and comprehensive picture of the interactions.

Principal components have continued to play a valuable role in the analysis of near infra-red spectral data. Analysis of pigmeal samples, in conjunction with I. A. Cowe¹ and D. C. Cuthbertson¹, revealed a clear shift in a principal component peak associated with water if the samples were infested with the mite *Acarus siro* L. It was also possible to derive regression models from the spectral data to predict the level of mite infestation in the samples.

The Virology Department's comparisons between amino acid sequences for different viruses has generated some work. One problem was to evaluate a matching score obtained between given pairs of sequences. Theoretical expressions were derived, and a program for their evaluation was written in ISO Pascal. However the demands of the program on processing time were so great that only cases of short strings with a limited number of amino acids could be handled. Until the program has been made more efficient it is not possible to assess its general usefulness.

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

Image analysis

Some new uses for the Quantimet 900 were investigated. Leaf areas were measured from blueprints for a study of potato leaf growth and development. Holes due to damage were checked by the operator and filled in automatically. The same routine was used to measure leaf production in swedes. A routine was developed for ground cover measurements from monochrome infra-red photographs of potato and cereal canopies. A densitometric application was a routine for measurement of stained lipid in nematodes, using selective filters. Measurements of autoradiographs of nucleic acid hybridization 'blots' showed differences due to the quantity of radioactivity and duration of exposure; these would have exceeded the linear optical density range of the television scanner, but a calibration curve using optical density and spot size was constructed which might have future application.

Fodder rape stem has a ring of lignified vessels which determines in part both its mechanical properties and palatability. A routine was devised to measure from stained sections the cross-sectional areas of the stem and of the lignified ring, and to calculate the ring's dimensions.

(P. Smith)

Software development

Most of the Apple software was transferred to the Apricots, the portability of the UCSD Pascal software facilitating the transfer. Some UCSD Pascal indexing routines were bought to allow database systems to be written for the Apples and Apricots.

¹Chemistry Department

An interactive program for the Chemistry Department is being developed to work with a Comparamill which is to be installed shortly.

The feasibility of transferring the near infra-red software to a powerful microcomputer was examined. Although it was felt that the calculations could be handled by such a micro, some worries remain about the programming overheads in carrying out such an exercise in UCSD Pascal.

Many of the older Epon HX20 programs were rewritten in response to feedback from users.

The herbicide information file, HERBREX, was doubled in size. The number of herbicides increased from 57 to 105 and it became expedient to rewrite the program which maintains the weed/herbicide susceptibility tables to cope with this increase. The opportunity was taken to extend the program to include the provision of tabular displays of weed and herbicide names, and to ease the task of updating the information files. Four short programs were also written to edit the information in the file during the annual update. These are used to cross-tabulate crop and herbicide information, merge sections of information on herbicides from two files, display the pagination and form columns of text within a 20-line screen 'page.' In order to monitor the usage of HERBREX a 'shell' program was written to access the information file, then record user identification and comments with the duration and cost of the enquiry. A HERBREX SYSTEM GUIDE was prepared, and programming documentation is in preparation.

Plant parasitic nematodes cause crop damage, either directly or by transmission of viruses, and it is desirable to distinguish species. Characters used for identification can be categorical (e.g. head shape), meristic (e.g. number of tail annules), measurements (e.g. length of stylet), or taxonomic ratios. A BASIC program was written for the BBC microcomputer to integrate data collection, calculation of sample statistics, and assist in the identification of the species by calculation of a dissimilarity statistic for comparisons with a table stored on disk. Measurements are made by means of a microscope fitted with a drawing arm and a digitising tablet. A maximum of 30 characters can be defined for a particular nematode group, such as the genus *Helicotylenchus*, with more than 150 species. The program was developed with an inexpensive digitiser using rotary potentiometers, and was modified to use a high-precision digitiser. A four-button cursor is used to record co-ordinates and select the lens in use.

Many buffer solutions are used in biochemistry, physiology and microbiology. Buffers may differ in pH range, and often have particular advantages or disadvantages, such as toxicity or inhibition of enzymes. This information and buffer composition was not readily accessible for many buffers. To allow rapid selection of a suitable buffer, a computer program was written to display a list of buffers usable at a given pH,

their components and molecular weights and a list of advantages and disadvantages, and, for the majority of the 53 buffers chosen, give details for the preparation of a buffer of given pH, in steps of 0.1 or 0.2 pH units.

The experiment allocation program for the Tektronic 4051 was extended by a further five fields, bringing the total to ten. Each field outline is stored, together with functions used to obtain the position on the base-line and the maximum extent. The opportunity was taken to simplify the program and to give a visual indication of the search process.

Different book and journal publishers often require references in different formats. Where many references are cited, as in review articles, the labour involved in proof-reading each draft of typescript is considerable. To help get round both problems a computer program, PRINTREFS, was written in IMP80 to run on the EMAS 2900 mainframe computer at ERCC, to take references in a standard format, and print selected references according to specific formatting requirements, selected from a list of about 20 options. The standard format has five fields, author, year, title, journal and keyword; an accession number in the keyword field can be used to select references using a list of numbers, either in alphabetical order or strictly in the order cited. The journal title can be coded, then expanded either in full or according to the World List or Chemical Abstracts forms of abbreviation. Formatting options allow, for instance, numbering of references. The line length can be specified, and the second and subsequent lines can be indented. Fields may be separated by commas, and the year may be placed second or last. The PRINTREFS program is used together with the EMAS utility CATALOG, which is used to order the references alphabetically by author, or on the citation order inserted automatically in a copy of the file when required.

Little progress has been made with the controlled environment monitoring project because the analog to digital Multiplexors were found to be inaccurate at their lowest input setting. It was therefore necessary to redesign the sensor circuits. This has been completed and it is hoped that the system will start this year.

A program is under development, using Pascal on the BBC micro-computer, to determine enzyme concentration from the analog output from a Pye Unicam SP800 Spectrophotometer. The analog output is proportional to the optical density of a liquid sample and the program estimates enzyme concentration in the sample from a linear regression of optical density against time. The program allows the user to remove data points from either end of the density-time trace and re-fit the regression line to the truncated trace. A measure of deviation from linearity of the trace is also produced. The current trace and the fitted regression line are always displayed on the screen.

(J. W. McNicol, R. Kidger, P. Smith, J. B. Cowan)

VIROLOGY

B. D. HARRISON

The methods of biotechnology, that currently overworked word, are now being used in several kinds of work of direct relevance to the control of plant virus diseases. One kind of application is in providing virus diagnostic methods of improved sensitivity and precision. This year further examples are described of the use of radioactively labelled DNA copies (cDNA) of plant virus nucleic acids in spot hybridization tests for detecting furoviruses and tobnaviruses. Also, a start has been made in assessing the merits of non-radioactively labelled cDNA probes. Another development is the preparation of panels of monoclonal antibodies to two viruses. These antibodies have the advantage that they can be produced in large amounts and uniform quality, and they should give no background reaction with proteins of the host plant. Their value for virus detection and diagnosis is being assessed, and they are also being used, as too are the cDNA probes, as tools for investigating the molecular basis of the biological properties of viruses.

A second application of biotechnology is in genetic engineering of plants. This year the first results are described from a collaborative project that attempts to improve the virus resistance of crop species by inserting copies of pieces of virus nucleic acid into the genetic material of the plant. In the course of this work it was found that when plants transformed with DNA copies of a virus satellite RNA are inoculated with the virus, the satellite RNA is produced in large amounts and is then transmissible along with the virus to other plants. In this way the virus has acquired genetic material from the plant genome, a process that may be relevant to virus evolution.

Other noteworthy results described in this year's report include the first evidence of the existence of plant-infecting picornaviruses, discovery of reservoirs of a common raspberry virus in wild raspberry and bramble, the application of ELISA to detection of narcissus viruses in dry bulbs, the description of three new cassava viruses and the use of immunogold labelling to detect particles of three viruses in sections of leaf cells.

Aphid-transmitted viruses resembling picornaviruses [PU 15(f)]

Anthriscus yellows (AYV) and parsnip yellow fleck (PYFV) viruses are transmitted by aphids (*Cavariella* spp.) in the semi-persistent manner. They are of particular interest because although AYV is transmissible by

aphids on its own, PYFV is transmitted only when the aphids are also carrying AYV. However PYFV, but not AYV, is also transmissible manually to herbaceous hosts.

Both viruses have isometric particles about 30 nm in diameter, and those of PYFV have a sedimentation coefficient of c. 150S. In work with eight PYFV isolates, four of the parsnip serotype (from parsnip, celery and *Heracleum sphondylium*) and four of the *Anthriscus* serotype (from *A. sylvestris* and carrot), the RNA and protein components of virus particles were found to resemble those of picornaviruses. The RNA of all eight PYFV isolates consisted of a single species of mol.wt. c. 3.3×10^6 , estimated by electrophoresis of glyoxylated RNA in 0.75% agarose gels. This RNA was retained on oligo(dT) cellulose in the presence of 0.4M NaCl, which suggests that the RNA molecules possess a polyadenylate sequence, and infectivity was greatly decreased after treatment with Pronase or proteinase K, which suggests that they need a genome-linked protein for infectivity.

The particle protein of all the PYFV isolates was found by electrophoresis in polyacrylamide/SDS gels to contain three main components. The two largest proteins had mol.wt. c. 31,000 and c. 26,000 in all eight isolates but the smallest protein had mol.wt. c. 22,500 in the four isolates of the parsnip serotype but of c. 24,000 in the four isolates of the *Anthriscus* serotype.

Isolates of the two serotypes also differed appreciably in host range and symptomatology. Isolates of the *Anthriscus* serotype did not infect celery, parsnip, *Nicotiana glutinosa* or *Petunia hybrida*, and most of them infected *N. clevelandii* only rarely and usually only in inoculated leaves, whereas isolates of the parsnip serotype infected all these species readily. In contrast, isolates of the same serotype showed only slight differences in host range and symptomatology.

Particles of the phloem-limited AYV, purified from infected coriander or chervil plants by an enzyme digestion method, had RNA and protein components of sizes and properties resembling those of PYFV. The single RNA species had a mol.wt. of c. 3.7×10^6 , estimated as above, and contained polyadenylate. In a single experiment, three protein species were found, of estimated mol.wt. 33,500, 25,000 and 23,500.

Thus, although PYFV and AYV are serologically unrelated to each other and differ also in other important respects (e.g. manual transmissibility, tissue localisation, and cytopathology), so that they are unlikely to be classified in the same virus group, the properties of their nucleic acids and coat proteins are similar and resemble those of the (animal-infecting) picornaviruses. However, their transmission by aphids does not depend on infection of the insect.

(S. K. Hemida, A. F. Murant)

Despite these points of resemblance between PYFV and AYV, no RNA sequence homology between the two viruses was detected by cDNA hybridisation tests although about 12% homology was found between the genomes of a parsnip isolate and an *Anthriscus* isolate of PYFV. In gel diffusion and electron microscope serological tests, PYFV particles did not react with antisera to two insect-infecting picornaviruses (cricket paralysis and drosophila C), nor to dandelion yellow mosaic virus, which resembles PYFV in several properties.

(A. F. Murant, S. K. Hemida, D. J. Robinson, I. M. Roberts)

Viruses dependent on luteovirus helpers for aphid transmission [PU 15(f)]

Carrot mottle virus (CMotV) is a sap-transmissible virus which relies for aphid transmission on its RNA becoming packaged in particles that have the coat protein of carrot red leaf luteovirus (CRLV). However, CMotV-infected plants characteristically contain double-stranded RNA (dsRNA) molecules of mol.wt. 3.2×10^6 and 0.9×10^6 . These dsRNA species are of interest because they may be an aid to devising a diagnostic test and to analysis of functions of the virus genome.

Plants infected with other virus isolates that resemble CMotV in host range and symptomatology were therefore analysed for dsRNA content. Samples of dsRNA from plants infected with a Scottish isolate from *Heracleum sphondylium* produced a pattern in polyacrylamide gel electrophoresis that was indistinguishable from that of CMotV. A carrot isolate from New Zealand* and a parsley isolate (Pc1) from England gave similar results except that their smaller dsRNA components had respectively slightly greater and slightly lower mobility than that of CMotV. A second parsley isolate (Pc2) yielded a more obviously different dsRNA pattern: in addition to two dsRNA species that had somewhat greater mobilities than those of CMotV, there were two prominent species of mol.wt. 0.38×10^6 and 0.34×10^6 , the former being very abundant. In contrast to these parsley isolates, the stock cultures of CMotV and CRLV either do not infect parsley or do so only with extreme difficulty. Moreover, although isolate Pc1 was transmitted efficiently by *Cavariella aegopodii* in the presence of CLRV, isolate Pc2 was barely transmissible, suggesting that it may have a different helper virus in nature.

Groundnut rosette and tobacco mottle (TMotV) are two other luteovirus-dependent viruses that have dsRNA patterns broadly similar to that of CMotV, and a similar pattern was also obtained with broad bean vein banding virus (BBVBV; supplied by A. J. Cockbain¹), which is transmitted by aphids (*Acyrtosiphon pisum*) in association with either pea enation mosaic virus or bean leaf roll luteovirus (BLRV). Broad bean

*Held under DAFS licence

¹RES

plants (cv. Beryl) infected with BBVBV contained dsRNA species of mol.wt. 3.2×10^6 and 1.0×10^6 , but in addition a prominent species of mol.wt. 0.78×10^6 and an extremely abundant species of mol.wt. c. 0.1×10^6 . All these sap-transmissible luteovirus-dependent viruses therefore also share other properties and seem to comprise a natural group.

(A. F. Murant, J. H. Raschké)

Tobacco vein distorting virus* (TVDV), the helper virus for aphid transmission of TMotV, is transmitted by *Myzus persicae* in a persistent (circulative) manner and has c. 25 nm isometric particles but is not fully characterized. However immunosorbent electron microscopy (ISEM) tests showed that it is a luteovirus with a closer relationship to beet mild yellowing luteovirus and BLRV than to potato leafroll, tobacco necrotic dwarf and subterranean clover red leaf luteoviruses. No relationship was detected to beet western yellows luteovirus or CRLV.

(G. H. Duncan, A. F. Murant)

Relationships among geminiviruses assessed with polyclonal and monoclonal antibodies [PU 15(g)]

Previous ISEM tests with several whitefly-transmitted geminiviruses have shown that all are related to African cassava mosaic virus (ACMV). As a result, positive reactions in such tests do not provide a precise identification of a virus isolate. The double antibody sandwich (DAS) form of ELISA typically is more discriminatory than ISEM. However, when eight known or probable whitefly-transmitted geminivirus isolates were tested for reactivity with polyclonal antibody prepared to the type Kenyan strain of ACMV, DAS-ELISA detected all of them (the type, cloned type, Nigerian (N) and Kenya coast (KC) isolates of ACMV*, bean golden mosaic* (BGMV), euphorbia mosaic* (EuMV) and tomato golden mosaic* (TGMV) viruses, and a non-sap transmissible tomato geminivirus* from Australia). In contrast, two leafhopper-transmitted geminiviruses, beet curly top* and maize streak*, were not detected.

In an attempt to obtain diagnostic reagents with greater specificity, a panel of BALB/c mouse monoclonal antibodies (MAbs) to the cloned type isolate of ACMV was produced. Of 25 antibodies secreted by hybridomas, 13 reacted with healthy plant components and 12 were ACMV-specific. After cloning at limiting dilution, seven stable hybridoma cell lines secreting MAbs to ACMV were produced. All seven cell lines were used to produce ascitic fluids in pristane-primed BALB/c mice. All MAbs were of the IgG immunoglobulin class; MAb 1 was of the IgG1 subclass and MAbs 2, 3, 4, 6 and 7 were of the IgG2a subclass. All but two MAbs (5 and 7) gave a precipitin reaction with ACMV-containing *Nicotiana benthamiana* sap in agarose gel double-diffusion serological tests.

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Table 1. Reactions with geminivirus isolates of monoclonal antibodies (MAbs) to African cassava mosaic virus (ACMV)

Test antigen*	Mab 2		Mab 4		Mab 7	
	45 min	17 h	45 min	17 h	45 min	17 h
ACMV-type	1.44 †	> 2.0	1.30	> 2.0	1.07	> 2.0
ACMV-N	1.36	> 2.0	1.23	> 2.0	0.03	<i>0.45</i>
ACMV-KC	0.02	0.04	0.10	1.04	<i>0.62</i>	1.81
TGMV	0.02	0.11	0.01	0.12	<i>0.30</i>	1.65
EuMV	0.01	0.05	0.03	0.07	0.15	1.10
Normal sap	0.01	0.04	0.00	0.05	0.01	0.05

*For abbreviations see text.

†Figures are $A_{495 \text{ nm}}$ values obtained by ELISA.

Strong positive reactions are in bold type, less strong reactions are in italic.

Table 1 illustrates the range of specificities found in ELISA when polyclonal antibody was used as the coating globulin, hybridoma supernatant fluid as the reacting antibody, and detection was by a rabbit anti-mouse IgG alkaline phosphatase conjugate. Only MAb 7 differentiated the N and type isolates of ACMV, and only MAbs 4, 6 and 7 reacted with the KC isolate. Most MAbs did not react, or reacted only weakly, with other geminiviruses. However MAb 7 readily detected BGMV, EuMV, TGMV and the Australian tomato geminivirus, and seems to have group specificity for whitefly-transmitted geminiviruses. When used as coating globulin and conjugate in DAS-ELISA, the MAbs detected, *inter alia*, both main variants of ACMV (type and KC) in cassava leaf extracts.

(J. E. Thomas¹, P. R. Massalski, B. D. Harrison)

ISEM tests on further samples of leaf tissue* sent by V. Muniyappa² (*Ann. Rep. 1984*, 179) provided evidence on the nature of other whitefly-transmitted agents. Many typical geminivirus particles were detected in extracts of *Croton sparsiflorus* with yellow vein mosaic, using antisera to squash leaf curl virus and to ACMV. No such particles were found in extracts of *Malvastrum coromandelianum* or *Acalypha* sp. showing yellow vein mosaic but, in both, 'chains of pearls' similar to those ascribed by others to abutilon mosaic virus were found. In spot hybridisation tests, a cloned probe for ACMV DNA-1 gave a definite reaction with extracts from infected *C. sparsiflorus* and *M. coromandelianum*, and a weak reaction with an extract from infected *Acalypha* sp. but no reactions were obtained with a probe for ACMV DNA-2. These results re-emphasise the pattern of relationships established previously among whitefly-transmitted geminiviruses.

In tests with solanum apical leaf curling virus* (SALCV) from Peru, no serological relationship could be found to beet curly top virus (BCTV), despite similarities in the symptoms induced in graft-inoculated test plants. Similarly, no reaction was obtained in spot hybridisation tests with a full-length cloned probe for BCTV DNA provided by J. Stanley³. SALCV also differed from BCTV in that about 80% of the particles trapped from *Datura stramonium* sap by ISEM were trisegmented. Remeasurement of the size of the circular molecules of SALCV single-stranded DNA observed by electron microscopy gave a mean size of about 3000 nucleotides.

(B. D. Harrison, G. H. Duncan, I. M. Roberts, D. J. Robinson)

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²University of Agricultural Sciences, Bangalore, India

³JII

Structure and activity of tomato black ring nepovirus RNA [PU 15(g)]

Although the genome of nepoviruses has been known for several years to consist of two molecules, RNA-1 and RNA-2, work to determine and analyse the nucleotide sequence of these species has begun only recently. In collaboration with Christiane Fritsch¹, the newly available nucleotide sequence of RNA-2 of the S strain of tomato black ring nepovirus (TBRV) was compared with the sequences in other virus RNA species. Several features are worth noting.

The non-coding regions of the RNA differ markedly from the coding region in that they are rich in U and contain repeats of the sequence UUUUC. The 5' terminal sequence of TBRV RNA-2 is identical to that of the satellite RNA (RNA-3) which depends on TBRV for its multiplication. The 3' non-coding region is almost the same as that of RNA-1, but is not similar to the 3' end of RNA-3 (excluding the terminal poly (A)). The 3' sequence of TBRV RNA-2 also has several oligonucleotide sequences that resemble those in the 3' non-coding region of M-RNA of cowpea mosaic comovirus (CPMV).

The putative translation product of TBRV RNA-2 is a polypeptide of mol.wt. 150,000 (150K) and a comparison of its amino acid sequence with the amino acid composition of TBRV coat protein strongly suggests that the coat protein comprises the C-terminal third of the 150K protein. Efforts are now being made to determine chemically the C-terminal amino acid sequence of the coat protein.

A computer-assisted comparison of the amino acid sequence of the 150K protein with those of proteins from other viruses gave evidence of some similarity between sequences in the central third of the 150K protein and sequences in the 30K protein of sunn-hemp mosaic tobamovirus. Less extensive similarities were detected between the 150K protein and the analogous regions of the 30K proteins of other tobamoviruses, and also with part of the 105K protein of CPMV M-RNA just N-terminal of the proposed position of the coat proteins. This region of the 105K CPMV protein, and the 30K proteins of tobamoviruses, are thought to have a role in the transport of virus from cell to cell in an infected plant. As TBRV RNA-1 is able to multiply but not to move from cell to cell on its own, the central part of the TBRV 150K protein might also have a transport function. If so, the genetic map of TBRV RNA-2 would resemble that of CPMV M-RNA in this and in the position of the coat protein gene.

(M. A. Mayo, M. J. Farmer)

Like TBRV, tobacco rattle tobavirus (TRV) has a genome consisting of two species of RNA, and RNA-1 can replicate in the absence of RNA-2. However, unlike that of TBRV, the RNA-1 of TRV can spread system-

¹IBMC, Strasbourg, France

ically in plants. Experiments were therefore done to ascertain whether the hypothetical transport protein of TRV would facilitate intercellular movement of TBRV RNA-1. *Nicotiana clelandii* plants were inoculated with TBRV RNA-1, either simultaneously with TRV RNA-1, or on leaves that were already systemically infected with TRV RNA-1. Eleven days later, RNA was extracted from non-inoculated tip leaves, electrophoresed in agarose gel, transferred to nitrocellulose and probed with ³²P-labelled cDNA copies of TBRV RNA-1. No TBRV RNA-1 was detected in these extracts, although it was readily found in comparable extracts from control plants inoculated with TBRV RNA-1 + RNA-2. Thus the factors that enable TRV RNA-1 to spread from cell to cell are unable to perform the same function for TBRV RNA-1

(D. J. Robinson)

A few examples are now known where RNA transcribed from DNA copies of plant virus RNA is infective. This opens the way to studying the effects of controlled mutations introduced into the DNA. In collaboration with Christiane Fritsch¹, tests were made to see whether cloned DNA copies of satellite RNA from TBRV isolate L, or RNA transcripts made from these DNA copies, were biologically active. *Nicotiana clelandii* plants were inoculated with mixtures containing these DNA or RNA molecules and RNA extracted from plants infected with a satellite-free isolate of TBRV-L. The resulting progeny virus RNA was tested for the presence of satellite RNA. No evidence was obtained for activity of DNA copies in either orientation or of plus-sense RNA transcripts although these served as mRNA in *in vitro* translation experiments. The absence of activity may be because the molecules lacked the genome-linked protein that is attached to satellite RNA molecules extracted from virus particles.

(M. A. Mayo)

Nucleic acid hybridisation tests for relationships among furovirus isolates

[PU 15(g)]

Previous work has failed to detect any serological relationship between Indian isolates of peanut clump furovirus* (PCV) and other members of this proposed group of fungus-transmitted viruses. Indeed, three of the Indian isolates showed little if any antigenic relationship to one another although their nucleic acids shared substantial sequences. In further work, ³²P-labelled cDNA to unfractionated RNA of isolate B reacted in spot hybridisation tests with *N. benthamiana* sap containing isolates B, H or L of PCV but not with four other potential furoviruses: potato mop-top, beet necrotic yellow vein*, soil-borne wheat mosaic* (Japanese or U.S. isolates) and nicotiana velutina mosaic* viruses. Moreover, for

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the first three of these other furoviruses, the lack of detectable sequence homology with PCV, or with one another, was confirmed in solution hybridisation tests, using ^3H -labelled cDNA. A ^{32}P -labelled cDNA probe prepared from unfractionated RNA of PCV isolate L reacted in Northern blots with both RNA species of isolate B and of isolate H, showing that the sequence homology with strain L is not confined to one genome part.

(D. J. Robinson, D. V. R. Reddy¹)

Plants transformed with DNA copies of plant virus RNA [PU 15(h)]

Methods of genetic engineering have now advanced to the point where several novel approaches to improving the virus resistance of plants can be tested. One approach is based on the cross-protection phenomenon – the fact that plants infected with one strain (even a mild strain) of a virus do not develop additional symptoms when inoculated with a second strain. It is hypothesised that this effect is attributable to a specific part of the genome of the protecting strain and that if a DNA copy of this sequence could be incorporated in the plant genome, disease resistance might be enhanced. A second approach is to insert into the plant genome a DNA sequence which can be transcribed into RNA that is complementary to a key part of the virus genome. The presence of this anti-sense RNA is considered likely to disrupt virus replication in the transformed plants. A third approach is based on the discovery in virus cultures of satellite nucleic acids that depend on a specific virus for replication, interfere with virus replication and may either ameliorate or intensify disease symptoms. Hence plants transformed with DNA copies of a benign satellite RNA might develop only mild symptoms when inoculated with a satellite-free culture of the virus and/or might be resistant to infection. These three approaches are being tested in a joint project with D. C. Baulcombe² and M. W. Bevan². Initially work is centred on cucumber mosaic cucumovirus (CMV) and tobacco rattle tobnavirus (TRV), and complementary parts of the experiments are being done at the two institutes.

Three isolates of CMV, from raspberry (isolate R76B), lily and marrow respectively, all were free from satellite RNA species, suggesting that such satellites are not prevalent in field isolates of CMV in Britain. A French satellite-containing CMV isolate* was kindly provided M. Jacquemond³. DNA copies of this satellite RNA were cloned, and RNA transcribed from the clones was tested for biological activity by inoculating it, in mixtures with infective RNA of isolate R76B, to *Nicotiana*

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clevelandii. Transcribed RNA that contained molecules with either 1.3 or 2.3 complete unit lengths of the satellite RNA was biologically active. Systemically infected leaves contained unit-length satellite RNA in addition to CMV genomic RNA and showed less severe symptoms than the satellite-free leaves of plants inoculated with isolate R78B alone. No satellite RNA could be detected in plants inoculated with the transcripts alone.

Tobacco plants (cv. Samsun NN) transformed with either 1.3-unit length satellite DNA (construct 104) or 2.3-unit length satellite RNA (construct 105), and producing RNA transcripts corresponding to these sizes in small amounts, appeared to grow and develop normally. When they were inoculated with isolate R76B, however, large amounts of unit-length satellite RNA were produced in inoculated and systemically infected leaves. When sap from these leaves was inoculated to *N. clevelandii*, satellite RNA was again produced and was packaged in CMV particles, and the plants developed milder symptoms than plants inoculated with isolate R76B (Fig. 1). The virus cultures grown in plants transformed with construct 104 or 105 had therefore acquired genetic material from the host genome. Although this is an artificial system the results may be a clue to processes that have played a part in the origin of virus satellite RNA species and in virus evolution in general.

Figure 1



Decrease in virulence of a cucumber mosaic virus isolate caused by passage through plants transformed with DNA copies of satellite RNA. *Left and right*, *Nicotiana clevelandii* plants infected with virus isolate passed through plants transformed respectively with constructs 105 and 104; *middle*, infected with isolate from normal plants.

Work is proceeding on plants transformed with other nucleotide sequences of viral origin. Tobacco plants transformed with DNA copies of the coat protein gene of CMV or of tobacco mosaic tobamovirus (TMV) were not noticeably less susceptible to these viruses, respectively, than comparable non-transformed plants. However, when TMV isolate PM2, which produces a non-functional coat protein, was cultured in the plants transformed with the TMV coat protein gene, no virus-like particles were detectable. Hence the amount of TMV coat protein produced by the transformed plants, which is known to be small, may have been too little for the potential biological effects of transformations of this type to be expressed.

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

Identification and detection of potyviruses in narcissus [PU 11(a)]

Potyvirus-like particles have been associated with several diseases in narcissus but in no instance has a causal relationship been proved. The most prevalent of these diseases in maincrop cultivars is late season yellows, which is associated with BA3-8 virus (*Ann. Rep. 1984, 199*). Two more antisera to isolates of this virus (coded BA3-3 and CA1-3) were prepared using immunogen purified by an improved method. These antisera gave lower background reactions in ELISA than the original BA3-8 antiserum and detected the virus with greater sensitivity. Results from a survey of several narcissus cultivars indicate that Dutch Master, Golden Harvest, King Alfred, Lothario and Rembrandt are probably totally infected with BA3-8 virus whereas the cultivars Barrett Browning, Carlton and Sempre Avanti seem free from infection.

(W. P. Mowat)

In an attempt to distinguish by ELISA distinct potyviruses occurring in narcissus and alstroemeria, tests were done with an antiserum to narcissus late season yellows virus (NLSYV), an antiserum to alstroemeria mosaic virus (ASMV) supplied by A. A. Brunt¹, sources of potyvirus particles in narcissus (cultivars Grand Soleil d'Or and Golden Ducat) and an isolate of ASMV cultured in *Nicotiana clevelandii*. NLSYV antiserum reacted with both narcissus samples, the first evidence that NLSYV occurs in tazetta narcissus, and did not react with ASMV, whereas ASMV antiserum reacted with the ASMV isolate but not with the narcissus samples. ASMV is therefore distinct from NLSYV. However, immunoelectron microscopy showed that the Grand Soleil d'Or plant contained some potyvirus-like particles which did not become coated with antibody to NLSYV but reacted with another antiserum provided by A. A. Brunt and known to contain antibodies to 'narcissus degeneration virus.' In addition, a carlavirus found in the the Grand Soleil d'Or plant was shown by immuno-electron microscopy and ELISA to react with antiserum to carnation latent virus.

(W. P. Mowat, G. H. Duncan)

¹GCRI

Symptom and serological variation in narcissus mosaic virus [PU 11(a)]

Although narcissus mosaic potexvirus (NMV) is common in commercial stocks of many narcissus cultivars, little is known about the possible occurrence of antigenic variants that might be inefficiently detected by ELISA.

An isolate of NMV, obtained in 1984 from narcissus cv. Dutch Master in Scotland and designated A4, produced only faint chlorotic lesions in inoculated leaves of *Chenopodium amaranticolor*, did not produce lesions in *Phaseolus vulgaris* cv. The Prince and was difficult to transmit to *Nicotiana clevelandii* plants which, when infected, remained symptomless and contained only low concentrations of virus. In contrast, the reference Scottish isolate M produced mostly distinct chlorotic lesions together with a small proportion of necrotic lesions in *C. amaranticolor*. Two sub-stocks prepared from isolate M by single lesion transfers produced exclusively chlorotic (isolate MC) or exclusively necrotic (isolate MN) lesions. In *Phaseolus vulgaris* cv. The Prince, isolate MC produced small necrotic lesions and isolate MN small chlorotic lesions, and in *N. clevelandii* both isolates produced a systemic mottle and reached high concentrations. In titrations of mouse antisera to each of the NMV isolates by a 'plate-trapped antigen' form of ELISA, isolates MC and MN were serologically indistinguishable, and isolate A4 differed only slightly from these two (serological differentiation index = 1). As these three isolates cover the extremes of the reported range of symptomatological variation in NMV, and differ antigenically only slightly, there seems no reason to suspect that antigenic variation will cause difficulties in detecting NMV by routine serological tests.

(D. J. Robinson)

VT-indexing of dry bulbs [PU 11(a)]

Although narcissus leaf tissue is a satisfactory source of virus for screening by ELISA, bulb scale tissue could be a useful additional source with potential uses for testing imported stocks before planting and for detecting current year infections.

In exploratory tests, extracts from individual fleshy scales of dormant bulbs of infected clones were used in F(ab')₂ ELISA for narcissus mosaic potexvirus (NMV) and narcissus tip necrosis tomosvirus (NTNV), both of which occur in large amounts in leaves, and for tomato black ring nepovirus (TBRV), which typically produces only small amounts of antigen in leaves (*Ann. Rep.* 1983, 198). All three viruses were detected, but whereas TBRV antigen occurred at a similar concentration in all scales, NMV and NTNV were not detected in about 20%. Detection of these two viruses was not improved when cellulase and pectolyase were used in preparing the scale extracts.

Although these results offer the prospect of screening dry bulbs by ELISA, further work is needed to assess the reliability of the test when composite samples from different bulbs are used and when current year infection has occurred.

(W. P. Mowat)

mosaic was associated with the combination RYNV + BRNV + RLSV. However, some Glen Isla plants containing RYNV + RLMV also developed mild veinbanding mosaic. All other grafted plants were free from obvious symptoms. These results indicate that veinbanding mosaic symptoms can be induced by more than one virus complex that includes RYNV.

(A. T. Jones)

dsRNA analysis of virus-infected *Rubus* [PU 9(d)]

To assess further the value of dsRNA analysis for studying *Rubus* viruses (*Ann. Rep. 1984, 198*), dsRNA was extracted from leaves, fractionated on cellulose columns, analysed by polyacrylamide gel electrophoresis and detected by staining gels with silver. Two main virus-specific dsRNA components were readily detected in extracts from herbaceous plants infected with arabis mosaic, raspberry ringspot, strawberry latent ringspot or tomato black ring viruses, but these dsRNA species could be detected only erratically in extracts from infected raspberry plants kept in the glasshouse. Interpretation of the analyses was also complicated by the sporadic occurrence of additional dsRNA species in small amounts and of components of mol.wt. below 1.0×10^6 . These low mol.wt. components occurred in extracts from different plant species, from plants infected with unrelated viruses and from apparently healthy plants. Despite these difficulties, virus specific dsRNA species were readily detected in raspberry infected with raspberry bushy dwarf virus (RBDV) or cucumber mosaic virus. The number and mol.wt. of the dsRNA species in raspberry was the same for common and resistance-breaking* strains of RBDV. Further tests on raspberry plants infected with black raspberry necrosis, raspberry leaf mottle, raspberry leaf spot, raspberry vein chlorosis and rubus yellow net viruses confirmed and extended last year's preliminary finding (*Ann. Rep. 1984, 198*) that little or no high mol.wt. dsRNA was detectable in the leaf extracts.

(A. T. Jones, M. J. Mitchell, M. A. Abou-Elnasr¹, M. A. Mayo)

Properties of wineberry latent virus (WLV) [PU 9(d)]

Further studies with this virus from *Rubus phoenicolasius* showed that its filamentous particles have a buoyant density in Cs_2SO_4 of 1.2 g cm^{-3} and contain polypeptides of estimated mol.wt. 31,000 (main component) and 28,000 (subsidiary component), respectively. Few intact nucleic acid molecules were obtained from purified virus particles by the standard phenol/SDS method but more success was achieved by digesting the particles with proteinase K. Such nucleic acid preparations contained ssRNA which, when denatured in glyoxal, had an estimated mol.wt. of 2.7×10^6 . These properties of WLV resemble those of potexviruses and,

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in F(ab')₂ ELISA, purified WLW particles reacted strongly with antiserum to cactus X (CXV) and viola mottle (VMV) potexviruses but did not react with antisera to seven other potexviruses. In ISEM tests, WLW particles were coated with antibodies to VMV but not with CXV antibodies.

(A. T. Jones, M. J. Mitchell, I. M. Roberts)

Resistance to aphid vectors in raspberry [PU 9(d)]

Previous work has shown that raspberry genotypes with gene A₁₀, which confers resistance to *Amphorophora idaei*, remain essentially free from infestation by this aphid in the field and become infected with aphid-borne viruses much less rapidly than do aphid-susceptible genotypes. Experiments were begun to examine the mechanism of this aphid resistance and its effect on virus transmission.

Evidence of differences in behaviour of *A. idaei* was obtained when detached leaves of plants of different cultivars were floated on water, loaded with five aphids and the number remaining on such leaves counted the following day. In one such test, the mean numbers of *A. idaei* remaining on cultivars Malling Jewel (aphid susceptible) and Bliss (resistant, containing gene A₁₀) were 4.7 and 0.5 respectively. Moreover, in similar tests with *Macrosiphum euphorbiae*, which also can transmit BRNV, a similar pattern of resistance emerged with mean aphid numbers of 3.0 and 0.8, respectively. Thus the resistance mechanism operating in Bliss may not be species-specific. When small leaf discs from Bliss leaves were placed on whole leaves of Malling Jewel before loading with *A. idaei*, the numbers of aphids remaining on the leaves was 86% less on leaves bearing discs from Malling Jewel leaves. Evidently the aphids were repelled by the Bliss leaf discs.

(A. T. Jones, M. J. Mitchell)

Virus indexing of *Rubus* cultivars and selections [PU 9(e)]

During the year, seven *Rubus* selections from overseas and two seedlings of blackberry and raspberry found in England and thought to be of commercial interest were indexed for virus infection. Only the blackberry seedling was infected: it contained BRNV. In tests on 69 selections or advanced selections from the raspberry breeding programmes at SCRI and EMRS, BRNV was found by ELISA in five selections, and two selections from EMRS contained RBDV. Two loganberry clones, one thorny and one thornless, were obtained free from all known *Rubus* viruses and will be used to provide healthy foundation material for the MAFF Certification Scheme.

(M. J. Mitchell, A. T. Jones)

Severity of potato leafroll luteovirus (PLRV) symptoms in relation to inoculation date [PU 13(j)]

One of the most important methods for controlling the spread of PLRV in potato crops is the roguing of infected plants, usually during early July. Any tendency of infected plants not to develop obvious symptoms may decrease the effectiveness of roguing and increase the chance of virus spread. Cultivars in which PLRV remains at a low concentration in leaves, such as Pentland Crown, tend to develop milder symptoms than cultivars such as Maris Piper in which the virus reaches a higher concentration (*Ann. Rep. 1984, 194*). In a field trial in 1984, plants of Pentland Crown and Maris Piper were inoculated with viruliferous *Myzus persicae* (Fig. 2) at several times during the growing season. Tubers produced by the plants that became infected were planted in the field in 1985 to assess the effect of inoculation date on incidence and expression of secondary symptoms. In early July, plants of both cultivars were stunted and showed obvious leaf symptoms when grown from tubers of plants inoculated up to 12 July in the previous year. However plants grown from tubers of plants inoculated after 2 August showed no stunting and, although the lower leaves of Maris Piper developed characteristic rolling, infected plants of Pentland Crown were symptomless and could be identified only by testing leaf extracts by ELISA. Interestingly, these tests revealed no difference in virus concentration between

Figure 2



Inoculation of field grown potato plants in terylene cages with potato leafroll luteovirus by infestation with viruliferous aphids (*Myzus persicae*).

symptomless infected plants and plants of the same cultivar with obvious symptoms. The difference in symptom severity persisted until the end of July but in August characteristic symptoms developed in the plants that previously showed few or no symptoms. Thus one result of late season spread of PLRV in seed crops would be that secondary symptoms in the following year are very slow to develop, especially in some resistant cultivars, and therefore that roguing will be inefficient and not all PLRV sources in the crop will be removed.

(H. Barker)

Production and properties of monoclonal antibodies to potato leafroll luteovirus (PLRV) [PU 13(k)]

The specificity of a monoclonal antibody (MAb) for a small region of a protein antigen known as an epitope is a great advantage where variants of a virus need to be distinguished but it can be a disadvantage where the aim is to detect any virus variant that may be present. The strength and pattern of reactivity of individual MAbs and the extent of antigenic variation in each virus therefore have to be assessed. This is being done for PLRV.

Ten stable hybridoma cell lines secreting mouse MAbs to PLRV were produced. All MAbs were of the IgG immunoglobulin class; MAbs 7, 8 and 10 were of the IgG1 subclass, MAbs 1, 2, 3, 4, 5 and 9 were of the IgG2a subclass, and MAb 6 was of the IgG2b subclass. The ten cell lines were used to produce ascitic fluids in pristane-primed BALB/c mice. None of the MAbs gave a precipitin reaction with purified PLRV particles in agarose gel double diffusion serological tests. However, with an indirect ELISA, in which bound antibody was detected with a rabbit anti-mouse IgG-alkaline phosphatase conjugate, all ten MAbs readily detected intact virus particles bound to the microtitre plates, but MAbs 6, 7, 8 and 10 did not react with dissociated virus particles. All MAbs could detect PLRV particles trapped from sap of infected *Physalis floridana* or potato by a layer of rabbit polyclonal antibodies.

Isolates of PLRV proved to be remarkably uniform antigenically. By comparing their relative reactivity with different MAbs and with polyclonal antibodies, no antigenic differences were detected between two PLRV isolates differing in symptom severity in field-grown potatoes, five isolates differing in symptom severity in *P. floridana* grown in the glasshouse, or 29 isolates from different naturally infected potato cultivars. However, MAbs 8 and 10 scarcely reacted with one PLRV isolate, which initial tests showed is not readily transmissible by *Myzus persicae*. The same two MAbs reacted only weakly with purified particles of strain 15, an isolate previously shown (*Ann. Rep. 1980*, 105) to be poorly transmitted by aphids, but they reacted strongly with purified preparations of four isolates that are readily aphid-transmissible.

All MAbs reacted with two isolates of PLRV[†] from potato in Australia, although MAbs 8 and 10 reacted only about half as strongly with these isolates as they did with typical British isolates. Similarly, all MAbs reacted with nine Australian isolates of the tomato yellow top strain of PLRV[†], although MAbs 8 and 10 again reacted weakly compared to the polyclonal antibody control. None of the MAbs reacted with the F or B isolates of barley yellow dwarf luteovirus, provided by L. Torrance¹, or with an isolate of beet western yellows luteovirus provided by D. Walkey². It is concluded that MAbs 8 and 10 are directed against the most variable epitope(s) in PLRV coat protein and that these epitopes may play a key roll in transmission by aphids.

(P. R. Massalski, J. E. Thomas³, B. D. Harrison)

Weeds in the ecology of potato leafroll luteovirus (PLRV) [PU 13(k)]

As previously reported (*Ann. Rep. 1984*, 196), PLRV could be transmitted in the glasshouse from infected shepherd's purse (*Capsella bursa-pastoris*) to potato using *Myzus persicae*, suggesting a possible role for weeds in the field ecology of the virus. However, in field plots, no PLRV infection was detected by ELISA in 30 potato plants, each surrounded from emergence by eight PLRV-infected shepherd's purse seedlings, and nor was infection found in the progeny of these potato plants. The virus was detected by ELISA in 3.5% (4/116) shepherd's purse seedlings growing in a field plot containing PLRV-infected potato plants, but was not detected in 25 plants of each of 10 other common weed species growing in the same plot. PLRV reaches only a low concentration in shepherd's purse, which is therefore a weak source of inoculum for aphids. This probably explains the lack of transmission from shepherd's purse to potato in the field, and shepherd's purse seems unlikely to play an important part in the ecology of PLRV in Scotland.

(P. R. Massalski, B. D. Harrison)

Inability of beet western yellows luteovirus (BWYV) isolates to infect potato [PU 13(k)]

Leafroll is an economically important disease of potato worldwide and is considered by most workers to be caused by potato leafroll luteovirus (PLRV). However, a few reports, notably from the western United States and Tasmania, that the disease can also be caused by BWYV, which in Britain is widespread in crops such as sugar beet and oil seed rape, prompted tests to ascertain whether such infected crops present a threat to nearby seed potato crops. Four British potato cultivars were tested extensively as possible hosts for two isolates of BWYV originally obtained from sugar beet and oil seed rape in England. Neither isolate

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¹MAFF, Harpenden

²NVRS

³Visiting Worker

was transmitted by large numbers of viruliferous *Myzus persicae* to young virus-free potato plants of cultivars Maris Piper, Kerr's Pink, King Edward and Pentland Crown as indicated by ELISA, by ISEM tests or by return inoculation to indicator plants using *M. persicae*. Similarly, no evidence was obtained that BWYV can infect potato in association with PLRV. There is therefore no evidence that British strains of BWYV pose a threat to the potato crop in this country.

(H. Barker)

Cassava viruses from South America [PU 12(a)]

The potexvirus transmitted previously from cassava plants with frogskin disease obtained from CIAT, Colombia, was named cassava X virus* (CsXV). Virus particles contained a single protein species of estimated mol.wt. 26,000 and single-stranded RNA with a mol.wt. of 2.0×10^6 , estimated after glyoxylation. Although CsXV is serologically related to some other potexviruses, no relationship was detected with chaya mosaic virus, a potexvirus recently found in chaya (an euphorbiaceous species) in Florida. CsXV was transmitted by mechanical inoculation from herbaceous test plants to several cassava cultivars, including one (cv. Secundina) that quickly develops obvious leaf symptoms when grown in areas where frogskin disease is spreading rapidly. However, no leaf symptoms developed in any of the mechanically inoculated cultivars. This suggests that CsXV does not cause frogskin disease on its own but the possibility is not excluded that it is a component of a frogskin-inducing complex. Indeed, a second virus with filamentous particles has now been detected in frogskin-affected plants and is being characterised. This virus and CsXV both are serologically distinct from cassava common mosaic potexvirus, and cassava plants containing CsXV were readily infected by mechanical inoculation with cassava common mosaic potexvirus.

Characterisation has also begun of a virus mechanically transmitted to *Chenopodium quinoa* plants from cassava with caribbean mosaic*, a widespread disease in the northern coastal region of Colombia.

(A. M. Lennon, M. M. Aiton, B. D. Harrison)

A cassava virus from the Solomon Islands [PU 12(a)]

The virus obtained previously from mottled leaves of cassava from the Solomon Islands was named cassava green mottle virus* (CGMV). It was mechanically transmitted to a wide range of species, in many of which it initially caused severe systemic symptoms whereas leaves developing later were almost symptomless. The virus produced countable local lesions in *Chenopodium quinoa* and was propagated in *Nicotiana clevelandii*. When transmitted back to cassava, 2-5 months elapsed before systemic mottling developed; subsequently, symptomless leaves were produced in which the virus could still be detected easily. CGMV was not transmitted by *Myzus persicae* but was seed-transmitted in *N. clevelandii*.

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Purified preparations of the 30 nm-diameter isometric virus particles contained two main nucleoprotein components. These were composed respectively of single-stranded RNA of mol.wt. about 2.3×10^6 and 2.9×10^6 , packaged in coat protein of mol.wt. 53,000. An antiserum prepared to CGMV particles had a titre of 1/1000 in gel diffusion precipitin tests and proved suitable for detecting CGMV in cassava and herbaceous test plants both by ELISA and by ISEM. CGMV resembles nepoviruses in its wide host range, symptom type, seed transmissibility, particle properties, and coat protein and RNA sizes. However, CGMV particles did not react with antisera to any of 19 nepoviruses.

(A. M. Lennon, M. M. Aiton, B. D. Harrison)

Cassava viruses from Africa [PU 12(a)]

Cassava brown streak is a disease found in parts of East Africa and thought to be caused by a whitefly-transmitted virus. Other workers have shown that affected plants contain a sap-transmissible virus but this has not been characterised in detail. Clones of three cassava cultivars with typical brown streak symptoms*, obtained from I. A. D. Robertson¹, each contained two viruses that were mechanically transmissible to *Nicotiana benthamiana*. The first virus, referred to as cassava brown streak virus (CBSV), infected several species in the Solanaceae systemically and some in the Chenopodiaceae locally. *N. benthamiana* and *N. debneyi* were used to propagate the virus and *N. debneyi* was also used as a local lesion host. The virus particles, slightly flexuous filaments 650-690 nm long, were purified by a method that included clarification of leaf extracts with silver nitrate and chloroform, and precipitation of the virus with polyethylene glycol. An antiserum with a microprecipitin titre of 1/1000 was prepared and used in ELISA and ISEM tests, which detected the virus readily in *N. benthamiana* and erratically in cassava. Both tests also detected a distant relationship between CBSV and cowpea mild mottle, a whitefly-transmitted virus tentatively assigned to the carlavirus group.

The second virus had the same host range as CBSV but somewhat longer particles that broke easily and reacted with antiserum to wild potato mosaic potyvirus in ISEM tests. Moreover, in sections of infected *N. benthamiana* leaf tissue, numerous pinwheels were observed, suggestive of potyvirus infection. Neither virus was transmitted by *Myzus persicae*, or through seed of *N. benthamiana* or *N. debneyi*, and no differential host has been found. The association of these two viruses in all three cassava sources examined and the similarity in their host ranges suggest that both may be necessary components of a virus complex that causes brown streak disease.

(A. M. Lennon, M. M. Aiton, B. D. Harrison)

*Held under DAFS licence

¹CIBC, Muguga, Kenya

Third country quarantine of cassava [PU 12(a)]

To assist in the transfer of cassava germplasm from Africa to South America without the risk of introducing exotic pathogens, a series of screening tests was devised for use in an intermediate country. The cassava genotypes were received from IITA, Nigeria, as aseptic plantlets, and subcultures were established in pots, observed for virus-like symptoms and tested by ELISA for African cassava mosaic, cassava brown streak, cassava common mosaic, cassava green mottle and cassava X viruses. Leaf extracts were inoculated to indicator plants and examined for virus-like particles by electron microscopy and ISEM, and spot hybridisation tests were done for African cassava mosaic virus. No infection was detected in the first batch of material tested and sister subclones were sent to G. G. Henshaw¹ for reculturing and dispatch to CIAT, Colombia.

(A. M. Lennon, M. M. Aiton, B. D. Harrison)

Detection of viruses in brassicas [PU 10(d)]

ELISA provides the plant breeder with a ready means of screening large numbers of plants for virus infection whereas most other methods are more time consuming and costly. This assay procedure, already provided for the detection of turnip crinkle virus, was made available for the detection of turnip mosaic potyvirus (TuMV) and turnip yellow mosaic tymovirus (TYMV). The TuMV test will be used by Forage Brassica Breeding Department in studies on the inheritance in swede of resistance to infection with the virus. The TYMV test was used in seed-transmission experiments with *Brassica campestris* (*Ann. Rep. 1984, 193*); preliminary trials, in which up to 98 seedlings from each infected mother plant were tested for virus, provided no evidence for seed transmission.

(W. P. Mowat, J. R. T. Hodgkin²)

Using the techniques described previously (*Ann. Rep. 1984, 188*), a search was made for abnormal dsRNA species in leaf tissue of cytoplasmic male sterile (CMS) cabbage and Brussels sprout lines and of their parents, a male fertile line of cabbage or Brussels sprout, and a male sterile radish. Five dsRNA species with estimated mol.wt. (each $\times 10^{-6}$) of 1.96, 1.30, 1.23, 1.14 and 1.08 were detected in CMS radish donor plants but not in the cabbage or Brussels sprout fertile parents. Two dsRNA species with estimated mol.wt. of 2.37×10^6 and 2.31×10^6 , and possibly a third of mol.wt. 2.21×10^6 , were detected in the CMS Brussels sprout line, and in a fertile radish line, but none was detected in the CMS cabbage line. The dsRNA species detected in leaf extracts of the Brussels sprout line were also detected in mesophyll protoplasts from

¹University of Bath

²Forage Brassica Breeding Department

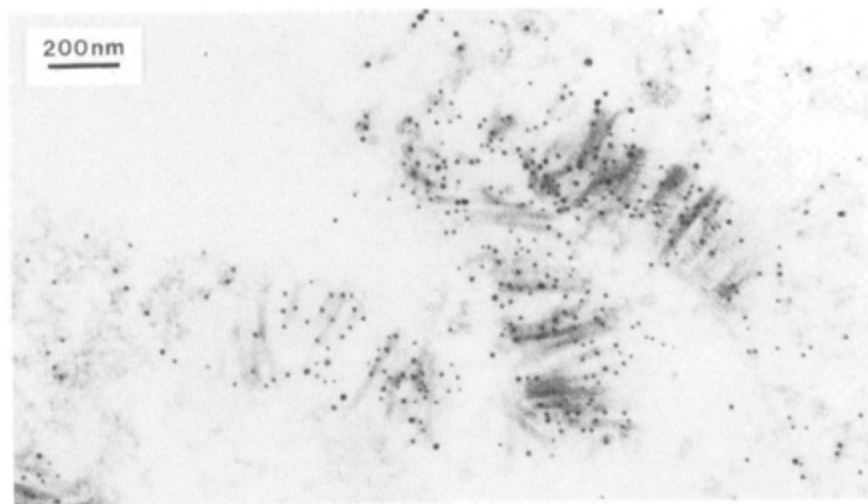
these plants. No dsRNA species were detected in plants of *Brassica napus*, another source of CMS. The dsRNA species detected in the CMS radish donor parent are similar in number and mol.wt. to those of radish yellow edge, a non-sap transmissible virus reported from Japan. The dsRNA species detected in the other plants suggest that these contain another virus or viruses of this type, but there is no evidence that such agents are involved in the CMS condition.

(A. T. Jones, M. A. Abou-Elnasr¹, M. A. Mayo, J. R. T. Hodgkin²)

Immunogold labelling of virus particles in tissue sections [PU 16(b)]

Immunogold labelling is a potentially powerful method for locating viral antigens in cells, but has been little used with plant viruses. In work to devise suitable procedures, thin sections of virus-infected leaf tissue which had been fixed in glutaraldehyde with or without post-fixation with osmium tetroxide, and embedded in Araldite resin, were assessed for labelling of virus particles with antibody followed by protein A/gold (PAG) complexes. Particles of narcissus mosaic potexvirus (NMV) and tulip X potexvirus (TVX) were readily labelled even after post-fixation with osmium tetroxide, whereas those of pepper ringspot tobnavirus* were only well labelled (Fig. 3) when fixed with glutaraldehyde alone. Polyclonal γ -globulin gave better labelling than unfractionated anti-

Figure 3



Electron micrograph of section of leaf cell showing immunogold labelling (black dots) of the rod-shaped particles of pepper ringspot tobnavirus.

¹Visiting Worker

²Forage Brassica Breeding Department

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serum, but antiserum dilution and the time of incubation of sections on drops of antiserum were important. Best results were given by long incubation times (>4 h) and γ -globulin concentrations of c. 10-40 $\mu\text{g}/\text{ml}$. Of three blocking agents tested to decrease non-specific PAG labelling, only bovine serum albumin (BSA) at 0.5-1.0% was effective; buffer containing gelatin, ovalbumin or detergent, and several combinations of these were less satisfactory. Long incubation times (>10 h) with the PAG complex diluted in blocking agent to an OD_{520} value of 0.5 gave best results. Of two PAG complexes containing different sized gold probes (7 and 20 nm diameter), that containing the smaller probe gave the greater label density on sections. To improve further the density and specificity of labelling, several ways of treating sections before incubating them with antiserum and PAG were tried and, of these, floating on 15% (w/v) sodium metaperiodate consistently gave good results. In contrast, hydrogen peroxide treatment gave dirty sections and made post-staining with uranyl acetate and lead citrate more difficult. Work is continuing to improve the specificity and reliability of labelling and to use the technique to study other virus-containing plant material.

(I. M. Roberts)

Scanning electron microscopy of frozen hydrated specimens [PU 16(b)]

The JEOL T200 scanning electron microscope was fitted with an EMSCOPE SP2000 cryogenic preparation system to enable frozen fully hydrated specimens to be examined. Artifacts caused by chemical fixation, dehydration, air drying or critical point drying can therefore be avoided. Specimens can be examined frozen with or without any combination of etching, fracturing and sputter coating, all in carefully controlled conditions.

Initial observations on fungal mycelium and spores, drupelets of raspberry fruit, leaf surfaces, fractured leaves and protoplasts, and nematodes and nematode eggs show that a diverse range of specimens are well preserved and that a wealth of information about them can be obtained.

(G. H. Duncan, B. Williamson¹)

Detection of tobacco rattle tobnavirus (TRV) infections by spot hybridisation [PU 16(c)]

Previous work showed that spot hybridization, using a ³²P-labelled probe prepared by nick-translation of a DNA clone containing part of the nucleotide sequence of RNA-1 of TRV strain SYM, is a reliable method of detecting infections with particle-producing (M-type) isolates of TRV. However, detection of NM-type isolates, which produce only uncoated

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virus RNA, was much less sensitive, partly because hybridisation occurred mostly at the edge of the spot, leaving a clear centre. Reconstruction experiments suggested that this behaviour is a consequence of the stronger binding of protein than of RNA to nitrocellulose. Thus with sap from plants with NM-type infections, plant proteins exclude RNA from binding at the centre of the spot. It seems that, with sap from plants infected with M-type isolates, virus nucleoprotein is initially bound *via* the coat protein and some subsequent step in the treatment of the nitrocellulose makes the virus RNA available for reaction with the probe. As predicted by these findings, NM-type isolates were readily detected in spot hybridisations when extracts were made from infected plants with the aid of phenol.

For routine diagnostic work, it would be convenient to be able to use non-radioactively labelled probes. Accordingly, two such systems were investigated. In the first, an enzyme such as horseradish peroxidase is covalently linked to the cloned DNA probe *via* a polyethyleneimine spacer arm. After hybridisation in the usual way, the enzyme is detected by a specific staining reaction. This method proved to be unsuitable for probing blots of untreated sap because of non-specific binding of the polyethyleneimine spacer to components of uninfected plants. This reaction was not observed on blots made using phenol extracts, but neither was any reaction obtained with phenol extracts from infected plants, suggesting that the sensitivity of the method is very low. In the second system, the probe is labelled using a photo-reactive derivative of biotin and, after hybridisation, the bound probe is located by reaction with an avidin-alkaline phosphatase complex followed by staining for the enzyme. This method also produced undesired reactions with blots of untreated sap from uninfected plants. However, when blots were made using phenol extracts, the probe reacted with virus-infected but not with healthy samples, although the sensitivity of detection of viral RNA was much less than that obtained with a ^{32}P -labelled probe.

(D. J. Robinson)

Detection of virus relationships by immunoblotting [PU 16(c)]

Many antisera raised against particles of plant viruses will react with virus coat protein that is bound to nitrocellulose after electroelution from acrylamide gels following electrophoresis in SDS. The applicability of this method to the detection of relationships among three isolates of peanut clump furovirus* (PCV) from India and one from West Africa was assessed using ^{125}I -labelled protein A to detect bound antibody. Immunoblots of protein from particles of PCV strain L reacted very strongly with antisera to strains L and H, moderately strongly with antiserum to strain B and positively though less strongly with antiserum

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to a West African strain. The sensitivity of the method is illustrated by the fact that none of these relationships was detected by ISEM in earlier work. However, no reaction was detected between protein of PCV strain L and antisera to either potato mop-top or soil-borne wheat mosaic furoviruses.

(M. A. Mayo)

Anomalous reactions of root extracts in ELISA [PU 16(c)]

In experiments to study the transmission of nepoviruses to bait plants by nematodes, anomalous results were obtained in $F(ab')_2$ ELISA using the horseradish peroxidase (HRP) system for detecting the viruses in extracts of roots of *Chenopodium quinoa*, cucumber and petunia. High A_{450} values were obtained whether or not the roots contained the virus that was the subject of the test. In more detailed tests on root extracts from cucumber and petunia plants, high A_{450} values were given by healthy plants following transplanting, or after mechanical inoculation of their cotyledons or leaves with buffer or virus-containing sap. This effect was detectable by ELISA using either homologous or heterologous polyclonal antibody to a range of nepoviruses, or polyclonal antibody to black raspberry necrosis virus, or a monoclonal antibody to raspberry bushy dwarf virus (supplied by R. R. Martin¹). No such effect was detectable with these antisera when extracts from leaves or cotyledons of the same plants were used, when the root extracts were diluted to 1:50, or when root extracts from raspberry or strawberry were tested. More importantly, no anomalous effects occurred when the alkaline phosphatase version of $F(ab')_2$ ELISA was used. These results indicate that roots of some healthy cucumber and petunia plants contain oxidising activity which is boosted substantially by mechanical injury to leaves or roots, and/or by virus infection. The HRP version of ELISA is therefore unsuitable for virus detection in root extracts from these two species.

(A. T. Jones, M. J. Mitchell, D. J. F. Brown²)

dsRNA species in strawberry affected by June yellows [PU 16(c)]

In the past 2-3 years, June yellows has become a serious problem in some strawberry cultivars in the UK. This condition is pollen- and seed-borne but little is known about its cause despite intermittent investigations over many years. As a new approach, affected strawberry leaf was analysed for abnormal dsRNA species of the kinds that are associated with virus infection. Difficulties in preparing suitable dsRNA samples for gel electrophoresis, caused by mucilaginous material in strawberry sap, were largely overcome by using a large volume of extraction buffer (3-5 ml buffer: 1 g leaf) and by two successive adsorptions on cellulose powder and elutions of the dsRNA. Small quantities of several dsRNA species with

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mol.wt. of 1.0×10^6 to 3.5×10^6 were detected in yellows-affected plants of the cultivars Cambridge Favourite, Domanil and Tyee; no dsRNA species greater than 1.0×10^6 mol.wt. was detected in healthy 'green' clones of the cultivars Cambridge Favourite, Marmion, Silver Jubilee and Tantallon kept in the glasshouse, in symptom-free Cambridge Favourite plants growing in the field, or in healthy or strawberry mottle virus-infected *Fragaria vesca*. Further studies are necessary to ascertain whether the large mol.wt. dsRNA species found in June yellows-affected plants are specifically associated with this condition.

(A. T. Jones, M. J. Mitchell, M. A. Mayo, M. A. Abou-Elnasr¹)

Lucerne Australian symptomless virus* (LASV) [PU 16(c)]

This virus, isolated from symptomless lucerne in Australia, was shown previously to have isometric particles c. 28 nm in diameter with a sedimentation coefficient of c. 130 S and to contain two polypeptides of estimated mol.wt. 26,000 and 40,000 (*Ann. Rep.* 1983, 191). Further tests showed that these particles contain two ssRNA species which, when denatured in glyoxal, had estimated mol.wt. of 2.5×10^6 and 1.4×10^6 . The infectivity of non-denatured RNA was abolished by incubation with proteinase K. These properties, together with the serological data reported earlier, distinguish LASV from lucerne Australian latent virus and from all recognised nepoviruses and comoviruses. However, its particle properties and composition resemble those of two tentative nepoviruses, strawberry latent ringspot and rubus Chinese seed-borne viruses, and these three viruses may comprise a distinct virus group or nepovirus sub-group. Arracacha virus B*, a possible fourth member of this group, has particles with a sedimentation coefficient of 126 S and was shown to contain ssRNA of estimated mol.wt. 2.5×10^6 and 1.25×10^6 but has polypeptides of mol.wt. 21,000 and 26,000. Purified particles of LASV failed to react with antiserum to any of these three viruses or to broad bean wilt virus.

(A. T. Jones, M. J. Mitchell)

Parsley latent virus (PLV) in parsley seed [PU 16(c)]

About 66% of seedlings grown from a commercial stock of parsley seed (Sutton's Claudia D4) were found to be infected with parsley latent virus (PLV), which was reported by Bos, Huttinga & Maat (*Netherlands Journal of Plant Pathology* 85: 125, 1979) to be common in parsley seed stocks. However an isolate from one of these seedlings infected several plant species that were not infected by the isolate of Bos *et al.*, notably *Nicotiana clevelandii*, *N. debneyi*, *N. glutinosa*, *N. rustica*, *N. tabacum* cv. Samsun, *Petunia hybrida* (all symptomlessly infected) and *Chenopodium murale* (local lesions and severe systemic necrosis).

(A. F. Murant, G. H. Duncan)

¹Visiting Worker

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A possible new virus from plum in Poland [PU 16(c)]

A virus associated with a severe disease of plum in Poland was at first thought to be raspberry ringspot virus (RRV) because it reacted in gel diffusion tests with a Polish antiserum to an isolate of RRV from forsythia. Tests at SCRI in collaboration with B. Zawadska¹ showed that the plum virus* is unrelated to RRV and that the Polish antiserum contains antibodies to this virus as well as to RRV. The plum virus has non-angular particles *c.* 29 nm in diameter (somewhat larger than those of RRV) which are not penetrated by negative stain. Purified preparations of these particles yielded a single sedimenting component with a sedimentation coefficient ($s_{20,w}^0$) of 116S, and containing protein of mol.wt. 39,000 and RNA species of mol.wt. 1.3×10^6 and 0.5×10^6 , estimated by electrophoresis in 0.75% agarose gels after denaturation with glyoxal. In addition, there were small amounts of several RNA species of intermediate mobility. In its particle properties the plum virus resembles elderberry latent virus (ELV), or possibly the dianthoviruses, although it is unlike any definitive dianthovirus in host range and symptomatology. Serological tests have not revealed any relationship to ELV or to several members of the dianthovirus and tombusvirus groups, and the virus may be previously undescribed.

(A. F. Murant, J. H. Raschké, I. M. Roberts, G. H. Duncan)

*Held under DAFS licence

¹Institute of Pomology, Skierniowice, Poland

ESTATE

W. I. A. JACK

Mylnefield

The new propagation glasshouse/potting shed complex, extending to 1314 m² was commissioned in March. The centralised facilities are excellent for all aspects of plant production and stock holding, and include some insect-proof glasshouses, glasshouses with computerised control of heating, ventilation, supplementary lighting and carbon dioxide enrichment, a stores, and a potting shed with adequate space for soil mixing and storage.

Progress was maintained towards establishing a regime for the Institutes farms in which 17 land 'packages' each of c. 10 ha grow a single crop. This provides an inbuilt flexibility of the cropping system that enables a prompt response to changing demands of the research programme, and the success of this approach was evidenced when the Cereal Breeding Department transferred to Dundee, and their requirement for land for field trials was readily fulfilled.

Cool, wet and sunless was the weather pattern of the year, especially during the critical months of June to September. However the early indications for crops led to optimism so far as prospective yield and quality were concerned. However, thinking changed dramatically once harvesting started, with frustration and despair increasing daily as the harvests progressed, starting with the soft fruit right through to the cereals, leaving behind a trail of rutted fields and rotten or poor quality produce. Good weather in October gave almost perfect conditions for potato harvesting; however, once the crop was in store for a few weeks problems appeared, with soft rots taking a heavy toll. The final overall view of cropping performance at the Institute was that although poor, the harvest turned out better than had at one time been thought possible.

Farm crops and field experiments

There was a total of 237 field experiments and off station trials, a decrease of two compared with 1984. Forty-one different crops were grown, using 86 management schemes with many special requirements utilising 23 fertiliser and trace element formulations, 42 herbicides, 22 insecticides, 18 fungicides, and several experimental chemicals supplied by sponsors of field trials. The crops grown included 11 ha raspberry, 8 ha black currant, 1.5 ha strawberry, 1.25 ha black and hybridberry,

8.5 ha brassica, 8.5 ha potato, 3.75 ha cereal, 1.5 ha field bean and pea, with a miscellany of minor crops occupying a further 4 ha. This is an increase overall of 5.75 ha on the previous year.

Servicing requirements for the programme of field experiments as a whole have continued to become more diverse and more specialised, and this imposes increasingly severe demands on manpower, materials and money within the Department. Also the drilling or planting of crops now occupy every month from February through to December, and harvesting the same crops occupy every month from June through to the following April; ending with overwintered brassica. Standard management and special inputs for these annual and perennial crops, together with off station trials and minor crops also continue throughout the calendar year, while the supervision of harvesting squads, the collection of records for many sponsors of field experiments, and general maintenance duties serve to more than fill the year.

Several special projects were undertaken: mildew, yellow rust and leaf blotch cereal disease nurseries were established; a comprehensive report on the provision of water supplies to service irrigation requirements at Gourdie Farm and North Bullion, and updating and expansion of existing system at Mylnefield, was completed; investigation of geographical/climatological effects on the germination of *Claviceps purpurea* sclerotia from a variety of sources was continued in co-operation with J. R. Coley-Smith¹; and work continued on the exploitation of facilities provided by a microcomputer which has resulted in the field experiment forms, and the whole SCRI field experiments index book, being stored on diskette ready for rapid recall, amendment, and printing.

(G. Wood)

Farm crops included 50.6 ha barley, 44.5 ha winter wheat, 24.8 ha grass, 3.4 ha field bean, 1.5 ha potato and 17.6 ha fallow; this is an increase of 7.8 ha from 1984.

Barley cv. Tweed sowing started on 11 March into average seed bed conditions and continued until the 14 March when adverse weather conditions intervened, and was eventually completed on the 21 April. Germination and the establishment of correct plant populations were satisfactory and subsequent growth was good, certainly better than was expected in the dull wet and cool growing conditions that prevailed throughout the year; mildew (*Erysiphe graminis*) was evident in all fields in mid June and required an application of tridemorph (Calixin) to control the disease. Harvesting starting on the 4 September, took 35 days to complete under the worst harvesting conditions in memory. The yield of 4.5 t/ha although up 0.3 t/ha on the previous year did not give the true picture of the potential yield of this cultivar, as it was estimated that

¹Department of Plant Biology & Genetics, University of Hull

a third of the crop was lost due to lodging, shedding, and where combining could not take place due to ground conditions. Grain samples in general were good but of a high nitrogen content and with a moisture content averaging 22.6%; only 45% of the crop was sold for malting.

Wheat cultivars Stetson and Avalon which were sown in the autumn of 1984 overwintered well and plant populations were satisfactory in the spring. The customary high input strategy including rigorous pest and disease control was practised, except that the final nitrogen application was not applied because of the prevailing weather conditions at that time. Harvesting started on the 14 September and was completed on the 7 October, under difficult conditions. The yield 5.5 t/ha was down 0.9 t/ha from the previous year, again with an estimated 30% left in the field; the grain samples were of fair quality but low in protein value, and all was sold for feeding.

Grass grew well in the early part of the year with a good crop of hay in prospect. However, once cutting started on 17 June the rain never ceased, and after 5 weeks 6 t/ha had been carted, down 0.4 t/ha on the previous year. The quality ranging from poor to compost and at the end of the season almost 40% of the crop had to be returned to the field for ploughing in.

Field bean cultivars Herz Freya and Alfred were sown on 11 March into good seedbed conditions. The crop got away to a good start and maintained growth throughout with plant populations and pod numbers satisfactory, although Herz Freya suffered badly from chocolate spot (*Botrytis fabae*) and from lodging resulting in moderate field losses. The crop was harvested on the 14 October, and the yield of 4.8 t/ha was 3.2 t/ha better than for the previous year.

Soil conditions were almost perfect at potato planting time. The crops of cultivars Maris Bard and Maris Piper progressed well and looked healthy, and protective sprays against pests and diseases were applied throughout the growing season. Lifting started on 12 July and continued until the 16 December; however, had it not been for the dry October coupled with an extension of the local school holidays we would have been in a very serious position in getting the crop lifted from difficult land conditions. The keeping quality of the harvested crop was much in doubt, and as this proved the case, the crop had to be double dressed to obtain a reasonable market sample, and in the end 37.5% of the stored crop was discarded. The yield for Maris Piper at 49.4 t/ha was 17 t/ha better than for the previous year.

Fruit picking started with strawberry on 3 July, followed by raspberry 17 July, black currant 17 July, Tayberry 24 July, hybridberry 15 August, blackberry 20 August and blueberry 30 August. The weather was the worst experienced for many years, and had it not been for adequate number of pickers throughout the season the losses from grey mould

would have been much higher than those estimated of 33% for strawberry and 20% for raspberry; another problem encountered was the shorter shelf life of the picked fruit. The fruit crop sold included 29.6 t raspberry, 4.2 t strawberry, 0.4 t black currant, 0.5 t of other fruits. This was a decrease of 7.1 t compared with 1984, largely due to a reduction in the area of raspberry grown at Lonsdale.

The protracted harvest and wet ground conditions seriously upset the autumn schedule of work, and straw chopping and incorporation, and ploughing for winter cereals, took preference over the traditional programme of stubble cleaning and sub-soiling. Winter barley trials were sown starting on 29 September and carried on through October, and 33.4 ha of winter wheat was sown by the 11 November; the winter barley crops established well and entered winter in fine fettle, however, the same could not be said for the winter wheat, which was thin and lacked vigour.

Estate work was confined to repairing and installing field drains and the trimming of windbreaks. New farm roadways were constructed at Gourdie Farm and the rear entrance roadway to the Institute was realigned and surfaced.

With the loss of the tenancy of Kingoodie Quarry as a dump, a midden was constructed to take the spoil from the glasshouses and crop handling buildings.

New farm equipment acquired during the year included a MF 250 tractor and a tractor-mounted sprayer with accessories.

(W. I. A. Jack)

Glasshouses

The glasshouse department moved into their new propagation/potting shed/stores complex, starting in March, and this was accomplished over 4 busy spring months without any disruption to the requirements of the scientific departments. The complex provides modern and efficient working facilities for large scale plant production with the view to a rapid throughput of containerised plants.

Plant production at 151,477 units was 10,132 up on the 1984 total, an increase of 7.2%. Departmental totals were 61,260 Virology, 19,498 for Soft Fruit Breeding, 16,282 for Zoology, 14,169 for Estate, 13,512 for Mycology and Bacteriology, 9,834 for ODA, 9,398 for Forage Brassica Breeding, 6,165 for Cereal Breeding and 909 for Physiology and Crop Production.

Other projects included the maintenance of 131 cultivars and advanced selections of virus-free nuclear stock of raspberry and hybridberry for the production of root material, and root from 15 cultivars was dispatched to NSDO for the production of 17,150 plants and enough root from 32 cultivars was dispatched to various organisations to produce 350 plants.

Stock was maintained of a further 127 cultivars and advanced selection, at various stages of testing for freedom from viruses.

The move into new buildings afforded the opportunity to reorganise a seed bank of 167 species.

During the year two mist and one dry bench propagation units were constructed within the new glasshouse complex; five tunnels were constructed, four for Brassica Breeding Department and one for Virology's narcissus bulb production; a glasshouse was dismantled and rebuilt close to the new glasshouses; some draining work done and improvements made to the water supply, and windbreaks planted, all in the plastic tunnel area in South Bullionfield.

(R. D. Taylor)

The Murrays Farm

In late 1984 the weather turned cold and very wet, a pattern that was to prevail throughout winter, spring and the complete 1985 growing period. July, August and September were disastrously wet with violent winds causing havoc to the winter wheat in particular.

The rainfall was for some months over 200% above the 30 year average in parts of south-east Scotland. Surprisingly, harvesting the spring-sown cereal crop was relatively straightforward although the opportunities were few and in the main confined to the afternoons following evening and overnight rain. Harvesting the later badly lodged winter wheats was very different.

Cereal trials and experiments were grown in Crowfield, while related pure stocks were to the east in Wallfield which also contained the winter trials and experiments. The farmer/grower plots of State bred spring and winter cereal cultivars were demonstrated by NSDO in the Westerby Crow reserve field.

Spring drilling was completed slightly later than usual and the plots were harvested mainly in September. The weaker and longer strawed genotypes were by then badly lodged, with second growth and sprouting in the ear, and getting sufficient combine traction was difficult. Hand pulling was less affected by the weather but sheaves required drying for safe storage. The winter trials stood well compared to the commercial crops in adjacent fields. The favourable conditions of 1984 strongly influenced thinking about the '85 season. The '84 harvest was both fruitful and painless, and plans were formulated for record yields from both spring and winter corn. The terribly wet conditions changed that dramatically, especially affecting the performance of the winter wheats leaving one considering how best to salvage the completely laid crops.

The spring barley cultivars Heriot, Tweed, Doublet and Corgi were grown and sold for malting. Yields averaged 6.13 ha with 1.6% nitrogen.

Heriot, Doublet and Corgi required the application of a fungicide for mildew, and the control was good. No further treatments were required. The major disease was *Rhynchosporium* on Tweed, which was difficult to control in conditions which were constantly ideal for its development. Straw was sold for feed where possible, and for bedding, but as conditions deteriorated some was reluctantly burnt. The winter wheat cultivars Longbow, Galahad and Renard were grown. These overwintered well and responded to a spring top-dressing but excellent stands with tremendous head density potential had a lushness that was to fall foul of the inclement weather. Applications of straw 'shorteners' were planned but when the appropriate growth stages were reached conditions were such that the crop could not be sprayed. The crops remained standing until July indicating the inherent stiffness of the cultivars chosen, considering that approaching 500 units/ha of nitrogen had been applied. Severe lodging took place in mid-July and the crop was not to recover.

Nevertheless the crop continued to look promising until the incessant rains of September induced sprouting in the ear. Combining was slow and tedious with moisture contents over 25%. The farm drying system was unable to handle grain in this condition and the crop was sold off the field. Yields averaged 8.8 t/ha – satisfactory given the conditions. No major machinery problems were encountered but everything operated painfully slowly adding to the tedium of a real harvest.

Potato trials were grown in Longriggs field, early material in the southern portion, maincrop trials in the mid and northern portions of the field. The crop grew well and only minimal pesticide use was required to keep the field free from all disease. Fortunately, sufficient good weather windows allowed the application of these sprays and finally a desiccant prior to harvest. The crop was fairly easily harvested in the wet conditions although mud on the tubers was a problem at times.

Brassica cultivar trials were sited in the north-west part of Longriggs field; three crops were under test – swede, kale and rape. The kale grew well initially but growth slowed later in the season when the ground became extremely wet and yields were disappointing. The swede trial did moderately well and appeared less affected by the constant inclement weather. Unfortunately, the rape required re-drilling following poor establishment and pigeon damage.

Twenty-five hectares of winter wheat cv. Brimstone has been drilled this autumn into fairly poor seed beds. Unfortunately following the late harvest we were not in a position to take advantage of the fairly dry October.

Cottage and Loan fields were let for grazing in 1985, but hay will be taken in 1986.

(I. M. Chapman)

INFORMATION SERVICES

R. J. A. EXLEY

It is widely accepted that scale usually offers economies, and the continuing increase in staff at Invergowrie, largely due to the merger of the institutes in 1981, is predictably generating greater demands on support services. The number of jobs done by Visual Aids has increased by almost 30% since 1981 and the demands on the Library, although more mechanistic, have also increased substantially.

Interestingly, although the greater application of technology may offer the prospect of increased productivity, for instance in the preparation of graphics, similar technology is increasing the demand for service in other areas for instance literature searches by the Librarian. However, the greatest opportunity for maintaining the quality of service lies with the users, particularly by knowing in advance exactly what it is they require and as far as graphics are concerned by the meticulous preparation of drafts. Additionally, and as mentioned previously (*SHRI Ann. Rep. 1975, 97*), the widely differing demands for finished artwork of the many journals in which staff publish is an anachronism, and an impedence that staff with editorial influence should endeavour to eliminate.

LIBRARY

Mylnefield

After spending a year in temporary and dispersed accommodation while a new administration wing was built, the Mylnefield Library was moved back in August, and after various delays it was in normal operation again by December. As a result of the alterations the main part of the library now has had to accommodate four extra structural pillars, but two small rooms have been added one of which is used to house special collections and a computer terminal and the other as a store. The opportunity was taken to redesign the layout of the library thereby eliminating a passageway, the shelving accommodation for journals was extended, and the office was moved to an enhanced location by the main library entrance. Also while journals were being moved the opportunity was taken to shelve all pre-1960 runs in the mobile shelving.

At the end of the year, 33 staff at Mylnefield received the Current Awareness Bulletin and 68 received circulated journals. 442 items were borrowed from stock and 1427 were obtained by interlibrary loan. This change in the loan figures reflects the inaccessibility of part of the stock

during the year, and consequent need to borrow externally. There were 13 computerised full literature searches as well as other brief searches, and an automated literature search (SDI: selected dissemination of information) on raspberry breeding was set up on DIALOG.

The Scottish Agricultural Librarians Group (SALG) meetings, the NLS Interlibrary Lending Seminar and the Scottish Library Association's Annual General Meeting were attended. The autumn meeting of SALG took place on 1st November at Mylnefield; the programme included a talk on the work of the Institute, and a talk on the Data Protection Act and its relevance to libraries by R. White, lecturer in the Department of Jurisprudence of the University of Dundee.

(U. M. McKean)

Pentlandfield

Most of the books and journals concerned with cereals were transferred to the Mylnefield library in October, following the departure of the Cereal Breeding Department.

The cancellation of some duplicated journal subscriptions was agreed between the libraries, and Pentlandfield cancelled 19 titles, and transferred to Mylnefield 13 titles previously held only at Pentlandfield. A system of exchanging contents pages of previously duplicated journals is now in operation. Certain periodicals of short-term current interest are exchanged after a 2-week display period in the subscribing library.

The number of internal loans dropped 186, but inter-library loans (187 from the British Library, 56 from other libraries) slightly increased. Literature searches online numbered 15, and there were twelve other detailed enquiries. Fifty-five books were purchased.

The Librarian attended two meetings of the Scottish Agricultural Librarians Group and one half-day Dialog Refresher Course.

(E. W. Vandome)

VISUAL AIDS

Production figures for the year in photography and graphics show increases of 11 and 25% respectively.

	PHOTOGRAPHY					GRAPHICS	
	<i>Jobs</i>	<i>Colour</i>	<i>Monochrome</i>	<i>Diazo</i>	<i>EM/Prints</i>	<i>Jobs</i>	<i>Graphics</i>
1984	2012	6706	9354	814	2076	104	611
1985	2068	7538	10365	844	1986	218	756

During the year black and white infra-red photography was used to assess total ground cover in winter barley plots and monitor frost damage in winter and regrowth in spring, and to record, non-destructively, the expansion of potato canopies that were healthy or infected with potato leafroll virus; in both instances the photographs were for analysis by the

Quantimet image analyser. As part of a study on the dispersal of spores of *Botrytis* in wind, sporulating mycelium of *Botrytis fabae* and *B. cinerea* were blown with puffs of air from a photographic dusting brush and the effects filmed with a colour TV camera and recorded with VHS equipment. The recordings were played at normal and reduced speed for analysis at a monitor screen magnification of c. 300 x. Time-lapse video recordings with a new recorder were used in the screening of chemicals for nematocidal action, and it is to be employed in investigation of the feeding behaviour of aphids on susceptible and resistant hosts.

To facilitate the process of putting together a poster demonstration, the largest part being the text, the EMAS Graphics package was employed. The program enabled the text to be printed onto paper by means of a graph plotter allowing a variety of size and colour of lettering, and the system proved to be very helpful in the planning and layout stage.

Early in the year submissions of photographs from all government departments for the national photographic exhibition 'Public Eye—the photography of government' were requested from the Cabinet Office. Seven samples were sent from SCRI, including a photograph of the SCRI swede cultivars Melfort and Angus taken by G. Cruickshank and which was subsequently selected from over 600 submissions for final display. This photograph was also chosen to appear on the cover of an edition of the *British Journal of Photography* as being representative of the high standard of the exhibition.

Many and various displays and posters were produced during the year but worthy of particular note was a large display on potatoes for the EAPR Conference at St. Andrews, which consisted of 16 panels with a total of 64 colour prints, 14 diagrams and accompanying text.

T. G. Geoghegan and M. I. McMaster attended the 'Graphic Design and Reproduction' exhibition, 19 March, at Glasgow.

(T. G. Geoghegan)

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The Society is a specially authorised Society under the provisions of the Friendly Societies Act, 1974. Its objects are the promotion of agriculture, arboriculture, or horticulture and the operations of the Society in carrying out these objects shall be exclusively scientific, and shall be limited to experimental and other research for the improvement of plants and crops in Scotland, investigating conditions affecting their production, and by maintaining an association with the Scottish Crop Research Institute.

Report by the Committee of Management

The Committee of Management met on three occasions (14th March, 29th August and 11th December) during 1985 for the transaction of Society business. There were also meetings of the Crop Sub-Committees on various dates during the year.

The members of the Committee who will retire by rotation with effect from the date of the 1986 Annual General Meeting are Messrs G. Bruce, A. D. Kay, J. McFarlane and J. Niven. Two of the members of the Committee of Management elected during the year (Messrs E. Jeffrey and J. Lind) were in the event unable to accept office. Mr A. Leith was co-opted to take the place of Mr Lind, but the other vacancy remained unfilled.

Mr A. G. M. Forbes was appointed a Trustee of the Society by resolution of the 1985 AGM in place of Mr J. Arbuckle, CBE.

During the year a number of meetings for members of the Society and guests were organised. These included:—

- (i) a Cereal Varieties Demonstration at The Murrays Farm, Pathhead, on 12th July, in association with the National Seed Development Organisation,
- (ii) The traditional Fruit Walk at Invergowrie on 13th July,
- (iii) a Seed Potato Symposium at the Angus Thistle Hotel, Dundee, on 20th November,
- (iv) arrangements for a half-day Fruit Meeting at Dundee University on 22nd January 1986.

The proceedings of the Seed Potato Symposium will be published in the near future as a Society Bulletin for distribution to members.

An abridged edition of the SCRI Annual Report for 1984 has been published and distributed to members. Anyone who wishes to have a copy of the full Report should apply to the Society Secretary; the cost is £5·00 per copy (postage paid).

The Society gratefully acknowledges the assistance and help given by the Director and staff of the Scottish Crop Research Institute in arranging and presenting these meetings, and in preparation of the Society publications.

During the year the Committee authorised the payment of grants as listed below:—

- (i) *From the General Fund:* £415 to cover the cost of Dr D. L. Jennings (SCRI Soft Fruit Breeding Dept.) attending the Fourth International Rubus and Ribes Symposium in Scandinavia during July/August 1985.

- (ii) *From the Reid & Munro Bequests Fund: £500* towards the cost of Dr A. F. Murrant (SCRI Virology Dept.) attending the Symposia on Small Fruit Virus Diseases and Fruit Tree Virus Diseases held at Bordeaux, France, during June 1985.
- (iii) *From the Thyne Bequest Fund: £325* towards the cost of a visit to the INRA Research Station, Landerneau, France, during September 1985 by Mr G. R. Mackay (SCRI Potato Breeding Dept.).

The 1985 Society Lecture was given on 14th March 1985 by Mr N. P. G. Saphir, Chairman of the Food from Britain organisation, on the topic 'Is British Farming Still Deaf?' Copies of the text of the Lecture have been circulated to members. The Committee has decided that in view of the declining interest in the Annual Lecture shown by members it should be discontinued.

As at 31/12/85 the membership of the Society stood at 530.

METEOROLOGICAL RECORDS

Mylnefield

After a fine April for planting the summer was dull and wet. A large number of rainy days gave harvesting problems for fruit and for the first time for several years the control of potato blight was a problem. Very wet soil conditions in August and September made the harvesting of cereals and potatoes difficult and on some sites there was waterlogging.

Wind

March and June were the calmest for these months since records began and, with the exception of August, windspeeds for all other months were at or below average. As a result this was the second calmest year since our records began, with only 1968 having lower average windspeeds.

Rainfall

In each month from March to September inclusive rainfall was above average and we experienced the wettest July-September period on our records (by 36.1 mm). The high rainfall was due more to frequent rain than to heavy rain; (the months of June to September had respectively, 15, 14, 18 and 15 days on which more than 1 mm of rain fell (56% above average).

Temperature

January was cold with air temperature 1.5°C below average and the highest incidence of ground frost for any month on our records. April and May were slightly warmer than average and from then to September temperatures were below average again. The highest daily maximum for the year was 21.9°C on 25 July and is the lowest value for an annual maximum on our records.

Sunshine and Solar Radiation

June and July gave one of the dullest such periods on our records but, despite the very high number of rainy days, sunshine for August was above average. Incident solar radiation was below average in each of the months June to September.

(D. K. L. MacKerron)

MYLNEFIELD

Temperature

Month	Daily air maxima		Daily air minima		0.1m Soil		0.3m Earth		Accumulated degree days		Days ground frost	Potential evaporation mm	Rainfall		Bright sunshine hours		Mean daily solar radiation		Windspeed	
	Mean °C	DFA*	Mean °C	DFA*	Mean °C	DFA*	Mean °C	DFA*	Above 6°C	Below 6°C			Total mm	DFA*	Total	DFA*	mWh/cm ²	DFA	Mean km/h	DFA†
January	3.6	-1.9	-1.2	-1.2	-0.2	-1.7	2.1	-0.4	1.4	149.4	30	0.0	76.6	+13.8	70.9	+17.8	50	9.7	-3.2	
February	5.7	+0.1	0.1	+0.1	1.3	-0.3	2.3	-0.3	11.4	98.5	21	10.2	10.9	-37.1	58.8	-12.8	101#	11.8	-0.4	
March	7.1	-0.8	1.2	-0.5	3.0	-0.3	4.4	+0.1	15.3	72.4	20	25.5	76.8	+27.9	88.7	-16.6	183	10.3	-4.5	
April	10.9	-0.1	3.8	+0.5	7.1	+0.8	7.2	+0.3	63.7	21.7	10	54.8	50.8	+10.7	123.8	-33.6	317#	13.1	-1.1	
May	13.9	+0.2	6.1	+0.3	10.9	+0.7	9.8	-0.3	130.1	7.0	8	83.5	55.8	+0.2	185.6	+3.4	435	11.0	-1.5	
June	14.8 ¹	-2.1	7.8 ¹	-0.9	13.9 ¹	0.0	12.5 ¹	-1.0	160.6	3.3	3	81.9	57.8	+7.5	165.3	-13.1	467	9.6	-2.2	
July	17.6	-0.9	10.7	+0.5	15.3	0.0	14.5	-0.6	252.5	0.0	0	78.9	101.0	+39.5	133.2	-41.7	392	10.7	0.0	
August	16.7	-1.6	9.4	-0.7	13.4	-1.0	14.0	-0.9	214.5	0.3	1	73.1	99.4	+33.8	173.2	+19.4	351#	12.5	+2.7	
September	15.2	-0.7	8.9	+0.3	11.4	-0.1	12.4	-0.3	181.5	1.3	2	38.0	151.4	+88.3	100.2	-17.9	224#	9.3	-2.0	
October	13.7	+1.2	6.8	+0.6	8.7	+0.6	11.2	+1.5	139.0	7.5	12	19.2	12.1	-49.6	117.3	+26.6	154#	8.4	-3.2	
November	5.8	-2.5	0.1	-2.1	1.9	-2.2	5.2	-0.7	7.8	99.1	26	3.9	64.7	+8.7	73.2	+5.2	71#	8.3	-3.8	
December	7.4	+1.1	1.7	+0.9	3.0	+0.7	4.7	+1.1	32.4	76.2	19	3.9	101.1	+31.3	37.8	-6.1	29	12.5	-0.2	

*DFA Deviation from 1954-1983 average

¹Means calculated for 29 days only

†DFA Deviation from 1959-83 average

#Some values missing - mean calculated from values present

THE MURRAYS FARM

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Month	Mean air temperature °C		Mean soil temperature °C		Number of days air temperature 0°C		Total rainfall mm	Number of wet days >1.0mm
	Max.	Min.	5 cm	10 cm	Air	Grass		
January	3.1	-1.8	0.5	0.9	20	27	41.4	9
February	5.4	-3.8	1.0	1.0	14	20	3.6	1
March	6.5	0.4	2.5	2.7	11	24	78.3	13
April	10.5	3.7	7.4	6.6	3	7	51.4	15
May	12.4	5.5	11.0	9.6	1	4	41.5	9
June	14.8	6.9	14.4	12.7	0	0	61.1	12
July	17.5	10.2	15.6	14.2	0	0	143.5	17
August	16.4	9.5	13.8	12.7	0	0	82.8	19
September	15.6	8.8	12.1	11.3	0	0	123.1	13
October	13.3	7.6	9.4	9.0	0	7	19.1	6
November	5.8	0.9	1.9	2.6	16	22	52.6	12
December	7.4	2.9	3.6	3.8	6	10	72.4	13
Annual total	—	—	—	—	71	121	770.8	139
Annual mean (365 days)	10.7	4.2	7.8	7.3	—	—	—	—

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SCRI CULTIVARS FOR WHICH NSDO HAS
DEVELOPMENTAL RESPONSIBILITY

Spring barley

Ayr
Esk
Heriot
Nairn
Tweed

Potato

Ailsa
Baillie
Croft
Kirsty
Moir
Morag
*Pentland Crown
*Pentland Dell
Pentland Hawk
Pentland Ivory
Pentland Javelin
Pentland Lustre
Pentland Squire
Provost
Rhona

Forage rape

¹Arran

Swede

Angus
Melfort

Turnip

*Appin

Savoy cabbage

*Celtic
*Corsair
*Lundie

Black currant

Ben Lomond
Ben More
Ben Nevis
Ben Sarek

Hybrid berry

*Tayberry
Tummelberry

Raspberry

Glen Clova
Glen Moy
Glen Prosen

Strawberry

Saladin
Silver Jubilee
Tantallon
Troubadour

Lily

Achilles
Pandora
Phoebus

*No Plant Breeder's Right

¹Not on UK National List

LIST OF ABBREVIATIONS

Organisations

AAB	Association of Applied Biologists
ADAS	Agricultural Development and Advisory Service
AFRC	Agricultural and Food Research Council
ASS	Agricultural Scientific Services (DAFS)
ATB	Agricultural Training Board
BAPB	British Association of Plant Breeders
BBC	British Broadcasting Corporation
BCPC	British Crop Protection Council
BSPB	British Society of Plant Pathology
BTG	British Technology Group
CEC	Commission of European Communities
CIAT	Centro Internacional de Agricultura Tropical
CIBC	Commonwealth Institute for Biological Control
COSAC	Council of Scottish Agricultural Colleges
CPRA	Centre de Perfectionnement et de Recyclage Agricole de Saida
CPRI	Central Potato Research Institute
DAFS	Department of Agriculture and Fisheries for Scotland
DANI	Department of Agriculture for Northern Ireland
DSIR	Department of Scientific and Industrial Research
EAPR	European Association for Potato Research
EEC	European Economic Community
EMBO	European Molecular Biology Organisation
EMRS	East Malling Research Station
ERCC	Edinburgh Regional Computing Centre
ESCA	East of Scotland College of Agriculture
FRI	Food Research Institute
GCRI	Glasshouse Crops Research Institute
HFRO	Hill Farming Research Organisation
IBMC	Institut de Biologie Moleculaire et Cellulaire
IBPGR	International Board for Plant Genetic Resources
ICETEX	Instituto Colombiano de Especializacion Tecnica en al Exterior
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IITA	International Institute of Tropical Agriculture
INRA	Institut National de la Recherche Agronomique
IOBC	International Organisation for Biological Control of noxious animals and plants
ISHS	International Society for Horticultural Science
JII	John Innes Institute
LARS	Long Ashton Research Station
MAFF	Ministry of Agriculture, Fisheries and Food
MISR	Macaulay Institute for Soil Research
NATO	North Atlantic Treaty Organisation
NFU	National Farmers Union
NIAB	National Institute of Agricultural Botany
NSCA	North of Scotland College of Agriculture
NSDO	National Seed Development Organisation
NVRS	National Vegetable Research Station

ODA	Overseas Development Administration
ORSTOM	Office de la Recherche Scientifique et Technique d'Outre Mer
PBI	Plant Breeding Institute
PMB	Potato Marketing Board
RES	Rothamsted Experimental Station
RMS	Royal Microscopical Society
SAC	Scottish Agricultural Colleges
SARI	Scottish Agricultural Research Institutes
SEB	Society for Experimental Biology
SERC	Science and Engineering Research Council
SHRI	Scottish Horticultural Research Institute
SNFU	Scottish National Farmers Union
SNSA	Scottish Nuclear Stocks Association
UB	United Biscuits
UCSD	University of California San Diego
UCW	University College of Wales
USA	United States of America
WPBS	Welsh Plant Breeding Station
WRO	Weed Research Organisation
WSAC	West of Scotland Agricultural College

Miscellaneous

ACAS	Agricultural Chemical Approval Scheme
EHF	Experimental Husbandry Farm
EHS	Experimental Husbandry Station
EMAS	Edinburgh Multiple Access (Computer) System
EPPNS	European Plant Parasitic Nematode Survey
IMENS	interactive mapping of the European nematode survey
JMT	joint main trial
NFT	National Fruit Trials
NLT	National List Trial
RCCA	Research Council Co-operative Award
RLT	Recommended List Trial
SDS	scientific data systems
VTSC	virus tested stem cutting

INSTITUTES FOR AGRICULTURAL AND FOOD RESEARCH IN GREAT BRITAIN

The research programmes of all the institutes supported from public funds are co-ordinated by the Agricultural and Food Research Council. Most publish a report annually and details are obtainable from the Secretary of the Institute concerned.

AFRC Institutes

Animal Breeding Research Organisation	King's Buildings, West Mains Road, Edinburgh EH9 3JQ
Food Research Institute	Shinfield, Reading RG2 9AT
Institute of Animal Physiology	Babraham, Cambridge CB2 4AT
Institute for Research on Animal Diseases	Compton, Newbury, Berks. RG16 0NN
Poultry Research Centre	Roslin, Midlothian EH25 9PS

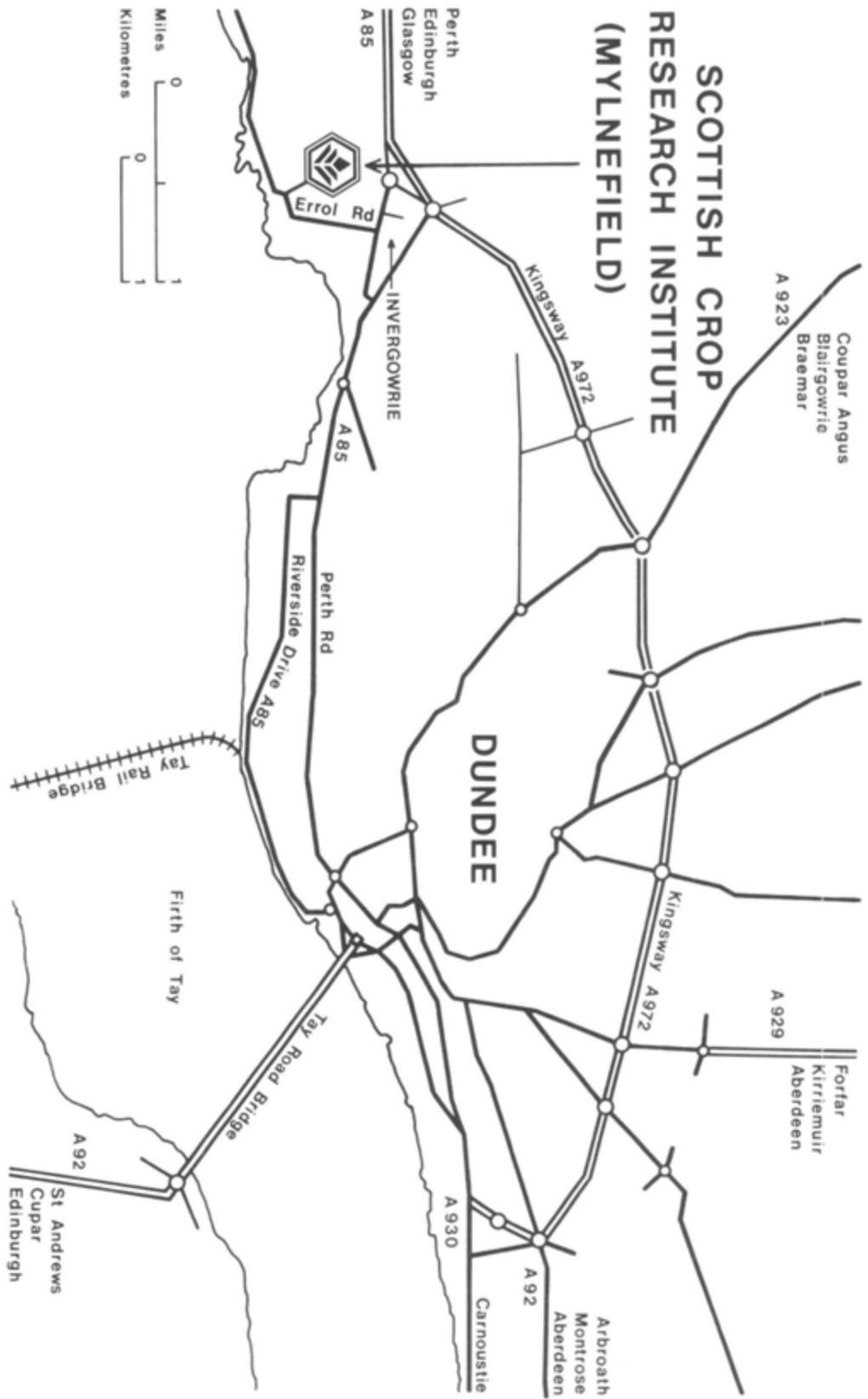
State-aided Institutes in England and Wales

Animal and Grassland Research Institute	Hurley, Maidenhead, Berks. SL6 5LR
Animal Virus Research Institute	Pirbright, Woking, Surrey GU24 0NF
Horticultural Research Institute	East Malling Research Station, East Malling, Maidstone, Kent ME19 6BJ
Houghton Poultry Research Station	Houghton, Huntingdon PE17 2DA
John Innes Institute	Colney Lane, Norwich NR4 7UH
Long Ashton Research Station	Long Ashton, Bristol BS18 9AF
National Institute of Agricultural Engineering	Wrest Park, Silsoe, Bedford MK45 4HS
Plant Breeding Institute	Maris Lane, Trumpington, Cambridge CB2 2LQ
Rothamsted Experimental Station	Harpenden, Herts. AL5 2JQ
Welsh Plant Breeding Station	Plas Gogerddan, Aberystwyth, Dyfed SY23 3EB

State-aided Institutes in Scotland

Hannah Research Institute	Ayr, Scotland KA6 5HL
Hill Farming Research Organisation	Bush Estate, Penicuik, Midlothian EH26 0PY
Macaulay Institute for Soil Research	Craigiebuckler, Aberdeen AB9 2QJ
Moredun Research Institute (ADRA)	408 Gilmerton Road, Edinburgh EH17 7JH
Rowett Research Institute	Bucksburn, Aberdeen AB2 9SB
Scottish Crop Research Institute	Invergowrie, Dundee DD2 5DA
	Pentlandfield, Roslin, Midlothian EH25 9RF
Scottish Institute of Agricultural Engineering	Bush Estate, Penicuik, Midlothian EH26 0PH

SCOTTISH CROP RESEARCH INSTITUTE (MYLNEFIELD)



Coupar Angus
Blairgowrie
Braemar
A 923

Forfar
Kirriemuir
Aberdeen
A 929

DUNDEE

Arbroath
Montrose
Aberdeen
A 92
Carnoustie

Perth
Edinburgh
Glasgow
A 85

Errol Rd

INVERGOWRIE

A 85

Perth Rd

Riverside Drive A 85

Firth of Tay

Tay Road Bridge

Tay Rail Bridge

A 92

St Andrews
Cupar
Edinburgh



Forth Road Bridge
Perth
Dundee

A90
(M90)

A720

A8
(M8) (M9)

A71

A70

PENTLANDFIELD

Abington
Carlisle

A702

A701

EDINBURGH

A702

A720

A703

A68

Galashiels
Selkirk
Hawick

A7

DALKEITH

A6124

MUSSELBURGH



THE MURRAYS

Jedburgh
Coldstream

A68

B6371

B6093

A1

