SCOTTISH CROP RESEARCH INSTITUTE

ANNUAL REPORT

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SCOTTISH CROP RESEARCH INSTITUTE

SECOND ANNUAL REPORT 1982

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* 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.

GENERAL REPORT

C. E. TAYLOR

Staff inspections by the ARC Management Services were undertaken during the year for Administration, Estates, Engineering and Maintenance and Information Services. This completed the review of the management structure, outlined in the 1981 Annual Report, and which at the end of the year was approved by the Department. The restructuring will take some time to implement as newly identified posts have to be found from the present staff complement and it cannot be fully effective until the removal of staff from Pentlandfield to Invergowrie has been completed. During the year a limited number of new appointments were made in potato physiology, which is an area of expanding research interest, and new posts in virology, entomology and a senior post to lead the plant breeding activities have been approved and will be filled in 1983.

Following the termination of the strawberry breeding programme at the West of Scotland Unit, Auchincruive, and the removal of basic plant material to Long Ashton Research Station, there was a transfer of staff to Invergowrie. The transfer of the first group of staff from Pentlandfield, namely the Brassica breeders, has been postponed until summer 1983, but a start on transferring staff was made with the appointment of Dr R. J. Killick as Assistant to the Director.

The rate at which staff can be removed from Pentlandfield to Invergowrie is dependent on progress with new buildings. In July, the Virology glasshouse complex, consisting of 954 square metres of automatically ventilated glasshouses and 428 square metres of associated laboratories was officially opened by the Earl of Mansfield, Minister of State at the Scottish Office. Work continued on the Zoology glasshouse complex and this is expected to be completed by July 1983. A start was made in December on the Brassica crop handling building and a farm building and it is hoped to commence further building projects in 1983 that include laboratories, cereal crop handling facilities and plant propagation.

Between November 1980 and April 1982, the Institute's research programme was examined in a series of four-yearly DAFS Package Reviews relating to Soft Fruit, Forage Brassicas, Cereals and Other Arable Crops (potatoes and field beans). Following these reviews and with some agreed modifications, the various components making up the Institute's research programme have been re-commissioned. The soft fruit

programme will concentate on the breeding of raspberry, hybrid berries, blackberries and black currants, with supporting research particularly on crop production (including mechanical harvesting) and the maintenance of plant health of raspberry and other *Rubus* crops.

Following the advice of the ARC Programme Review Group (1980), work on horticultural brassicas is being brought to an end. Breeding of late maturing, hardy hybrid cabbages resulted in the cultivar Celtic which continues to occupy a significant market position. Some improvements have been obtained but not in the desired late maturity and further cultivars of Celtic type have therefore not been released. However, exchange of breeding material between Asmer Seeds Limited and SCRI has produced the cultivar Corsair and further hybrids of the January King type may follow. Improvements of the Savoy parent of Celtic led to a programme to produce Savoy hybrids. Three have been named and are in commercial trials and a further two cultivars may reach commercial standard before trialling is completed in 1986. Inbred lines from the cabbage breeding programme will be distributed to commercial breeders from 1983 through the British Association of Plant Breeders (BAPB). Breeding material from the Brussels sprout and calabrese programmes on selection methods will also be made available to members of BAPB. Staff from horticultural brassica breeding will transfer to forage brassica breeding when this is transferred from Pentlandfield to Invergowrie in 1983. SCRI has the sole programme in the Agricultural Research Service and will concentrate on swedes, rape and kale with improvements in dry matter, resistance to fungal and viral diseases and to pests, and lower levels of toxic chemicals such as S-methyl cysteine sulphoxide and glucosinolates. The swede cultivars Angus and Melfort which were recently introduced are on the NIAB Recommended List and their early commercial performance is highly satisfactory.

The role of the public sector institutes in cereal breeding has been the subject of much discussion in the past year or so. When reviewed by DAFS in March 1981, the special requirements of Northern Britain were recognised and approval was given to continuation of spring barley and the initiation of winter barley breeding in the SCRI programme. The spring barley cultivar Tweed, which was noted in the 1981 Annual Report, has been included in the Scottish Colleges' Recommended List; it is high yielding, mildew resistant and with malting potential better than Golden Promise. Other selections from the SCRI programme are in their second year of testing in the National List Trials and further recommended cultivars are confidently expected from the spring barley breeding programme and in due course also from that of winter barley which is still in its early years.

The potato breeding programme will continue with its objective of producing cultivars to suit the needs of the UK market, improvements in yield, quality and resistance to pests and diseases. Attention will also be

given to the specific needs of overseas markets particularly in the Mediterranean region where trials have already been established in Algeria, Israel and Spain. We shall be co-operating with Solanex and with the Scottish Seed Potato Development Council in identifying the breeders' selections and cultivars that are best suited to these markets. Research on the health of the potato crop has particular relevance to seed production and the maintenance of healthy stocks. However, problems such as the blackleg/soft rot complex (*Erwinia* spp.) are of particular importance overseas and a collaborative programme has been established with the Volcani Research Center, Israel, to investigate the incidence and spread of these diseases in warmer climates.

The general aim of research on potato physiology is an understanding of the process controlling growth and development, with the underlying commercial objectives of controlling tuber yield, size, grading, maturity date and quality. Investigations in progress include the effect of weather factors on the physiological response of the crop, the processes involved in the partioning of dry matter and the physiological basis of competition between sprouts of a tuber during the pre-emergence growth phase. The effect of mineral nutrition on the growth and development will be studied in collaboration with the Macaulay Institute for Soil Research and problems relating to chitting and damage in collaboration with the Scottish Institute of Agricultural Engineering. The Institute has also been asked to formulate proposals for a co-ordinated programme on potato physiology, involving ARC, ADAS, PMB and the Universities, and following the circulation of a discussion document on research objectives prepared by Dr P. D. Waister, Head of the Physiology and Crop Production Department, a meeting for those involved has been arranged for early 1983.

The SCRI research programme has a sound scientific base and with a degree of inbuilt flexibility that can respond to the changing needs of the agricultural industry. In broad terms the programme is designed to increase productivity by the breeding of new cultivars of crop plants, by the introduction of improved cultural practices and by the protection of crops against pests and diseases. Increased yield will continue to be one of the objectives, but increased yields of specific end products that satisfy the needs, both with regard to quality and economics, of the market to which production is directed. This research will add value to the commodity whether marketed fresh, processed or as manufactured food and recognise the continuum of the food chain from primary production to consumption or other utilisation.

In addition to the Earl of Mansfield, who opened the Virology glasshouse complex, distinguished visitors to the Institute included Professor W. F. Raymond of the MAFF Chief Scientist Group who gave the twelfth lecture of the Scottish Society for Crop Research on 'Factors in Optimum Crop Production'; Sir James Hamilton, Permanent

Secretary of the Department of Education and Science; Professor J. A. F. Rook, Second Secretary of the ARC; Mr J. Ellis, Chairman and Mr N. Greenwood, Chief Executive, NSDO; and from overseas Dr G. Frith, Director, Horticultural Research Institute, Victoria, Australia; Professor F. Lamberti, Director, Institute of Agricultural Nematology, Bari, Italy; Dr S. Leuty, Director, Vineland Research Station, Canada; Professor A. H. Halevy, Hebrew University of Jerusalem, Israel; and Dr A. Nachmias, Director, Gilat Experimental Station, Israel. It was also a pleasure to receive the large number of scientists, students, farmers and other visitors both from home and overseas who expressed interest in the work of the Institute. In addition to general visitors there were many individuals or groups who had specific links with the Institute and whose co-operation and help are gratefully acknowledged.

Mr William Robb joined the staff of the Scottish Society for Research in Plant Breeding in 1921 when it was located at Craigs House, Corstorphine. He was appointed Director in 1925 and retired in 1950. His death on 18 December 1982 at the age of ninety-seven is recorded with regret.

G. C. Nicol was killed in a tragic accident on 25 April. He was an ASO in the Crops Research Section from 1973 and was responsible for meteorological recordings.

Governing Body

Mr John Arbuckle, Chairman, was severely injured in a road accident in Brussels on 18 November. At the end of the year he was showing good signs of recovery and it is hoped that by the time this report is published he will be restored to good health and his former activity.

In March 1983 the present members of the Governing Body will have completed their three-year term of office. They are thanked for the support given to the Institute during a period when the process of amalgamation has required their considered and careful attention.

It is with deep regret that we record the death of Mr James Gray on 13 August. Mr Gray had a long association with the Scottish Society for Research in Plant Breeding having been elected to the Board of Directors in 1954, appointed Vice-Chairman in 1971, and Chairman in 1980. His guidance was much valued in the development of the Scottish Plant Breeding Station and in the events leading to the formation of SCRI.

Appointments

Eileen Baird	ASO, Cereal Breeding Department
Eve M. Borrino	SO, Tissue Culture and Cytology Unit
Elizabeth H. Elliott	CA, Administration Division
Anne C. Jolly	ASO, Virology Department
Karen P. Mackie	ASO, Soft Fruit Breeding Department
Mrs Catherine J. McDougall	Information Services Division

B. Marshall	SSO, Physiology and Crop Production Department
Jacqueline J. Mitchell	ASO, Mycology and Bacteriology Department
R. Neilson	ASO, Physiology and Crop Production Department
I. Paxton	CO, Administration Division
Gillian M. Peaston	ASO, Forage Brassica Breeding Department
A. Purves	AW, Estates Division
A. Jane Sim	ASO, Forage Brassica Breeding Department
Elizabeth A. Willison	ASO, Mycology and Bacteriology Department
Kathleen A. Wilson	ASO, Tissue Culture and Cytology Unit
J. A. Young	Storeman, Administration Division

Promotions

F. J. W. England	PSO-SPSO
N. D. Anderson	SEO-Principal
B. Boag	SSO-PSO
A. Dale	HSO-SSO
G. H. Duncan	HSO-SSO
J. H. Rashké	SO-HSO
Mrs Eveline M. Wiseman	SO-HSO
Margaret Cannon	ASO-SO
Mrs Irene E. Geoghegan	ASO-SO
Mrs Lisbeth J. Hyman	ASO-SO
Geraldine Cruickshank	Photographer-Senior Photograher
Mrs Joan Jenkins	LA-EW
Mrs Rena Reid	LA-EW

Awards

C. S. Aveyard	Ph.D., University of London
I. E. Burdge	First prize in nursery practice, Elmwood College
Margaret J. Cannon	HNC
T. G. Geoghegan	Associateship of the Master Photographers' Association
T. Gifford	ATB Certificate of Competence in fork lift truck operation
D. H. Goodall	ATB Certificate of Competence in fork lift truck operation
	Scottish Association of Young Farmers' Clubs Certificate of Proficiency in the use of crop sprayers and root harvesters

B. S. Griffiths	Ph.D., University of Dundee
D. J. Hall	HNC
R. Macdonald	Ph.D., University of Edinburgh
Karen P. Mackie	HND
J. G. McCluskey	HNC
D. Ritchie	ATB Certificate of Competence in fork lift truck operation
J. C. Sequeira	Ph.D., University of Dundee
K. Taylor	HNC
Judith Thomson	HNC
Mrs Naomi A. Williams	HNC
Mrs Gladys Wright	HNC

Resignations

Mrs Susan Bradley	ASO, Virology Department
W. Cherrie	Storeman, Administration Division
A. Dale	SSO, Soft Fruit Breeding Department
Mrs Susan Henderson	SO, Virology Department
J. H. W. Holden	SPSO, Potato Breeding Department
Mairi-Christine Mackay	SO, Chemistry Department
Mrs Valerie Magrath	CA, Administration Division
Alison M. McRitchie	ASO, Forage Brassica Breeding Department
Mairi L. Williamson	ASO, Cereal Breeding Department
Elizabeth A. Willison	ASO, Mycology and Bacteriology Department

Retirements

P. P. Bonnington, EO in the Administration Division, retired on 31 January after 8 years service.

M. Paolozzi, AW, retired on the grounds of ill health on 1 October after 15 years service in the Estates Division.

D. W. Speed, SSO in Engineering and Maintenance Division, retired on 31 May. His career with SPBS began in 1955 as a cereal breeder.

R. N. H. Whitehouse, SPSO, retired on 2 April. He was latterly Officer-in-Charge at Pentlandfield. He came to SPBS in 1973 as Head of the then Forage Department.

Redundancies

R. Dornan, J. C. Goddard and C. A. Reid, EW's at the West of Scotland Unit, Auchincruive, were made redundant upon the closure of the Unit.

Visiting Workers

Dr T. Bleve-Zacheo and Dr G. Zacheo (Istituto di Nematologia Agraria del CNR, Bari, Italy) arrived in June to spend 3 months in the Zoology Department working on the feeding of *Xiphinema index,* histology of the Z organ and techniques in electron microscopy.

Dr Mariella Coiro (Istituto di Nematologia Agraria del CNR, Bari, Italy) left in June after spending 9 months studying the morphology and biology of, and virus transmission by, longidorid nematodes.

Dr Maria Arias Delgado (Instituto Espanol de Entomologia) and Dr Antonio Bello Perez (Instituto de Edafologia y Biologia Vegetal, Madrid, Spain) continued their ecological analysis of several data sets on nematode species in Central Spain during August.

Miss Nina Heiberg (Department of Pomology, University of Norway) worked from February to April on frost-tolerance in black currants.

Ms Lieke Kraak (Seed Testing Station, Wageningen) spent one week in October undertaking the statistical analysis of seedling emergence trials.

Dr H. S. Pepin (Agriculture Canada, Vancouver, British Columbia) commenced a years's study of variation in pathogenicity of isolates of *Didymella applanata* on raspberry cultivars from Britain and N. America.

Mrs Lesley Thom spent a month learning plant virus techniques before joining the Overseas Development Administration crop virology team in Kenya.

D. de Waele (Laboratorium voor Morfologie en Systematiek der Dieren, Belgium) spent 1 week in November analysing and mapping nematode distribution data as part of the European Plant Parasite Nematode Survey.

Professor K. Wright (Department of Zoology, University of Toronto, Canada) spent 1 week in December in the Zoology Department studying stylet probing and rotation.

Professor U. R. Wyss (Institut für Pflanzenkrankheiten und Pflanzenachutz, Hannover, West Germany) spent 1 week in September in the Zoology Department working on a joint review of feeding processes in nematodes.

Mr B. van der Zaal (Department of Plant Pathology, Agricultural University, Wageningen) visited for 3 months to study soft fruit pathology.

Research Students

Madiha Al-Hashimi (Government of Iraq, Baghdad) commenced studies on the ecology and epidemiology of *Fusarium nivale* on barley (Mycology and Bacteriology Department).

Vivienne M. Anthony (SRC-RCCA post-graduate student, jointly with the University College of North Wales) continued research on the infection of raspberry by rust *Phragmidium rubi-idaei* (Mycology and Bacteriology Department).

R. A. Bain (ESCA) continued his studies on gangrene of potatoes (Potato Breeding Department).

Lucy M. Cotes (PMB post-graduate student) completed her studies on tolerance of potato to potato cyst nematode (Zoology Department).

Angela Cunningham (Edinburgh University/RCCA Award) continued studies on pollen, embryo and endosperm development following cross-pollination within and between *Brassica* and *Raphanus* species (Forage Brassica Breeding Department).

Sarah Dodd (ARC post-graduate student) continued her studies on the genome nucleic acids of nepoviruses (Virology Department).

J. G. Elphinstone (ARC post-graduate student) continued studies on contamination of potato stocks by *Erwinia carotovora* (Mycology and Bacteriology Department).

B. S. Griffiths (ARC post-graduate student) completed his studies on the changes induced by the feeding of *Xiphinema diversicaudatum* and *Longidorus elongatus* in plants of different host status (Zoology Department).

M. R. Groom (MAFF research assistant, jointly with University of Dundee) commenced studies on the causes of cavity spot of carrots (Mycology and Bacteriology Department).

J. Hinton (SRC-RCCA post-graduate student, jointly with the Institute of Animal Genetics and University of Edinburgh) commenced studies on the genetics of *Erwinia carotovora* (Mycology and Bacteriology Department).

W. W. Kirk (ARC post-graduate student) commenced studies on leaf growth of the potato (Physiology and Crop Production Department).

V. M. Lumb (PMB post-graduate student) continued studies on the effects of climate in Scotland and Israel on the epidemiology of blackleg of potato (Mycology and Bacteriology Department).

N. Ross (SRC-RCCA post-graduate student, jointly with University of Aberdeen) continued studies on the biology of *Erwinia carotovora* in the potato phylloplane (Mycology and Bacteriology Department).

J. C. Sequeira (Calouste Gulbenkain Foundation research fellow) completed his studies on cassava latent virus and returned to the Estacao Agronómica Nacional, Oeiras, Portugal (Virology Department).

Z. A. Stephan (Iraq post-graduate student) continued his studies on the biology and life cycle of *Meloidogyne ardenensis* in Scotland (Zoology Department).

D. T. Stevenson (Edinburgh University/RCCA Award) continued his studies of tillering in barley (Cereal Breeding Department).

Helmy Wahdan (Horticultural Research Institute, Cairo) completed his studies on environmental effects on the growth and development of the strawberry (Physiology and Crop Production Department).

Gretel White (SRC-RCCA post-graduate student, jointly with the University of Durham) commenced studies on pod setting and development in new genotypes of *Vicia faba* L (Physiology and Crop Production Department).

Sandwich Course Students

G. Barclay (College of Commerce, Dundee) was seconded for job experience from a Manpower Services computer course (Data Processing Department).

Karen-Anne Black (Napier College of Commerce and Technology) worked on the development and components of yield in barley (Cereal Breeding Department).

Elaine A. Doughty (Coventry (Lanchester) Polytechnic) worked on powdery mildew in swedes (Forage Brassica Breeding Department).

Kathleen Forbes (Dundee College of Technology) worked on nematode transmission of viruses and on the fate of juveniles of potato cyst nematodes in resistant plants (Zoology Department).

I. Leith (Dundee College of Technology) worked on the transmission of potato leafroll virus and the susceptibility of potatoes to top roll (Zoology Department).

Carol Manhood (North London Polytechnic) is investigating glasshouse screening techniques for scab resistance and drought tolerance of potatoes (Potato Breeding Department).

S. O'Rourke (Dundee College of Technology) worked on the effects of calcium and light on sprout growth and protein degradation in potato tubers (Physiology and Crop Production Department).

G. Ritchie (Dundee College of Technology) worked on production, isolation and testing metalaxyl-resistant mutants of *Phytophthora cactorum*, cause of strawberry crown rot (Mycology and Bacterilogy Department).

C. Simpson (Dundee College of Technology) spent 3 months working on the development of a pollen bioassay (Forage Brassica Breeding Department).

D. Wilson (Dundee College of Technology) worked on the role of micro-organisms in raspberry replanting disorders (Zoology Department).

J. R. Wood (Coventry Polytechnic) worked on late blight and soft rot of potatoes (Potato Breeding Department).

Sabbatical Leave

Mrs Jill E. Middlefell Williams spent 3 months from November at the John Innes Institute learning tissue culture techniques.

Visits Abroad

D. J. F. Brown visited the Istituto di Nematologia Agraria del CNR, Bari, Italy, from 13 September to 16 December to study aspects of taxonomy, biology of, and virus transmission by members of the Longidoridae (nematoda).

J. Brown visited Wageningen, Holland, 18-25 July, to discuss ideas with Dutch breeders and scientists and see commercial potato breeding groups.

P. D. S. Caligari went to Valencia and Majorca, Spain, 9-16 May, to visit trial sites, collect data and select SCRI potato clones. He visited Wageningen, Holland, and Cologne and Munich, Germany, 18-25 July, to visit scientists and breeders to exchange ideas and information.

I. A. Cowe visited the Department of Biotechnology, Carlsberg Research Centre, Copenhagen, from 5-9 July, to discuss collaborative NIR work on cereal quality with Dr Jensen.

M. F. B. Dale visited Burgos, Spain, 26 September-3 October, to visit trial sites, collect data and select SCRI potato clones.

R. P. Ellis was at DSIR/CRD Gore, New Zealand, from 11 January to 18 April selecting SCRI spring barley breeding material.

R. A. Fox visited the International Potato Centre, Lima, Peru, 1-2 March, to participate in a workshop 'Late blight research for the 80's and 90's.' He paid an invited visit to the Volcani Center, the Gilat Experiment Station and various experiment sites and commercial potato growing areas in Israel from 31 May to 8 June. He went to the International Agriculture Center, Wageningen, 21-24 June, to attend EAPR Editors meeting and Disease Assessment Committee and to visit the Plant Protection Institute.

B. D. Harrison visited the International Potato Center, Lima, Peru, on 1-3 March and took part in a workshop on strategies for the control of viruses, viroids and mycoplasmas in potatoes. On 14-15 October he visited the Agriculture Canada Research Station, Vancouver, to discuss research on plant viruses of potato and other crops. From 6-28 November he made a tour, sponsored by the British Council, to eleven centres of plant virus research in India, giving lectures and discussing work in progress.

A. T. Jones and A. F. Murant attended the 12th International Symposium on Fruit Tree Virus Diseases on 18-26 June at Vancouver and Summerland, Canada, and Yakima, USA.

V. M. Lumb worked at the Volcani Center, Bet Dagan, Israel, between March-June and October-December carrying out field experiments in relation to the joint project on potato blackleg between SCRI and the Volcani Center. The visits were supported by the PMB and Volcani Center.

G. R. Mackay made four visits abroad: to Lima, Peru, 19 February-5 March, to attend conference on 'The Potato in the year 2000' at the International Potato Center; to Wageningen, Holland, 22 May, to attend EEC Workshop on the conservation of old potato cultivars; to Israel, 25 May-4 June, to visit trials of SCRI seedlings at Gilat Experimental Station; and to Algeria, 18-23 December, as a member of Scottish Seed Potato Development Council party to visit centres of potato production.

I. H. McNaughton visited ITV, IVP and SVP, Wageningen, The Netherlands, from 30-31 March, to attend a meeting of the Co-ordinating Committee for the EEC Programme. 'The Collecting of Land Races of Cruciferous Crops in EEC countries' and to discuss *in vitro* mutation work.

M. C. M. Pérombelon visited the Volcani Center, Bet Dagan, Israel, 11-19 Decmber, to discuss future work on the joint project on potato blackleg with Dr D. Zutra. He also toured centres for potato research and gave informal talks on blackleg.

D. A. Perry visited GEVES, INRA, La Minière, Versailles, France, 6-8 May, to attend the Interconvention Meeting of the International Seed Testing Association. He toured several centres of research in Brazil during July to advise on testing seeds for health and vigour under the auspices of the Inter-American Institute for Co-operation in Agriculture.

W. Powell visited Risø, Denmark, 16-30 March to study tissue culture techniques in barley.

W. M. Robertson visited the Max Planck Institute, Göttingen, West Germany, between 22-24 June to discuss with Dr E. Schierenberg the feasibility of using laser equipment to undertake microsurgery of *Xiphinema* spp.

Ruth M. Solomon and Helen E. Stewart visited the Agricultural Institute, Oak Park Research Centre, Carlow, and Plant Pathology Department, University College, Dublin, 4-6 August to see and discuss work on potato viruses and potato blight.

C. E. Taylor attended three meetings as a member of the Scientific Council of CNR Instituto di Nematologia Agraria Applicata ai Vegetali, Bari, Italy, from 8-10 March, 4-6 July and 20-22 December.

D. L. Trudgill visited six centres of nematology in West Germany between 7-17 November to discuss research, particularly in relation to virus vector and potato cyst nematodes.

Conferences at which papers were given

7 January	Society for General Microbiology Virus Group, University of Liverpool	
	D. J. Robinson	Detection of virus RNA for diagnosis of infections with a plant virus that does not produce coat protein

19 February	Stokes Bomford Chemicals Ltd Meeting, Droitwich, on Soft Fruit: Production and Marketing	
	A. T. Jones	Viruses and vector control
22-27 February	Research for the Potato in the Year 2000, CIP, Lima, Peru	
	R. A. Fox	Potato plant health; its future prospects
	B. D. Harrison (D. J. Robinson)	Use of complementary DNA to detect tobacco rattle virus in potato foliage
10-12 March	ADAS Plant Pathologists' Technical Conference, Great Malvern	
	A. T. Jones	Virus diseases of cane fruit
19 March	Royal Society of Edinburgh and Royal Meteorological Society (Scottish Branch) symposium on 'Wind and its effects on man, plants and animals,' Edinburgh	
	P. D. Waister	The effect of wind on agricultural and horticultural crops
29 March-1 April	7th ARS Conference on Electron Microscopy, Reading	
	I. M. Roberts	Simple routine magnification calibration
	W. M. Robertson	Carbohydrate histochemistry using the electron microscope
1-2 April	AAB Physiology Group, Reading	
	R. Thompson	Changes in the partition of assimilate in *Vicia faba* L. in response to environment
12-13 April	Royal Microscopical Society's Annual Histochemistry and Cytochemistry Meeting, London	
	B. S. Griffiths (W. M. Robertson)	RNA and protein changes induced by *Xiphinema diversicaudatum,* measured using a novel technique for measuring section thickness
14-18 June	3rd International Symposium on Small Fruit Virus Diseases, Vancouver, Canada	
	A. T. Jones	Distinctions between three aphid-borne latent viruses of raspberry

	A. T. Jones (Susan J. Badenoch)	Recent studies on virus and virus-like diseases of *Rubus* in Scotland
	A. F. Murant (A. T. Jones, D. L. Jennings)	Problems in the control of raspberry bushy dwarf virus
21-25 June	European Association for Potato Research, Physiology Section, Wageningen, The Netherlands	
	D. K. L. MacKerron (P. D. Waister)	Light interception and dry matter accumulation in potato cultivars of contrasting habit
23-26 June	'Pollen: Biology and Applications in Plant Breeding' 2nd International Pollen Symposium, Lake Garda, Italy	
	J. R. T. Hodgkin (G. D. Lyon)	Germination of *Lilium* and *Petunia* pollens on TLC plates and their inhibition by extracts from *Brassica oleracea* tissues
28 June-2nd July	7th World Cereal and Bread Congress, Prague, Czeckoslovakia	
	I. A. Cowe (M. J. Allison, D. C. Cuthbertson)	Determination of barley malting quality by NIR analysis
6-8 July	SEB Environmental Physiology Group Session, Dublin	
	B. Marshall (G. R. Squire)	Effects of temperature on light interception and dry matter production of pearl millet and groundnut
24-25 August	AAB Physiology Group, Dundee	
	P. D. Waister (H. M. A. Wahdan)	Genetic and environmental control of flowering in strawberries
	AAB Physiology Group, Dundee	
	S. Gowers	Manipulation of flowering in crop plants
	S. Gowers (Dorothy J. Gemmell)	Vernalisation of swede (*Brassica napus* ssp *rapifera*)
24-26 August	AAB Virology Group Meeting, Dundee	
	H. Barker	Behaviour of viruses in potato mesophyll protoplasts

24-26 August	G. H. Duncan	A freeze-drying device for obtaining improved preservation of virus particles
	B. D. Harrison (D. J. Robinson)	Detection and diagnosis of NM strains of tobacco rattle virus in potato
	A. T. Jones (M. A. Mayo, G. H. Duncan)	A small circular RNA in particles of lucerne transient streak virus
	W. P. Mowat	Production of virus-free narcissus stocks in Scotland
	W. P. Mowat	Epidemiological studies on viruses infecting narcissus
	W. P. Mowat	Three viruses recently found in tulips
	A. F. Murant	Dependence of the closterovirus heracleum latent virus on another virus for transmission by the aphid *Cavariella theobaldi*
	D. J. Robinson	Complementary DNA: a research tool with practical applications
	D. L. Trudgill (W. M. Robertson, B. S. Griffiths)	Ultrastructure and feeding behaviour of *Xiphinema diversicaudatum* and *Longidorus elongatus*, their effect on plant roots and implications for virus transmission
	J. A. T. Woodford (C. S. Aveyard)	Early haulm destruction to prevent the spreading of potato leaf roll virus in Scottish seed potatoes
30 Aug.-3 Sept.	COMPSTAT 82, Toulouse, France	
	J. W. McNicol (S.C.M.Ng)	An experimental design and analysis package for microcomputers
30 Aug.-3 Sept.	European Society of Nematologists XVI Symposium, St Andrews, Scotland	
	T. J. W. Alphey	The effect of host plant on the control of nematodes by systemic nematicides

30 Aug.-3 Sept.	A. Bello (B. Boag, Pauline B. Topham)	Biogeographical variation of Criconematidae
	D. J. F. Brown	Variability between populations of *Xiphinema diversicaudatum*
	M. I. Coiro (D. J. F. Brown)	Status of some plants as hosts for individual *Xiphinema index* for populations from France, Israel, Italy and the USA
	M. F. B. Dale (G. R. Mackay)	Recent developments in breeding for disease resistance to potato cyst nematode
	J. M. S. Forrest (Linda A. Farrer)	The hatching response of eggs of the white potato cyst nematode *Globodera pallida*
	B. S. Griffiths (W. M. Robertson)	The use of oil red 'O' to measure nematode lipid content
	B. S. Griffiths (W. M. Robertson)	Morphological changes during the life span of ryegrass galls induced by *Longidorus elongatus*
	M. S. Phillips (J. M. S. Forrest)	The resistance of *Solanum tuberosum* × *S. vernei* hybrids to *Globodera pallida*
	W. M. Robertson	Structure and function of the oesophageal bulb of *Xiphinema index*
	Z. Stephan	Selection of root-knot nematode, *Meloidogyne hapla* on cucumber
	Pauline B. Topham (Maria Arias A. Navas)	Ecological characterisation of Longidoridae in Spain
	D. L. Trudgill (Lucy M. Cotes)	Mechanisms of tolerance of potato to potato cyst nematodes
	D. L. Trudgill (W. M. Robertson)	Feeding and salivation behaviour of *Xiphinema diversicaudatum* and *Longidorus elongatus*
6-10 September	7th International Botrytis Symposium, Aberdeen	
	J. G. Harrison	Chocolate spot of field beans
7-9 September	AAB: Crop Establishment	
	D. A. Perry	Factors influencing the establishment of cereal crops

8-9 September	Society for General Microbiology Virus Group Meeting, Dundee	
	Susan M. Dodd (D. J. Robinson)	Sequence conservation and divergence in the genome RNA species of four strains of tomato black ring virus
	B. D. Harrison	Differentiating and common features in vector transmission of plant viruses
	A. F. Murant	Mechanisms of helper-virus dependent transmission of plant viruses by vectors
	J. C. Sequeira (G. H. Duncan, D. J. Robinson, B. D. Harrison)	Properties of cassava latent virus particles and their components
12-15 September	8th Long Ashton Symposium 'Improvement of vegetatively-propagated plants'	
	D. L. Jennings	Raspberries and black currants
	G. R. Mackay	Potato breeding: the state of the art
13-16 September	Eucarpia Fodder Crops Section, Aberystwyth	
	Cynthia J. Williamson	Development of clubroot resistance breeding programmes for the forage brassicas
15 September	Horticultural Education Association, day course on Micropropagation in Horticulture at Royal Botanic Gardens, Edinburgh	
	R. J. McNicol	An examination of the micropropagation of soft fruit
23-24 September	AAB/Plant Microbial International Group, London	
	H. M. Lawson	Integrated control – a weed scientist's viewpoint
	M. C. M. Pérombelon	Control of potato blackleg: an integrated approach
17-22 October	IVth International Conference on Comparative Virology, Banff, Canada	
	B. D. Harrison	Progress and problems in the control of arthropod-, nematode- and seed-transmitted plant viruses

17-22 October	B. D. Harrison	Epidemiology of plant viruses with nematode or fungus vectors
8-11 November	1 Congresso Nacional de Fitopatologia, Granada, Spain	
	A. Bello (Pauline B. Topham, A. Dale)	Contribucion al conocimiento de la estructura espacial de la distribucion de los nemotodos parasitos de plantas en España
23-25 November	British Crop Protection Conference – Weeds, Brighton	
	H. M. Lawson (J. S. Wiseman)	Tolerance of raspberry to new herbicides for control of perennial weeds
	H. M. Lawson (J. S. Wiseman)	Tolerance of strawberry to new herbicides for control of perennial weeds
	H. M. Lawson (J. S. Wiseman)	Relative tolerance of calabrese and swede to three specific graminicides

Conferences Organised

M. A. Mayo organised (with K. Harrap) a symposium of the Virus Group of the Society for General Microbiology on 'Virus Vectors,' held at Dundee University on 8-9 September.

W. P. Mowat was the local organiser for the AAB/BSPP/HEA meeting held at Dundee on 23-27 August. A. F. Murant arranged the Association of Applied Biologists Virology Group programme. Virology Department were hosts to the AAB Virology Group on their visit to SCRI on 26 August.

The XVIth International Symposium of the European Society of Nematologists was held in St Andrews from 30 August to 3 September. C. E. Taylor chaired the Organising Committee which consisted of T. J. W. Alphey, B. Boag, J. M. S. Forrest, T. Mabbot (DAFS). Muriel McKenzie (DAFS), G. M. Mackintosh (NSCA), W. M. Robertson and D. L. Trudgill assisted by D. J. F. Brown, Mrs Linda A. Farrer, Mrs Jean Findlay, Mrs Loraine A. Galloway, Mrs Irene E. Geoghegan, T. G. Geoghegan, Mrs Carol E. Henry, D. Hobbs, Mrs Sheena S. Lamond, S. F. Malecki, Maureen I. McMaster, M. S. Phillips and Mrs Freida F. Soutar. The Symposium was attended by 170 delegates from 29 countries.

Courses Organised

F. J. W. England and D. Miles (Guinness Barley Research Centre) jointly organised a disease scoring exercise for BAPB trials officers at the GBRC on 23 June.

S. C. Gordon and J. A. T. Woodford contributed lectures and practicals on soft fruit pests, potato aphids and the control of aphid-transmitted potato viruses for the Pest Module of the BASIS Training Course on Crop Protection at WSAC, Auchincruive, on 20 January.

D. L. Trudgill in association with ESCA demonstrated crop inspection for potato cyst nematodes.

The 3-week course of lectures at Dundee University on crop physiology, weeds, fungal pathogens and plant viruses was repeated in 1982.

Three members of Virology Department gave a short course of lectures to botany students from St Andrews University.

Courses Attended

Mrs Alison M. Campbell attended a course on 'Micropropagation in Horticulture' organised by the Horticultural Education Association (Scottish Branch) on 15 September at the Royal Botanic Gardens, Edinburgh.

R. J. Clark attended an ERCC Pascal programming course from 24-28 May.

T. G. Geoghegan and S. F. Malecki attended a course on colour video theory and practice at University of Dundee, 22-23 March.

R. J. Giles and Miss Deborah C. Page attended a workshop on seed management techniques in gene banks at the Royal Botanic Gardens, Kew, from 6-9 July.

D. Goodall attended a fork lift truck drivers' course organised by the ATB and given by the Fife Transport Training Centre on 1-2 March. T. Gifford, D. Ritchie and R. G. Tait attended a similar course on 3-4 March.

Dawn Harris attended a DAFS potato rogueing course, 21 June-2 July.

Mrs Carol E. Henry received a bursary from the Royal Microscopical Society to attend a course on principles of electron microscopy at the University of Leeds.

W. H. Macfarlane Smith, Cynthia J. Williamson, Deborah C. Page, G. W. Swinney and A. Whitelaw attended the first-aid course organised by the St Andrew's Ambulance Association and were awarded their Certificates.

Isabel K. Munro, Deborah C. Page and G. W. Swinney attended the NIAB course for licensed crop inspectors of cruciferous fodder and oil-seed crops and were awarded their licences.

W. Powell spent 3 months in the Genetics Department, University of Birmingham studying biometrical genetics.

W. M. Robertson attended an Open University associate student course on Biology: Form and Function.

Jacqueline Ross attended a course on high performance liquid chromatography, 5-9 July, at Loughborough University of Technology.

Pauline B. Topham attended the NATO Advanced Study Institute on Numerical Taxonomy at Bad Windesheim, West Germany, from 14-16 July.

Invited Lectures

I. A. Cowe gave three lectures on the application of Near Infra-red Reflectance to agricultural research. These were to the Royal Society of Chemistry, Irish Branch, in Dublin, on 28 January, The Royal Society of Chemistry, East Anglian Branch, in Norwich, on 23 March, and the Institute of Brewing, London Division, in Oxford, on 29 September.

C. E. Taylor gave a lecture on the work of the Institute to the Agrarian Society of Glasgow on 22 February. He gave a lecture on viruses and vectors at Strathclyde University on 16 March.

Editorial Duties

M. J. C. Asher	Chairman of the Editorial Committee for the *Proceedings of the Fourth International Barley Genetics Symposium*
P. D. S. Caligari	Member of Editorial Board of *Heredity*
R. P. Ellis	Member of the Editorial Committee for the *Proceedings of the Fourth International Barley Genetics Symposium*
R. A. Fox	Executive Editor *Potato Research*
B. D. Harrison	Editor of *Commonwealth Mycological Institute/ Association of Applied Biologists, Descriptions of Plant Viruses*
	Member of the Editorial Board of *Journal of General Virology*
	Member of Editorial Board of *Intervirology*
A. M. Hayter	Member of the Editorial Committee for the *Proceedings of the Fourth International Barley Genetics Symposium*
A. T. Jones	Member of Editorial Board of *Annals of Applied Biology*
H. M. Lawson	Member of Editorial Board of *Annals of Applied Biology*
I. H. McNaughton	Joint Editor *Eucarpia Cruciferae Newsletter*
A. F. Murant	Editor of *Commonwealth Mycological Institute/ 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 Board of Editors of *Horticultural Research*
Pauline B. Topham	Editor of *Crop Research*. Editor of *The Lichenologist*
D. L. Trudgill	Consulting Editor of *Plant and Science*
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 *Eucarpia Cruciferae Newsletter*

Service on Committees

T. J. W. Alphey	UK representative on the European Plant Parasitic Nematode Survey
M. J. C. Asher	UK Cereal Pathogen Virulence Survey Committee Business Group of the British Society of Plant Pathology
B. Boag	Nematology representative on the European Invertebrate Survey Committee Scottish representative on the ADAS Migratory Nematode Working Party
D. J. F. Brown	Secretary and Treasurer to the European Society of Nematologists
M. R. Cormack	NFT Scottish Soft Fruit Panel
A. Dale	NFT Scottish Soft Fruit Panel
R. P. Ellis	Member of the BAPB Cereal Crop Group BAPB representative on the Cereal Varieties Recommended List Committee of COSAC
F. J. W. England	BAPB, Member of Cereal Crop Group BAPB, Co-ordinator spring barley trials
J. M. S. Forrest	AAB, Member of Nematology Group Committee
R. A. Fox	EAPR, Council Member; Vice-Chairman, Pathology Section; Vice-Chairman, Disease Assessment Committee Association for Crop Protection in Northern Britain – Standing Committee Member; Organising Committee Member, Conference on Crop Protection in Northern Britain, 1984
S. C. Gordon	Member of the Pesticide Application Group Committee of the AAB ARC Pesticide Research Discussion Group
B. D. Harrison	Institute of Virology, Oxford, Advisory Committee

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	AAB Plant Breeding Group Committee Institute of Biology, Scottish Branch Council Member
H. M. Lawson	ADAS/WRO Liaison Group ARC Fruit Weed Control Group ISHS Working Group on Weed Control in Vegetables SAC Weeds Group
W. H. Macfarlane Smith	BAPB Oilseed and Industrial Crop Group Field Experimentation, Variety Development and Multiplication Panel of the National Proficiency Test Council
G. R. Mackay	BAPB, Member of Main Committee BAPB, Convener of Potato Crop Group EEC, Member of Potato Workshop
Jean F. Malcolmson	Member of Sub-Committee E (infra-specific), International Mycological Association; Scottish Joint Committee for National Certificates and Diplomas in Biology
B. Marshall	SEB Environmental Physiology Group Committee
M. A. Mayo	Society for General Microbiology, Virus Group Committee
I. H. McNaughton	Co-ordinating Committee of the EEC Programme on 'The Collecting of Land Races of Cruciferous Crops in EEC Countries'
J. W. McNicol	Research Councils Users' Committee of ERCC
R. J. McNicol	NFT Strawberry Panel NFT Scottish Soft Fruit Panel
W. P. Mowat	SNSA Bulb Technical Committee, Convener
A. F. Murant	International Society for Horticultural Science, Chairman of Working Group on Small Fruit Viruses International Committee on Taxonomy of Viruses, Member of Executive Committee and Plant Virus Sub-Committee AAB, Convener of Virology Group
M. C. M. Pérombelon	ISPP Member Bacteriology Section Committee Chairman, *Erwinia* (soft rot) Group
D. A. Perry	ISTA Vigour Test Committee, Chairman

I. M. Roberts	ARC Electron Microscope Advisory Group Committee
W. M. Robertson	AAB, Member of Nematology Group Committee
C. E. Taylor	ARC Research and Policy Advisory Committee ACAS Scientific Advisory Committee Chairman, European Plant Parasitic Nematode Survey (European Science Foundation) Chairman, SCRI/COSAC Liaison Group NFT (Brogdale) Advisory Committee PMB Research and Development Committee President, European Society of Nematologists Programme Organising Committee of the First International Congress of Nematology Publications Committee, *Journal of Horticultural Science* SNSA (Flower Bulbs) Adviser to Committee WSAC Glasshouse Technical Committee
R. D. Taylor	ATB Horticultural Training South of Scotland Committee Scottish Association of Young Farmers' Clubs Proficiency Tests, Council for Agriculture Horticultural Panel
Pauline B. Topham	Research Councils Users' Committee of ERCC Research Council Observer on Edinburgh University Working Party on the future of the Program Library Unit
P. D. Waister	Tayside and Fife Branch Committee of BA Chairman HEA Scottish Branch NFT Scottish Soft Fruit Panel Dundee University Botanic Garden Committee
A. B. Wills	BAPB Vegetable Crop Group AAB, Member of Plant Breeding Group Committee
J. A. T. Woodford	AAB, Member of Entomology Group Committee

Exhibitions and Poster Sessions

27 January	*Angus Agricultural Exhibition organised by ESCA* 'Eelworm – keeping fields clear'
29 March-1 April	*Seventh ARS Conference on Electron Microscopy, IRAD, Compton* 'Electropolishing of EM filaments'
15-16 April	*ARC Discussion meeting on photosynthesis, Sheffield* 'Effects of temperature on the carbon budget of pearl millet (*Pennisetum typhoides* S&H)'

28-29 April	*Spring Potato Demonstration, Stoneleigh* Information on and samples of the cultivars Provost, Baillie and Sheriff were displayed
2 June	*University of Dundee Department of Biological Sciences Open Day* 'Quality in calabrese'
21-24 June	*Royal Highland Show, Ingliston, Edinburgh* 'Timetable for producing a new potato cultivar' 'New potato cultivars' 'Potato cyst nematode management in seed potato land' 'SCRI forage brassica cultivars' 'New black currants for the 80s' 'Raspberry cane vigour control'
23 June	*Beecham Foods Black Currant Field Day, Sandringham, King's Lynn* 'New black currants for the 80s and 90s'
6-8 July	*SEB Environmental Physiology Group Session, Dublin* 'Winter losses in autumn sown onions'
28-29 July	*Fruit Focus, Hadlow College of Agriculture and Horticulture, Tunbridge, Kent* 'New cultivars of soft fruit bred at the Scottish Crop Research Institute' (with NSDO)
12-14 August	*Information Technology Exhibition, Edinburgh* 'Data capture at SCRI (P)'
25 August	*AAB/BSPP/HEA meeting 'Bulbs – Options for improvement'* 'Production of virus-free narcissus stocks in Scotland' 'Field protection of virus-free narcissus stocks from nematode-transmitted viruses' 'Effect of virus infection on yield of narcissus' 'Potato mop-top virus haulm symptoms and virus content estimated by immunoassay'
30 Aug.-3 Sept.	*ESN XVI Symposium, St Andrews* 'Field protection of virus-free narcissus stocks from nematode-transmitted viruses' 'Sugar characterisation of *Xiphinema index* body wall' 'Computer assisted identification of nematodes' 'Effect of feeding by *Xiphinema diversicaudatum* on plants of different host status' 'Microcomputing and potato cyst nematode screening' 'DNA, RNA and protein changes in root-tip galls of a good and a poor host, induced by *Xiphinema diversicaudatum*' 'Breeding for PCN resistance'

5-6 October	*PMB Autumn Potato Harvesting and Handling Demonstration, NAC, Stoneleigh, Warwickshire* 'Blackleg and tuber soft rot of potato'
29 October	*The Royal Institution, London* 'New black currants for the 80s'
18 November	*Biotechnology and Education, University of Dundee* 'Scientific theory becomes commercial practice with plant tissue culture'
15-17 December	*British Society for Plant Pathology Meeting 'Infection, Damage and Loss,' Guildford* 'Symptom expression and crop loss due to clubroot in swedes'
15-17 December	*Systematics Association Symposium, Southampton* 'Computer assisted identification of nematodes'

Radio and Television

J. H. W. Holden, 10 March, 'Potato breeding' (STV).
C. E. Taylor, 16 July, 'The SCRI' (Radio Tay).

INDEX TO PROJECTS

CEREAL BREEDING

A. M. HAYTER

The cv. Tweed was included in the 1983 Scottish College's Recommended List. This is the first SCRI spring barley to achieve this distinction, and results from the decision taken in 1974 to make malting quality our major breeding objective. Conventional pedigree breeding methods continue to dominate in the plant breeding programme and much research has concentrated on refinements of methodology. However, several interesting new techniques, including methods of predicting or estimating the yield potential of crosses from the early generations, the use of pollen irradiation for limited gene transfer and the existence of somaclonal variation following microspore culture, may find applications in the future. The study of mechanisms of partial mildew resistance also shows promise as an alternative or supplementary breeding strategy to the use of major gene resistance.

08001 *Collect, assess and maintain oat and barley genotypes of use to breeders. Use computer-based data systems.*

Over the last year, 129 accessions have been added to the barley collection bringing the total number of items to 3,269. The majority of the additions comprise winter cultivars and varieties in National List Trials.

Approximately 200 winter varieties in the barley collection were sown out in the autumn of 1981 and useful data on winter hardiness and disease resistance were recorded in 1982. The whole barley collection was planted in the spring of 1982 for observations on disease resistance and agronomic characters. A total of 545 accessions requiring regeneration were harvested. Twenty British land race accessions were sent via the PBI for long-term storage in the NVRS gene bank at Wellesbourne.

The data collected from the 1982 nurseries, collated with data from previous seasons, have been used to up-date the EXIR Barley Bank for frost susceptibility, aleurone colour, thousand grain weight, seed length, straw length, powdery mildew susceptibility and time of ear emergence. A new study has been started to provide information on some yield components. Samples of five ears were taken from each plot in the spring nursery for detailed measurements of spike and grain parameters. Each plots comprised a pair of drilled rows 1 m in length and 19 cm apart. Plots were separated by 50 cm along the drill and by 38 cm across the

drill. On completion, this survey will provide data on peduncle length, rachis length, numbers of nodes per ear (and hence, ear density), awn length, numbers of grains per ear and thousand grain weights for the whole SCRI barley collection grown in the same environment. The seed will be saved for future screening of grain quality characters using the Comparamill and Infra-Alyser.

Work on the major computer programs (Ann. Rep. 1981, p.162) has reached completion with translation into Fortran 77 and the provision of user documentation for the MUSEUM program.

(R. J. Giles, J. C. Penman)

08002 *Survey physiological characters related to crop performance in barley and construct breeding models.*

The growth and development of two spring barley cultivars, Golden Promise and Maris Mink, and two winter cultivars, Maris Otter and Igri, was followed in an experiment comparing three dates of autumn- and of spring-sowing. Accumulated day degrees (ADD) with base 0°C, were recorded to enable comparisons to be made between sowing dates. Ear emergence occurred in both winter and spring cultivars after 1,200 ADD from autumn-sowing. For spring sowings ear-emergence took place after an average of 800 ADD for spring cultivars and 1,000 ADD for winter cultivars. From these differences it is possible to study in detail the effects of daylength on plant development.

All of the components of yield in both spring and winter cultivars showed higher means from autumn- than from spring-sowings. In consequence, both spring and winter cultivars gave higher yields from autumn-sowing.

Selections from the cross cv. Golden Promise × cv. Ark Royal which showed combinations of early or late maturity, short or tall stature and high or low yield were examined in spaced-plant plots in 1982.

(R. P. Ellis)

08003 *Study inheritance of cereal performance characters. Design procedures to maximise and exploit variation.*

C. R. Tapsell[1] continued to analyse the data from collaborative investigations with Prof. J. L. Jinks[1] (Ann. Rep. 1981, p.164), although the CASE award ended in September 1981. The results from the random selection trials grown in 1981 gave better agreement with the cross predictions already made. However, the conclusions reached were generally similar to those obtained from the smaller trials.

Predictions of cross performance, based on the analysis of F_3 families, were made for six crosses from the breeding programme and will be tested by comparison with assessments of random inbred lines from each

[1]Department of Genetics, University of Birmingham.

cross. A much larger sample of crosses from the breeding programme was assessed in 1982 with F_2 population being grown at the same time as the F_3 rows for assessment. It was possible therefore to concentrate selection on the more promising crosses at F_2 on the basis of the analyses of the corresponding F_3 families. A comparison was made of the genetic parameters necessary for cross prediction when estimated from space-planted or drilled F_3 families. Some differences were found and further experimentation will be necessary to determine which method gives the more accurate prediction.

(W. T. B. Thomas, J. S. Swanston)

Following reports of the phenomenon of gene transfer in *Nicotiana* by the use of irradiated pollen, the application of this technique to barley breeding has been examined. Pollen from cv. Magnum was used either unirradiated to produce F_1 hybrids or following irradiation at 5, 10, 15 and 20 grays to produce M_1 derivatives, using cv. Golden Promise as female parent. Both the F_1 and M_1 embryos were recovered by embryo culture and examined in glasshouse experiments together with the parent cultivars. The F_1 exhibited the expected dominant expressions of a number of characters such as juvenile growth habit, mildew resistance and final plant height inherited from Magnum. The M_1 exhibited much greater phenotypic variation than the F_1. Some M_1 plants exhibited recessive traits inherited from Golden Promise, indicating that the phenomenon reported in *Nicotiana*, also occurred in *Hordeum*.

The M_2 and F_2 populations, produced by self-pollination, were examined in a randomised experiment at the Murrays farm in 1982 and scored for the same characters. A wide range of phenotypic variation was again observed in the M_2 and it was possible to recover lines which combined most of the maternal attributes of Golden Promise with particular components of genetic variation, for example mildew resistance, derived from Magnum. Data are still being collected on components of yield but the technique may be of particular value to breeders, for example in transferring attributes such as mildew resistance from poorly adapted to adapted cultivars.

Golden Promise and Magnum also possess distinct hordein electrophoretic patterns, being 1A and 15D respectively in the stocks used for these experiments. Electrophoretic examination of the M_2 and M_3 derivatives has been conducted in collaboration with M. J. Allison[1]. (See project 08009).

In barley there are two methods of deriving doubled haploids, *viz* by microspore culture and by inter-specific hybridization with *H. bulbosum*. The latter method is now used routinely in the breeding programme and a comparison was made of our technique and microspore culture in collaboration with J. M. Dunwell[2].

[1]Chemistry Department.
[2]JII.

Two cultivars, Golden Promise and Mazurka, and the F_1 hybrid between them were examined. The maximum yield of doubled haploids from the *bulbosum* technique was 15.4% of florets pollinated in the F_1 hybrid. The maximum from microspore culture was 0.5% of green plants, although a number of albino plants were also obtained, and again the F_1 hybrid was more productive than either of the pure-breeding parents.

Microspore culture derivatives of cv. Sabarlis produced at the JII were compared with a number of samples of Sabarlis from different provenances, in a replicated field experiment at the Murrays farm in 1982. The three components of yield, tiller number, grain number per ear and grain weight, and a number of agronomic characters, for example plant height, were recorded on material recovered from this experiment. For all characters there was significantly more variation in the microspore culture population than in the pure-breeding Sabarlis population. In some cases there was also a significant difference between the means of the two populations. This variability, which has been termed somaclonal variation, has been reported in a large number of species and genera, which have passed through a disorganised callus phase in culture.

(A. M. Hayter, W. Powell, W. Wood)

Three years of co-operative trials, which were grown by 13 spring barley breeders from nine European countries, have now been completed. There have been useful observations on yield which indicated that cv. Themis and cv. Regent produced high yields and were stable, with regressions of genotype on environment approximately 1.0. This contrasted with cv. Golden Promise which, in spite of disease being controlled, was the lowest yielding cultivar of 30 tested, but was nevertheless still stable. Cultivars with combinations of yielding ability and stability were noted. The analysis of quality factors is continuing. Plans have been made for a further 3 year trial series, following seed multiplication in 1983.

(R. P. Ellis)

08004 *Evaluate techniques for choosing parents and selecting offspring. Design data handling system for breeders.*

The investigation continued of selection for yield components, using single seed descent material. Selection for increased grain number (Ann. Rep. 1981, p.165) produced a difference between the means of the two populations but this was within the significance limits of the experiment. The effect of this selection on the other two components of yield was inconsistent, sometimes increasing and sometimes decreasing the mean. However, there appeared to be no adverse effect on other important characteristics as no significant differences were detected in awn emergence or in mildew resistance.

Material containing the haploid initiator gene was obtained from Professor A. Hagberg of Svalöv and grown in New Zealand from October 1981 to March 1982. Of 15 plants, 13 were fertile, one was male-sterile, and one haploid was observed. The 14 lines and other material obtained subsequently has been crossed to cv. Golden Promise to investigate the usefulness of this gene in the breeding programme.

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

08006 *Survey virulence genes in pathogens of barley.*

The relative frequency of virulence for identifiable Barley Mildew Resistance (BMR) groups was monitored, as in previous years, by exposing seedlings in the vicinity of the breeders' trials. In spite of the introduction of a widely virulent race (virulent on BMR groups 1, 2, 4, 5 and 6) on large numbers of plants in pots brought from the glasshouse in early May, the virulence pattern in early July reflected closely that obtained in previous years. Indeed the relatively low frequency of virulence for BMR group 6 and high frequency for BMR group 3 varieties corresponds with national surveys carried out by the UK Cereal Pathogen Virulence Survey Committee. Such results suggest that the pathogen population originated predominantly from the general air spora, generated by winter barley grown in the region and encouraged by the strip of autumn sown cv. Maris Otter surrounding the trials site. The artificial introduction of additional virulence on inolculated plants was ineffective. The widespread use of varieties of the appropriate BMR group may be necessary to specifically encourage less common virulences during the growing season. At present, the susceptible spring cultivar, Golden Promise, is used to encourage disease development.

In the artificially inoculated disease nursery (see Project 08009) set up to assess resistance to yellow rust (*Puccinia striiformis*) a widely virulent race (Race 24 vv, isolate 75/101) was used. However, the performance of standard differential varieties included in the nursery indicated the loss of one (BYV1) of the two identifiable virulence factors present in the isolate that was originally introduced. This was confirmed when spores collected at the time of assessment were tested on seedlings of the differential varieties in the glasshouse. The change in the pathogen population may have arisen through contamination from naturally occurring inoculum, though this seems unlikely as this race has not previously been recorded in surveys in the UK. Alternatively, mutation to the simpler virulence combination at an early stage in the development of the epidemic may have occurred. It is difficult not to believe that this isolate was at a competitive advantage compared with the original, given its prevalence at the end of the season. The incident serves to illustrate the need for the close monitoring of virulence in both naturally occurring and artificially introduced pathogen populations when screening for resistance to disease.

(M. J. C. Asher)

08007 *Study mechanisms of partial resistance of barley to* Erysiphe *and their use in resistance breeding.*

Studies continued on a number of spring barley selections exhibiting resistance to powdery mildew (*Erysiphe graminis* f. sp. *hordei*) in the absence of effective major resistance genes. The fifth leaf on plants raised in a spore-proof glasshouse was inoculated when recently fully-expanded, without infecting other leaves on the plant. Spores were collected from this leaf 10 days after inoculation and at intervals of 4 days thereafter, until sporulation on all host varieties ceased. The technique developed for counting spores by near-infra red reflectance (Ann. Rep. 1981, pp.147-148) was used for the first time as a routine method of estimating spore production. The most susceptible varieties produced an average of over 10^4 spores per colony over the 16-day sporulation period, equivalent to 0.5×10^6 spores per leaf. Some partially resistant selections produced less than half, and, in one case, less than one third this number of spores.

Latent period (LP), the time from inoculation to first appearance of colonies on the leaf surface, was also investigated, using detached leaf segments incubated at 5 and 10°C. LP was found to be longer in most partially resistant varieties, compared with some standard susceptible controls. There were also differences between resistant varieties, more pronounced at the lower temperature, which extended LP in all cases. LP was negatively correlated ($r = -0.959$) with infection frequency (IF) (Ann. Rep. 1981, pp.165-166) but no consistent correlation could be established with sporulation intensity (SI) among the varieties studied. One resistant variety, for example, exhibited a low IF, long LP but high SI; another showed low IF and long LP with very low SI. Not unexpectedly, the most susceptible control was characterized by high IF, short LP and high SI. This suggests that some of these characters are under independent genetic control and, potentially at least, may be recombined to enhance the level of overall partial resistance. Studies of the mode of inheritance of the individual components and a crossing programme to recombine them are in progress.

Further analysis was undertaken of data previously obtained in a genetic study of partial resistance, as expressed in the field (Ann. Rep. 1981, pp.165-166). By estimating the genetic parameters contributing to the control of resistance, it was possible to distinguish varieties in which partially effective major genes were operating, from those that lacked major resistance genes. The former were characterized by a significant dominance component in the analysis. It was concluded that selection for partial or background resistance, to which major resistance factors do not contribute, may be made on this basis, even in the presence of ineffective major genes.

(M. J. C. Asher)

08008 *Improve methods to establish barley disease nurseries.*

Disease nurseries to screen advanced breeding material for resistance were established for leaf blotch (*Rhynchosporium secalis*), yellow rust (*Puccinia striiformis*) and brown rust (*P. hordei*). Ethirimol-treated cv. Maris Otter was drilled in rows 110 cm apart in early autumn, 1981, in an area set aside for *Rhynchosporium* development. Chopped, infected straw was spread at the three-leaf stage in November and again the following February. In April, the area between the rows was rotovated and drilled down the centre with a double row of cv. Maris Mink. At the same time clumps of F_4 and more advanced breeding lines were sown at 0.5 m intervals between the rows of winter and spring barley.

Despite the severe winter and some waterlogging in the nursery causing losses in the winter barley spreader, sufficient viable inoculum remained for a slow but progressive natural infection of the Maris Mink. Repeated applications of different fungicides were necessary to control powdery mildew throughout the summer months but rain was sufficiently frequent to obviate the need for artificial irrigation this year. Ultimately, a uniform epidemic developed throughout the nursery and useful assessments of resistance were obtained for the 1,600 entries.

After 3 years of successful trials, it is tempting to claim that the methods adopted to generate this disease, under the sometimes adverse environmental conditions encountered at The Murrays farm are of proven reliability. However, none of these years was characterized by a period of drought which necessitated the use of overhead irrigation to ensure leaf wetness during the spring or summer months. Periods of up to 6 weeks without rain have been recorded in previous years and the reliability of the methods has yet to be tested under these conditions.

A spring sown nursery was established for screening for resistance to yellow rust, using a mildew-resistant but rust-susceptible variety as the disease spreader. Following the results of earlier trials (SPBS Ann. Rep. 1979-80, p.61) a dual inoculation technique, involving both syringe injection with spore suspensions and the transplanting of artificially infected seedlings from the glasshouse, has now been adopted as the routine method for this nursery. A widely virulent race (24 vv, isolate 75/101) was used. The disease developed rapidly without the need for overhead irrigation and an assessment of the reaction of over 2,000 breeding lines was achieved under conditions of a severe and uniform epidemic.

Brown rust, because of its requirement for warmer summer temperatures than normally experienced in Scotland, continues to present problems when selecting for resistance as part of national breeding objectives. The use of polythene tunnels and overhead mist irrigation, introduced for the first time in 1981, was supplemented with trickle irrigation at ground level for use when plants were fully grown and liable

to lodging. A late epidemic of the disease was recorded but assessment was made impossible by a severe infestation of cereal aphids. Further refinements of procedure are required.

(M. J. C. Asher)

08012 *Investigate inheritance of biochemical components of significance in breeding oats and barley.*

Evaluation of material from crosses between two-rowed and six-rowed barley cultivars confirmed that two-rowed progeny had higher levels of grain nitrogen and ß-amylase activity than did six-rowed progeny. This factor was inherited independently of the gene determining the Sd ß-amylase elecrophoretic pattern which is also associated with high ß-amylase. A combination of these two factors would explain the very high levels of enzyme activity associated with certain lines from the cross cv. Akka × cv. Feebar (SPBS Ann. Rep. 1978-79, pp.110-111).

Assessment of crosses, in which the Akka × Feebar lines had been used as one of the parents, suggested that a selection method based on two-tow ear-type and the appropriate electrophoretic pattern could be successfully applied in a breeding programme to produce cultivars with high diastatic power.

(J. S. Swanston)

08013 *Breed malting and feed barley cultivars.*

The new cultivar Tweed, SPBS648/18/68 from the cross (cv. Akka × cv. Mink) × Mink, was recommended to farmers after a first and very successful year in Scottish Colleges' Recommended List Trials. This is the first cultivar from the breeding programme to achieve this distinction. In 1982 Tweed performed particularly well in the north where it out-yielded cv. Triumph by 7%, Over all Scottish trials it had a yield advantage of 3% over Triumph and 9% over fungicide-treated cv. Golden Promise. Tweed is similar to Golden Promise in its resistance to ear loss and grain-shedding, it has grain of a higher specific weight and has stronger and slightly shorter straw. Tweed matures 3 days later than Golden Promise but is itself 3 days earlier than Triumph and 5 days earlier than cv. Midas. Tweed has the best mildew resistance of all currently listed clutivars and preliminary tests indicate that this resistance represents a completely new diversification group, so Tweed can be grown safely in conjunction with any other Recommended cultivar.
Malting tests on a commercial scale are still in progress but preliminary indications are encouraging, showing hot water extracts better than Golden Promise and an optimum level of post-harvest dormancy. The Institute of Brewing has shown interest in Tweed as a potential malting cultivar.

The cultivar Tay, from the cross Akka × Mink, SPBS213/11/4, completed Distinctness, Uniformity and Stability (DUS) tests in 1982 and was

eligible for addition to the National List. However, it proved impossible to distinguish Tay from cv. Leith in DUS tests without requesting additional tests, and since Leith was the higher yielding Tay has been withdrawn.

Leith, SPBS650/15/18 from a cross similar to that which produced Tweed, completed the second year of NLT in 1982. Leith performed well and has been selected for first year Scottish Colleges' Recommended List Trials in 1983. Leith may be slightly earlier, and higher yielding than Tweed, which it resembles in most other respects.

The cultivar Donan (formerly cv. Don), SPBS197/1/2/3 from the cross Triumph × cv. Ark Royal, failed to meet the standard for uniformity and a completely new submission has been made. Six deviant rows were detected in the second year of testing. This was disappointing because Donan has been shown to have high yielding potential, excellent disease resistance and malting quality equivalent to Triumph, but without the dormancy problem of Triumph.

Five cultivars submitted for NLT in 1982 successfully completed first year trials. The Joint Main Trial (Ann. Rep. 1981, p.167) series continued in 1982 and three cultivars have been submitted for the first year of NLT in 1983.

In 1982 post-harvest dormancy was systematically evaluated in all ARS breeding material in Joint Main Trials at The Murrays farm and showed that many lines which had Triumph as a parent, had inherited the excessive dormancy characteristic of Triumph. The average germinative energies (% grains germinated) measured at 12 days after harvest were:

	Including Triumph	Excluding Triumph
PBI lines	34.5 (9)	58.3 (7)
SCRI lines	– (0)	61.4 (16)
WPBS lines	43.3 (2)	71.4 (6)

The number of lines are indicated in brackets.

The germinative energy of Triumph itself was 36.7% and Golden Promise 84.7%. The decision to move away from Triumph as a parent in the SCRI programme was therefore wise but a number of other cultivars have been used which seem to present similar problems, notably Goldmarker and Magnum. Investigations of the dormancy problem are continuing.

Entries in Breeders' Preliminary Trials in 1982 included selections from the following crosses: BH4 × (Goldmarker × Ambre), BH716 × Ingot, (Goldmarker × Athos) × (Goldmarker × Magnum), Goldspear × Bella, BH655 × (Magnum × Aramis) and BH648 × (Magnum × Athos). With the exception of the last two crosses, all were of the erectoid type with a range of heights and maturities. The selections, which included several early ripening genotypes, were characterised by good all-round disease resistance and high yield. Several lines from the cross BH716 × Ingot outyielded Triumph by up to 15%.

Selections from the 1981 F_3 nurseries were screened with the Comparamill to identify those lines with low milling energy and possible malting quality. These comprised approximately 500 lines. The exchange of F_4 selections between the ARS barley breeding groups continued in 1982; seed from each selection was sent to both PBI and WPBS. In return a total of approximately 2,000 lines were received and, of these, 22 were retained for further study.

The Computer Housed Information Package (CHIP) developed by the Potato Breeding Department (Ann. Rep. 1981, p.175) was evaluated and proved useful for handling data from trials of breeding material. Increased use was made of the Apple II micro-computer both in logging data, such as plot yields, and in the provision of plot labels.

Conditions in 1982 proved favourable for the development of an epidemic of powdery mildew (*Erysiphe graminis* f.sp. *hordei*), allowing selection against susceptibility to the disease. Syringe inoculations of yellow rust (*Puccinia striiformis*) into susceptible control plots failed to produce an epidemic of the disease in the F_3 nursery due to unsuitable weather conditions but assessment of susceptibility of material in later generations was possible in the yellow-rust nursery. Straw infected with *Rhynchosporium secalis* was spread on some of the early generation nurseries but the occurrence of the disease was patchy and worthwhile selection against susceptibility proved difficult.

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

08015 *Produce pure seed stocks of new cultivars.*
Investigate diagnostic features of oats and barley.

Stocks from three new entries for the first year of National List testing, in addition to a re-submission of cv. Donan (SPBS297/1/2/3) were supplied to the Plant Variety Rights Office. The three new submissions were SCRI42/3/5, SCRI58/30/10 and SCRI130/73/2 (see Project 08013).

Poor plot establishment caused by a poor seed-bed and by an early and persistent spring drought made observations of ear-rows difficult and reduced yields below the levels necessary for continuation to the next stage of multiplication. BH808/3/7/9 ((BH218/4 × Hassan) × Minak) was re-selected and returned to final multiplication. Twenty other stocks were multiplied and re-assessed in New Zealand and will be returned to secondary multiplication in spring 1983.

Treatment of all stocks with Mancozeb (Dithane) plus Carbendazim (Bavistin) before and after anthesis (Ann. Rep. 1981, p.169) appeared to control leaf stripe (*Pyrenophora graminea*) very successfully. This preventative measure will be continued to prevent a recurrence of the leaf stripe problem.

Use of the database, PSUDB (Ann. Rep. 1981, p.169) has increased the overall efficiency of stocks administration by reducing routine, labour-intensive tasks such as the production of field plans and labels. The use of Apple II micro-computer and a hand-held terminal (M50F) also contributed to increased efficiency in recording and transferring data to PSUDB, to produce data files. Two complementary procedures, UPDATE and REPORT which provide stocks data and reports, respectively, continued to be developed.

(R. J. Giles, J. C. Penman)

FORAGE BRASSICA BREEDING

A. B. WILLS

The new Forage Brassica Breeding Department was created by the fusion of the Pentlandfield Brassica Department and the Brassica group of the Mylnefield Plant Breeding Section. The research programme at Pentlandfield remained virtually unchanged, while new work on forage brassica breeding problems partially replaced the Brussels sprout yield components and hybrid seed production investigations at Mylnefield. The transfer of breeders' trials and seed production facilities is anticipated in 1983 when a new building will be completed at Mylnefield for handling crops and seeds.

Agreement has been reached among DAFS, MAFF and NIAB to provide for trials of SCRI breeders' lines at suitable sites in England and Wales. This wider range of trials environments, compared to those available now, will give better assessments of genotype x environment responses, leading to a more informed choice of those lines submitted for NLT.

The two new swede cultivars, Angus and Melfort, were added to the National List in February. They were also included in the recommended list of swedes of the NIAB and that of the Scottish Agricultural Colleges. They are distinguished by their very high dry matter contents, turnip root fly resistance and good winter hardiness. The F_1 savoy cabbage cv. Monega, and the fodder radish cv. Crail, also were added to the National List. Sufficient quantities of seeds of some of these cultivars should be available from commercial sources for sowing in 1984.

Substances that will inhibit the germination of *Petunia* and *Lilium* pollen on silica TLC plates (pollen bioassay) can be extracted from brassica stigmas after they have developed self-incompatibility. These inhibitors therefore may be involved in the incompatibility reaction. Previously this possibility could not be tested by bioassay with brassica pollen because of the difficulty of germinating it *in vitro*. However, very high levels of germination have been obtained for the first time in hanging drop cultures by increasing the pH of the medium and this finding is being applied to obtain equivalent germination on TLC plates.

03010 *Brassicas: genetics of S-allele incompatibility system in* Brassica oleracea.

Nature of the incompatibility reaction.

Isoelectric focusing (IEF) experiments to detect proteins linked to, or specific to, incompatibility alleles were continued. Unpollinated stigmas

were obtained from buds and open flowers of three inbred lines homozygous for different codominant S-alleles (S_{14} ; S_{16} ; S_{29}) and the F_1 hybrids between them (S_{14} S_{16} ; S_{14} S_{29} ; S_{16} S_{29}).

For each genotype, 100 stigmas were ground in 300μl 10mM phosphate buffer (pH 7) using a ground glass homogeniser and centrifuged for 15 mins at 4°C. Samples of stigmas from each genotype were electrofocused on pH 3-11 polyacrylamide gels and stained for protein with coomassie brilliant blue R250. So many protein bands (*ca.* 25) were present in the pH 4-6 region that it was impossible to reach any firm conclusions regarding differences between genotypes within this range. There was less activity above pH 7 and, among the bands produced from the open flower stigma extracts, some were faint or absent from bud stigma extracts. The position of these bands on the gels differed for each S genotype. Seed of F_1 heterozygotes has been sown to enable the extent of the correlation of S-genotype with the variable bands to be tested during 1983. It has been shown that glycoproteins are associated with S-genotype but it is not known how many of the bands so far identified by our studies are glycoproteins because a satisfactory method of staining for their presence has yet to be devised.

Pollen germination inhibitors present in extracts of *B. oleracea* tissues have been further investigated using the thin layer chromatography (TLC) pollen bioassay technique described previously (Ann. Rep. 1981, p.67). Ethyl acetate soluble tissue extracts were obtained from the stigmas, styles and ovaries of self-pollinated, cross-pollinated (all harvested 24 h after pollination) and unpollinated flowers and from seeds, leaves and pollen of three unrelated inbred lines of *B. oleracea*. Samples of the extracts were chromatographed with chloroform, methanol (94:6) or hexane, propan-2-ol (80:20) on silica TLC plates. Pollen from *Petunia hybrida* or *Lilium lankongense* was sprayed on the plates to locate pollen germination inhibitors.

Each tissue tested possessed a unique distribution of zones inhibiting pollen germination, while differences between the lines tested appeared to be largely quantitative. Pollen from *P. hybrida* and *L. lankongense* gave identical results. Stigma tissue gave more and larger zones than any other tissue tested and there was some evidence that zones of inhibition tended to be slightly larger for self-pollinated stigma extracts than for the equivalent cross- or un-pollinated extracts. Another notable difference was the presence of a unique zone from pollen extracts.

In a further experiment, involving two inbred lines homozygous for different S-alleles, self- and cross-pollinated stigmas were collected after 2 h, 4 h and 24 h, together with unpollinated stigmas. Ethyl acetate soluble extracts were chromatographed with chloroform, methanol (94:6) and assayed with *P. hybrida* pollen. Extracts from self-pollinated stigmas taken 2 h after pollination gave inhibitory zones that were not present in

cross-pollinated or unpollinated extracts. These zones were markedly smaller from the 4 h and almost absent from the 24 h treatment. It appears possible therefore that incompatible pollinations in *B. oleracea* may induce the production of low molecular weight pollen germination inhibitors.

It has not been possible to substitute *B. oleracea* for *Petunia* and *Lilium* pollen owing to its low germination *in vitro*. The value of the pollen bioassay to investigations of incompatibility in *B. oleracea* would be considerably enhanced if this could be done and, accordingly, experiments to define a satisfactory medium were undertaken. High germination levels (>75%) have now been obtained repeatedly in hanging drop culture with a new medium, buffered to pH 8 with 20 mM TAPS. It was found that pH of the medium and ionic strength of the buffer were both crucial for successful germination. Altering the pH to 7.2 or 8.8, or increasing the TAPS concentration to 40 mM, gave germination of only 20-30%, similar to the unbuffered controls.

(J. R. T. Hodgkin, E. M. Wiseman, G. D. Lyon[1])

03011 *Brussels sprouts: breeding hybrid cultivars.*

The parents of those progenies which gave the highest yields and most uniform sprouts in 1980 (SHRI Ann. Rep. 1980, p.64) were self-pollinated to provide further seed. This seed is to be made available through BAPB to commercial breeders as preliminary breeding material with high yield potential.

(J. R. T. Hodgkin)

03012 *Cabbage: breeding hybrid cultivars.*

The parent lines of the hybrid cultivars Celtic and Monega were multiplied to ensure that sufficient stocks exist for the terminal stages of this programme. Nine savoy and five Celtic-type hybrids were re-synthesised in 12-plant cubicles using blowflies as pollinators. Parent lines of these hybrids were reproduced by manual self-pollinations of some that were homozygous for S-alleles and by blowfly sib-pollinations of others that had near-isogenic constituent lines.

Observations of over-wintering and seed setting ability were repeated on various parental lines of hybrids at an advanced stage of breeding. Little winter death resulted in spite of severe conditions in December (1981) and January, most plants having been short stemmed and covered with snow during the coldest period. The flowering periods of the parental lines for each hybrid were observed to ensure that they overlapped sufficiently for cross-pollination.

Three trials of cabbage were grown. Two repeated testing of savoy and Celtic types. The other tested Monega and other advanced F_1 hybrids, including two late autumn/winter savoys (C9392 and C9112) which were

[1]Mycology and Bacteriology Department.

entered for 1982 NLT. The trials were sown on 19 April, 10 May and 28 May and harvested in November and December. At the end of December Monega had an acceptable yield and was surviving best from the second sowing.

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

03013 *Brassicas: isoenzyme analysis in* Brassica oleracea.

The role of electrophoretic analysis has been extended during the past two years in response to the merger decision and now takes in the cruciferous forage species as well as the investigation of protein variation in different S-allele genotypes (see project 03010).

Analyses were also undertaken with G. Zacheo[1] to assess the variation in three enzymes and in soluble proteins over a number of generations of nine female populations of the nematode *Meloidogyne hapla*. In addition, two enzymes were studied in roots of tomato plants susceptible or resistant to this nematode.

A major part of the work during the year was to investigate the variation in allozymes of the Acp-1 and Acp-3 loci in a number of subspecies of *Brassica campestris*. These were obtained originally from the Zentralinstitut für Genetik und Kulturpflanzenforschung, Gatersleben (ZGK), and some have been used previously in the synthesis of artificial *B. napus* (SPBS Ann. Rep. 1977-78, pp.85-6). As classified by ZGK the accessions were : *B. narinosa* (1 accession tested), *B. nipposinica* (3), *B. chinensis* var. *chinensis* (10), *B.c.* var. *parachinensis* (4), *B.c.* var. *rosularis* (1), *B. pekinensis* var. *cylindrica* (8), *B.p.* var. *laxa* (17) and *B.p.* var. *pekinensis* (15). The pattern of allozyme variation in these materials accorded generally with that of other *B. campestris* subspecies examined previously and there were no new variants.

With the available experimental equipment there are technical problems in discriminating between certain Acp-1 allozymes of *B. campestris*. In particular, it is difficult to determine the number of different bands with mobilities from 0.28 to 0.30, and from 0.31 to 0.32. Further experiments were attempted to resolve these problems, using seed of the old turnip cultivars The Bruce and Snowball. At least eight bands were identified, as previously recorded (Ann. Rep. 1981, p.69) but the likely number was ten.

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

03015 *Brassicas: genetics and cytology of* Brassica oleracea *in relation to linkage groups.*

Small samples of each of 35 families from trisomic ($2n = 19$) plants were raised in a greenhouse and transplanted to a field plot for meiotic analysis and observations of gene segregations and general morphology. Among the genes segregating were fern-leaf (Fn), dominant glossy foliage (Go), recessive glossy foliage (gl), hairy leaf (Hr), pale green (pg), white petal

[1]Zoology Department.

(Wh) and crinkly petal (cp). Aberrant segregations of Hr were observed in four families and of Fn and pg in two others. Since no family had more than 28 plants it cannot be concluded without further data that these disturbed gene segregations were due to the transmission of the extra chromosomes. No consistent changes in general morphology that could have been associated with a trisomic condition were observed.

Owing to wide variation in flowering periods between and within families flower buds for meiotic analyses were obtained from less than half the number of plants in any family. A more efficient method for determining chromosome numbers was sought which would avoid both the need to maintain potted plants for root-tip collection and the use of flowering plants. Root-tips were taken from seeds that had been germinated in petri dishes in darkness. The tips were held in ice-water for 16h before fixing and staining. Large numbers of metaphases were accumulated by this treatment and chromosome counts were made of at least three cells in 90% of the tips. Synchronous germination was obtained by priming seeds with PEG6000 (−10 BAR) for 7 days prior to germination, enabling tips to be collected at the same time from all the viable seeds of a treated lot. The gametic transmission rate of the extra chromosome was determined by mitotic chromosome counts on germinated seeds in several progenies. Reciprocal crosses between one trisomic plant (1968.77.03, $2n=19$) and a diploid ($2n=18$), gave 18% trisomic seedlings when the trisomic was the male parent, compared with 42% when it was the female parent. Another trisomic plant (158.79.04), crossed as female to two different diploids, gave 36 and 43% trisomics respectively. From selfing 158.79.04, 43% trisomics were obtained, but only 3% of seedlings had higher chromosome numbers ($2n=20,29$). A small proportion of seedlings with $2n=20$ was also found in crosses when the trisomic was the female parent.

Seedlings with root-tips removed were grown on in dishes until they were fully emerged and were then individually pricked into pots and maintained in a greenhouse for further observation. In one cross family from 158.79.04, trisomic seedlings could be distinguished from diploids by the more rounded leaves of the former. But in field grown plants and in the second cross and the self-family this distinction was less certain.

In a further search for means to distinguish trisomics from euploid plants, the maximum pollen grain diameters and the proportion of viable grains were determined on stained pollen from plants with differing chromosome numbers (2n, $2n+1$, $2n+2$, $3n-2$, $3n-1$, 3n and 4n). The distribution of pollen grain diameters was approximately normal and no plant gave a clearly bimodal distribution. The ranges of mean diameters differed between diploid, triploid and tetraploid plants. Pollen size characteristics of $2n+1$ and $2n+2$ plants were like those of diploids and, similarly, $3n-2$ and $3n-1$ plant pollen size characteristics resembled those of triploids.

Genetic studies on *Brassica campestris* and *Brassica napus* have been extended. Ninety *B. campestris* accessions have been grown and examined for the presence of phenotypic variants. Variation has been observed in cotyledon number, anthocyanin pigmentation, hairiness of leaves and stem, leaf morphology, leaf waxiness, flower form and colour, and degree of self-incompatibility. Seed has been obtained by self-pollination from all annual flowering forms and from most of the variants noted within each accession. Initial pollinations to identify plants homozygous for different S-alleles have been made and 59 accessions have been screened for acid phosphatase isoenzymes in seeds and/or leaves (see project 03013). A number of *B. napus* accessions have also been grown. These include lines containing known marker genes obtained from Dr K. F. Thompson (PBI Cambridge) and phenotypic variants from Pentlandfield showing variation in leaf morphology, waxiness and colour.

(A. B. Wills, T. Hodgkin, P. Smith[1])

03019 *Broccoli: breed calabrese cultivars adapted to north European conditions.*

Ninety test-progenies produced by crossing plants selected from two randomly mated populations (Ann. Rep. 1981, p.71) to the tester cultivars Bravo and Corvet were sown in cold frames in April and transplanted into four randomised blocks. Because of the large number of plots involved, each block was divided into five equal parts and each sub-block included one plot each of Bravo and Corvet as controls. Plots were irrigated once after transplanting.

Plots were harvested twice weekly, when all mature primary spears were cut to a length of 15 cm. The majority of plants matured within 3 weeks of the start of heading. Spear weight, quality score and weight of attached leaf were recorded directly onto punched tape and principal components analysis was carried out for the complete data.

Test-progenies from the Corvet crosses were of consistently better agronomic type than those of Bravo and the choice of selection variate was made difficult by an overwhelmingly significant interaction between testers. The 30% best progenies were selected for further breeding of their half-sib inbreds, seeds of which were produced at the same time as the seed from cross-pollinations.

Extremely low temperatures together with pigeon damage destroyed F_4 broccoli × calabrese and F_2 calabrese × curly kale observation plots. Because of the decision to terminate work on horticultural brassica crops work on this material has now ceased.

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

07001 *Exploit interspecific and intergeneric crosses as sources of variation for brassica and radicole* (Raphanobrassica) *breeding.*

Fertility, seed production and germination of radicole have been improved by selection but because of other important problems cultivar

[1]Data Processing Department w.e.f. 1.10.82.

production will not be attempted. However, a small replicated trial was grown to compare some untested stocks with the rape cultivars, Lair, Emerald, Barsica and Winifred. In addition to yield, the trial was assessed for height, plant breaking, flowering and uniformity. The seed bed was very dry at sowing, and for several weeks afterwards. Under these conditions, the lines of radicole gave better emergence and establishment than the forage rape, and maintained this superiority right through to harvest. Due to premature flowering, some lines clearly had no potential for further development. All of the radicole lines had a better fresh weight yield than the mean of the controls, and only one line of radicole had a lower dry matter yield than the control mean despite the lower dry matter percentage of radicole compared with rape. Three radicole lines performed particularly well, with fresh weight yields equivalent to 60.33, 59.45 and 59.22 t/ha. The equivalent dry matter yields were 5.57, 5.85 and 6.03 t/ha respectively. The comparable fresh weight and dry matter yields for the best control cultivar, Barsica, were equivalent to 42.89 and 5.01 t/ha.

(W. H. Macfarlane Smith, I. H. McNaughton[1])

07006-8 *Brassica pathology.*

A trial of five advanced swede breeding lines and four control cultivars (Doon Major, Marian, Ruta Øtofte and Sator Øtofte) was grown to continue the study of the relationship between clubroot development and yield in forage brassicas. Symptom expression and plant weights of inoculated seedlings were recorded after 12 weeks growth in pots and on a further group of plants after transplanting and growing to maturity in the field. Clubroot scores and mean fresh weight per plant in each of the lines and controls were similar in range and rank after 12 weeks and at the final harvest. This association suggests that, for a given population of *Plasmodiophora brassica,* it may be possible to predict potential yield losses from tests on seedlings. However, the reliability of seedling tests in predicting performance over a wide range of field conditions has yet to be established.

The trial to investigate the relationship between severity of powdery mildew infection and yield loss in fodder rape (Ann. Rep. 1981, p.154) was repeated using the same eight cultivars and the results were in close agreement with those obtained in previous years. The least mildew developed on the cultivars Lair and Emerald and they had the greatest dry matter yield of infected plants. The highest mildew scores were obtained on cv. Winifred, which had a yield loss of 11.5% while cv. Camo scored slightly less but had the greatest yield loss (30%).

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[1]Tissue Culture and Cytology Unit.

Mildew development was monitored through the season on 11 swede cultivars and three advanced swede lines in plots which were exposed to inoculum from glasshouse-raised infector plants. The least mildew developed on the cultivars Magres, Melfort, Angus and Marian; the highest mean mildew scores over the season were obtained on the cultivars Acme and Doon Major. Control plots received one application of triadimefon (Bayleton) which reduced mildew infection to a very low level early in the season. A comparison of fresh weight yields from control and inoculated plots showed that the greatest yield losses of about 19% occurred with Acme and cv. Merrick, whereas there was no reduction in yield in Magres or Melfort.

(Cynthia J. Williamson)

07009 *Breed F_1 hybrid and inbred swede cultivars.*

Inbreeding within cultivars.

Selfing and selection was continued within several cultivars to produce high yielding and uniform lines. In a trial of lines from three old cultivars, the best results were given by a family of four lines from cv. Ingleston, which had a mean dry matter yield 9% higher than the mean of the control cultivars. Three lines from cv. Ne Plus Ultra produced slightly higher yields than the control mean, but all lines from cv. Ashgrove yielded poorly and will be discontinued. A trial was also grown using remnant seed of two families of cv. Ruta Øtofte which had yielded well in 1981 trials. Enough seed was available to sow five lines of one family and eight lines of the other. Both families gave mean dry matter yields over 18% higher than the mean of the parental cultivar (which was entered three times over the four replicates). Selections from cv. Criffel were grown to produce lines which were high yielding and homozygous for white flesh colour. Two families gave mean dry weight yields over 10% higher than Criffel, and one of these appeared to be true breeding for flesh colour.

A further generation of selections from cv. Bangholm Wilby was examined to compare their hardness and dry matter contents. Most of the lines had penetrometer acores of 45-48 mm and dry matter contents of 14.8-15.4% in comparison to 55-59 mm and 11.5-13.7% for the control cultivars. One Bangholm Wilby line appeared to be slightly softer than the rest, with 52 mm penetration, but this line also had a lower dry matter content with 14.2%. For comparison, the other inbred lines gave penetrometer readiness between 55-65 mm. The softest were found to be the selections from Criffel, which should, therefore, make them very suitable for sheep grazing.

F_1 hybrid breeding.

An experiment to examine methods of hybrid production was repeated because the previous attempt in 1981 failed due to severe frost damage.

Plots were set up to mimic single-cross, three-way cross and double-cross production in insect-proof cases, using blowflies as pollinators, and in isolation plots. The insect-proof cages were covered with white polythene and the isolation plots with nets. To examine how the behaviour of pollinating insects, and thus the extent of cross-pollination, was affected by differences in flower colour, either buff or bright yellow flowered plants were used as pollen donors while all the seed parents had buff flowers. Flowering occurred more rapidly and evenly in the insect-proofed cases than in the isolation plots where the later flowering exaggerated the differences in flowering times between the various lines, giving poor coincidence of flowering in some cases. Skin or flesh colour markers were incorporated in these crosses to allow the proportion of hybrid seed produced to be estimated when the progenies are grown out.

A trial was grown of hybrids produced by crossing inbred clubroot resistant lines with high yielding selections from the inbreeding programmes. The highest yield (16% more than the best control) was given by a cross between lines derived from cv. Gry (resistant) and cv. Pentland Harvester.

Pedigree breeding.

Most generations of the pedigree breeding programme are now represented in a continuing sequence from F_1 through to F_5 in both vegetative and seed production stages. The F_3 generation is not fully represented because material at this stage, which was derived from crosses between swede and rape, had poor bulb shape and so was not considered suitable for pedigree breeding. Instead, selected plants were mass multiplied in an effort to generate more desirable types. The gap in the programme is being filled with material obtained from WPBS. Breeding lines at various stages of development were received and a full assessment of their potential can now be made within the standard breeding schedule.

F_2 seed was produced overwinter and was sown out along with the F_1 trial containing the parental lines. This will allow selections to be concentrated on progenies from hybrids which performed well in the F_1 trial. Leaf cuttings were taken from plants selected in the field from those F_2 lines expected to segregate for clubroot resistance. The rooted cuttings were inoculated with clubroot in the glasshouse to examine the possibility of combining clubroot-resistance testing with agronomic assessment of field-grown plants. Some parents of F_2 lines had high dry matter contents. Several F_2 plants also had high dry matter contents (15-16%) but this may have been partly due to their having had small bulbs.

Trials at F_4 and F_5 were carried out with 60 and 56 lines, respectively, and four control cultivars. There were several promising lines in the F_4 trial, with four lines having dry weight yields over 10% higher than the mean of the control cultivars. Three of these lines were derived from a

cross between cv. Bangholm Magres and a breeding line coded CHO. highest yielding of these produced 21% more dry weight yield than the mean of the controls. In contrast, the F_5 trial results were disappointing, since the highest yielding line was less than 1% higher than the highest yielding control. Further selections from the best F_5 lines will be examined, but the results do not justify multiplying any line for more extensive testing.

Vernalisation of swedes.

Although swedes are grown on an annual basis in the glasshouse, they can produce seed within 8 months if sown at the right time for vernalisation to occur. For simple backcrossing programmes, it would be convenient to reduce the life cycle to 6 months. In an attempt to achieve this aim, experiments have been carried out to define the optimum vernalisation conditions. Because it is necessary for the treatments used to induce flowering in all plants, bolting resistant lines from the cultivars Ruta Øtofte and Bangholm Wilby have been used for most of this work. After allowing 2 days at 18°C for germination, seedlings were pricked out and allowed a period of pre-treatment growth at 18°C, or transferred immediately to 5°C for cold treatment. It was found that growing the plants under high temperatures before cold treatment could cause delays in flowering. Periods of over 4 days pre-treatment growth progressively delayed flowering in the Ruta Øtofte, but with the Bangholm Wilby line the delays started immediately after germination. In contrast the period of pre-treatment growth was found not to have any effect on a line from cv. Marian, which has low vernalisation requirments.

Giberellic acid (GA3) appeared to reduce the delays induced by long pre-treatment growth periods, but with no pre-treatment growth period it caused a delay in the time of flowering. The optimum treatment for vernalisation used in these experiments was a 9 week period at 5°C, without any pre-treatment growth period or GA3 treatment. Grown on at 18°C after vernalisation, all plants flowered within 16 weeks of germination. Allowing 2 months for seed set and ripening, the generation time has, therefore, been reduced to less than 6 months.

(S. Gowers, D. J. Gemmell)

Advanced swede lines.

The Field Trials Unit carried out a trial of advanced material at each of the following sites: The Murrays farm; Mylnefield; Tritlington Hall, Cockle Park, Northumberland; Yonderton Farm, near Ayr and Westerton of Pitarrow, Laurencekirk. The trial included a line from NVRS selected for resistance to turnip mosaic virus, four inbreds from within cultivars, six lines from the original inbreeding programme to replace cv. Pentland Harvester and five control cultivars. In addition a further three lines and one control were tested at The Murrays farm and

at Laurencekirk, there being insufficient seed of these to trial at all five sites.

Genotype-environment interaction was particularly evident and the relative ranking of some lines varied widely. From the mean of all sites, the best performances in dry matter production were from an inbred line from cv. Ruta Øtofte, the control cultivars Melfort and Bangholm Magres and a line, Da 671, from the inbreeding programme. The yields of these four were between 105% and 106% of the mean yield of all the controls. Further evaluation of the inbred lines will be necessary.

A small trial consisting of 19 advanced breeding lines and five control cultivars was grown at The Murrays farm. The dry matter yield of Da 671 in this trial was significantly higher than three of the controls. Da 671 is relatively uniform with a fairly dark purple skin and although its dry matter percentage is somewhat lower than that of cv. Angus and Melfort, it appears to be less susceptible to mildew than either.

(Isabel K. Munro)

Swede trials.

Work in collaboration with NSCA and WSAC on turnip rootfly resistance continued with further data on resistance in Angus and Melfort being obtained. This attribute could have considerable impact on swede growing in those areas of Scotland where the pest is a problem and might be of great value also in some other swede growing countries.

Trials conducted by the NSCA in 1982 compared Angus and Melfort with seven cultivars of varying dry matter contents. Although resistance to the pest has been obtained in both these high dry matter swedes, there are differences in the relative resistance which suggest that factors other than dry matter content *per se* are also involved. Work has therefore been started in collaboration with the Chemistry Department to ascertain whether any difference in chemical content between these two new cultivars and other commercial cultivars can account for this resistance.

(Isabel K. Munro)

07010 *Breed rape cultivars from natural and artificial genotypes of* Brassica napus *and related species.*

The forage rape breeding programme continues to be broad based with contributions from inter-specific and inter-cultivar crosses, and mutation treatments. The main source of material comes from progenies of artificial *Brassica napus (B. oleracea* × *B. campestris)* crossed with the highest yielding culticars. A number of them have good disease resistance, especially to clubroot (*Plasmodiophora brassica*) and single plants have been selected for this character at the F_2 or F_3 generation for selfing or for further crossing. Inter-cultivar crosses have been restricted to those where the parents have high fresh or dry weight yields, or possess specific disease resistance.

There is very little prospect of improving resistance to clubroot or powdery mildew *(Erysiphe cruciferarum)* by use of the mutagenic chemical ethyl methane sulphonate (EMS). However, some of the treated material which is taller and later flowering will be retained, and the possibility of induced lower levels of S-methyl cysteine sulphoxide (SMCO) and the glucosinolates will be investigated. A pilot experiment to determine the effective level of gamma-radiation on non-imbibed seed as an alternative mutagen has indicated that a dose rate in excess of 200 grays will be required.

A two replicate randomised complete block F_3 yield trial containing 43 breeding lines and 5 control cultivars was grown at The Murrays farm. The lines under test were inter-cultivar crosses, selfs, and back-crosses to cultivars of artificial *B. napus,* and cv. Lair treated with EMS. The trial was assessed for height, flowering, plant breaking, uniformity, fresh weight yield, dry matter percentage, dry matter yield and mildew resistance. Sixteen of the 43 breeding lines performed better than the mean of the controls in some respect, usually dry matter yield but in some cases dry matter percentage, and were retained to produce seed for further yield trials. Analyses of SMCO and glucosinolate contents have still to be completed. The mean fresh weight yield of the controls was equivalent to 33.47 t/ha (4.59 t/ha dry matter yield). The best breeding line, RS 78023, had an equivalent fresh weight yield of 50.17 t/ha (4.68 t/ha dry matter yield). Another line, RS 78017/6, with a very high dry matter percentage, produced fresh weight and dry matter yields equivalent to 42.33 and 5.36 t/ha respectively.

The line SCRI 57, now in the second year of NLT, was also tested in replicated trials at four sites in Scotland and Northern England – Ayr, Dundee, East Lothian and Newcastle. Due to severe drought and associated weed control problems, the trial at Dundee was abandoned. The control cultivars in these three-replicate randomised complete block trials were Canard, Emerald, Lair and Winifred. SCRI 57 confirmed its high fresh weight yield, being joint top over all the trials, but its dry weight yield was comparatively low due to the low dry matter percentage. The extent to which low DM% is important in a very leafy line such as SCRI 57, has still to be shown in grazing trials. SCRI continued to show better than average resistance to mildew, clubroot and *Alternaria.* Over the three trial centres the fresh weight and dry matter mean yields for the controls were equivalent to 45.59 and 5.43 t/ha respectively. The comparable figures for SCRI 57 were 50.81 and 5.11 t/ha.

The experiment to investigate the effect of seed size on yield was continued for a second year, in a four-replicate, randomised complete block trial, using the forage rape SCRI 57 and with cultivars Emerald and Barsica as controls. The three categories of seed size were 1.50 to 1.75 mm, 2.00 to 2.25 mm and 2.75 to 4.50 mm. Some of the seed was again treated with aluminium ammonium sulphate (Seedguard). The trial

was grown in a very dry area and consequently fresh weight and dry matter yields were very low (mean fresh weight yield of controls equivalent to 22.79 t/ha). Fresh weight and dry matter yields were not affected by seed size, contrary to the results of the previous trial (Ann. Report 1981, p.160), nor were height, plant breaking or dry matter percentage. The use of Seedguard also had no significant effect on any of these characters, although emergence of the treated seed was again earlier than the untreated seed.

The plant spacing trial was also continued for a second year, again using SCRI 57 and Lair. The four replicate randomised complete block trial was sown with interplant spacings of 5.0, 6.4, 10.2 and 12.7 cm. These vary slightly from those used in 1981, due to the use of different selector wheels in the Webb drill. Inter-row spacing (0.5 m) and seed size (2.00 to 2.25 mm) remained unchanged. This trial was also grown under very dry conditions which gave an average fresh weight yield equivalent to only 30.77 t/ha. As in 1981, spacing had no significant effect on yields, dry matter percentage or height.

(W. H. Macfarlane Smith)

07011 *Breed kale and fodder cabbage cultivars.*

Kale breeding.

Work undertaken in collaboration with FRI, to investigate the variation in glucosinolates in the leafy cruciferous fodder crops, has confirmed that a high content of glucobrassicin is present in kale leaves, and that rape leaves and stems have a high progoitrin content. Following ingestion, glucobrassicin breaks down and releases SCN^-, while goitrin is released from progoitrin. Both of these breakdown products are goitrogens. However, as the antithyroid effects of SCN^-, but not goitrin, can be overcome by added iodine, selection for lower contents of glucobrassicin in kale is not as important as selection for lower contents of progoitrin in rape.

Comparisons were made of half-sib, full-sib and selfed families, derived from the kale polycross improvement programme started in 1971. They suggest that S_1 family selection may be the best breeding method for lowering the contents of SMCO, which causes haemolytic anaemia, and of glucobrassicin, measured as SCN^-. With two replicates, 52% of the differences between the means of selfed families was genetical for SMCO and 75% for SCN^-. The range was from 5.75 to 9.50 g/kgDM for SMCO and from 0.113 to 0.438 g/kgDM for SCN^-.

In 1981 seed was harvested from 105 marrow-stem kale plants which had shown some resistance to clubroot in seedling tests in 1980. These single plant progenies were screened for clubroot resistance in seedling tests in 1982 and resistant plants were saved for seed production in 1983. In addition, the single plant progenies were grown in a yield trial. The mean dry matter yield of the progenies was 8.76 t/ha (114%) compared

with 7.66 t/ha for the mean of the six control cultivars Bittern, Canson, Condor, Kestrel, Merlin and Proteor. On a single plot basis additive genetical variance accounted for approximately half (51%) of the total variation between progenies. The fourth generation kale polycross families assessed in 1981 had a similar estimate (52%) but a lower mean yield relative to the same controls (103%). If the new marrow-stem progenies also have better potential for lowering SMCO and SCN^- levels, the polycross improvement programme will be discontinued. Because the progenies were derived only from marrow-stem kales their narrow morphological base should facilitate the production of a cultivar with sufficient uniformity for the relatively strict DUS requirements in NLT.

SCRI KB21, a distinct second generation polycross family, has been withdrawn from NLT because of lack of uniformity, despite selection to reduce its morphological variability. This has emphasised the problems of cultivar selection from morphologically heterogenous populations deriving from the initial population, created in 1971, which contained marrow-stem, thousand-head, and curly kales, Brussels sprouts and cabbages.

Four third generation polycross families were assessed at four sites in the south of Scotland and north of England in 1982. Four fourth generation families have been selected for mass-multiplication in 1983 in order to provide seed for trials in 1984 and 1985. Analyses of the 1979 and 1980 series of trials revealed large genotype environment interactions for dry matter and DOMD yield. These interactions make it difficult to predict the relative yield performance of potential new cultivars over a wider range of environments. Hence it is desirable to extend future trials beyond the south of Scotland and north of England to other kale growing areas in the United Kingdom.

(J. E. Bradshaw)

07012 *Breed turnip cultivars especially for Scottish uplands.*

Trials were sown in 1981 and 1982 using seed produced from a polycross in 1980 (SPBS Ann. Rep. 1980-81, p.65). Yield results were not obtained in either year; in 1981 there were severe attacks of second generation cabbage-root fly and swede midge, which were not controlled by the insecticide applied, and in 1982 there was poor germination due to drought, followed by heavy mildew and viral infection. However, advantage was taken of the prevailing conditions, and selections for winter hardiness were made from the 1981 plots, and for mildew and virus resistance from the 1982 plots. A polycross was made from each of the two sets of selections to produce seed for further studies.

The backcrossing series to transfer clubroot resistance from stubble turnip ECD 04 into cultivars of traditional turnips was continued. Fourth backcrosses were made using the cultivars Foll, Green Top Yellow and Green Top Scotch as recurrent parents. In addition, the lines from

ECD 04 crossed with cv. Hvit Mainepe have been selfed to isolate lines homozygous for clubroot resistance, with the intention of selecting for high dry matter content but with a globe shape intermediate between the two parents. A small multiplication was also made from each of the backcross lines. Assessment of this material should give an indication of the number of generations of backcrossing necessary to produce parental types with the required clubroot resistance.

(D. J. Gemmell, S. Gowers)

07015 *Test and multiply brassica, radish and radicole cultivars.*

In 1982 approximately 70 polythene tunnels of different sizes and approximately 70 insect cages were used for seed multiplication at Pentlandfield. In addition, five larger plots were used on sites in East Lothian to accommodate larger numbers of plants. Seed from some of these plots will go for NLT.

At one of these sites, there was a potential problem due to the proximity of two fields of oil seed rape to an established swede multiplication plot. Although the distance was greater than the statutory minimum, there was a risk of contamination due to the direction of the prevailing wind and the absence of any physical barrier. The swede plants were therefore cut back and the whole cage covered in close-weave material. Blowfly pupae were introduced to effect pollination, but weather conditions affected them badly and so a lower seed set resulted in this plot than in other unenclosed multiplication plots.

The upsurge of oil-seed rape may well cause further problems for multiplication in the future. Consequently, higher voluntary standards are being imposed over the isolation from other brassica crops, especially oil seed rape, and over the elimination of volunteer plants.

(Isabel K. Munro)

NEW SAVOY CABBAGE CULTIVAR

MONEGA

Origin	An F_1 hybrid developed from January King, Ormskirk savoy and Alexanders No. 1 Late.
Plant	Uniform, erect, short-stemmed, medium/strong savoyed, with dark, grey-green leaves. Without non-heading rogues.
Head	Uniform, solid, spherical, pale grey-green without anthocyanin. Yellow green interior, short core.

Monega is a late autumn maturing cultivar for the fresh market. It has moderately good winter-hardiness if sown from late May to early June. The plants mature uniformly, producing 1.5 kg heads at 400×600 mm spacing.

NEW SWEDE CULTIVAR

ANGUS

Origin	A line selected from Bangholm Wilby × Bangholm Danila.
Root shape	Globe.
Skin colour	Bronze-purple.
Flesh colour	Deep yellow.
Dry matter content	Very high.
Keeping quality	Excellent.
Clubroot resistance	Average.
Mildew resistance	Average.
Turnip root fly resistance	Very good.

In UK trials at several sites over three years Angus gave average dry matter yields 2% higher than those of cv. Bangholm, with dry matter content similar to cv. Melfort and greater than any other recommended cultivar. Angus has very good resistance to turnip root fly, making it particularly suitable for those areas where serious infestations occur. It has excellent keeping quality, usually with fewer splits and rots than any other cultivar, and is very suitable for storage or late grazing.

NEW SWEDE CULTIVAR

MELFORT

Origin	A line selected from Bangholm Wilby × Gullacker.
Root shape	Globe.
Skin colour	Green.
Flesh colour	Deep yellow.
Dry matter content	Very high.
Keeping quality	Very good.
Clubroot resistance	Average.
Mildew resistance	Average.
Turnip root fly resistance.	Very good.

In UK trials at several sites over three years Melfort gave average dry matter yields 5% higher than those of cv. Sator Øtofte, with dry matter content similar to Angus and greater than any other recommended cultivar. Melfort has very good resistance to turnip root fly, making it particularly suitable for those areas where serious infestations occur. It has very good keeping quality and is very suitable for storage or late grazing.

NEW FODDER RADISH CULTIVAR

CRAIL

Origin	A line selected from an induced tetraploid form of cv. Slobolt.
Skin colour	Red.
Flesh colour	White.
Bolting tendency	Late-flowering.
Dry matter content	Low.
Clubroot resistance	Very good.
Mildew resistance.	Very good.

The late-flowering character of Crail makes it available for utilization for a longer period than usual for fodder radish. It has average dry matter yields.

POTATO BREEDING

G. R. MACKAY

Potato breeding is, and probably will continue for some time to be, largely based on phenotypic selection. However, both the successful completion of the seedling blight experiment (09015) and the successful hybridisation of clones shown by progeny test to be duplex for their PVY resistance genes (09001) mark significant progress towards the production and identification of parental clones of proven genetic worth. At the other end of the scale the acceptance of cv. Kirsty on to the National List and the successful completion of first year National List Trials by the clones 10442 (8), 10333ab18 and 9869a9 provide tangible evidence of the contribution that the SCRI potato breeding programme continues to make to UK agriculture. It is also gratifying to record the submission to NLT of two maincrop clones, 11305a2 and 11233ab22 which have horizontal resistance to both the golden (*Globodera rostochiensis*) and white (*G. pallida*) potato cyst nematodes derived from *Solanum vernei*. These two clones have also exhibited high levels of tolerance to invasion by potato cyst nematodes in the absence of nematicides. We are extremely grateful to our colleagues in ADAS who collaborated in undertaking the trials which provided these data. Following discussions with representatives of ADAS, this collaboration has now been formalised and more extensive trials are planned in 1983. Similarly, the trialling of SCRI advanced clones in the principal ware growing areas of England and S. Wales has only been made possible by the welcome assistance of ADAS and UCW (09005).

Collaboration with the Potato Processors' Association continued through 1982 and, of the clones selected by SCRI for their processing potential and trialled by the processors, one in particular, 11396ab12, has excited a great deal of interest as a potential 'crisper' with unique storage characteristics.

1982 also marked the implementation of the new management structure of the Potato Breeding Department, formerly Division, and discussions have begun as to how to more closely integrate the breeding programmes of the former Strategic Breeding Department with that of the Commercial Breeding Department. At least one advanced clone in its final stages of assessment is a hybrid involving a Neo-Tuberosum parent, dating from speculative crosses made in 1974, which lends support to the planned use of selected clones emanating from the 'strategic' breeders'

programmes in more commercially orientated crossing schedules in the near future.

SCRI has continued to expand its involvement in the overseas trialling of selected advanced clones and for the first time a sample of 25 clones has been despatched to Algeria for trial in 1983. To date, results of trials in Spain have been encouraging; cv. Baillie continued successfully in Spanish National List Trials, cv. Kirsty was the highest yielding cultivar in the Solanex/Matutano trial at Burgos, Northern Spain, and the first early NLT submission 10337de40 performed exceptionally well at Malaga, Valencia and Majorca.

09001 *Breed maincrop potato cultivars for quality, disease resistance and yield for fresh use and processing.*

The early maincrop cv. Kirsty (clone 9006(6)) successfully completed NLT and was entered on to the National List. Its contemporary cv. Fiona (clone 8911abc15) was not considered of sufficient value for cultivation and use for entry to the National List but this decision is the subject of an appeal at the time of writing because the NLT data is inconsistent with the breeders' estimate of the clone's potential.

The two maincrop clones 10333ab18 and 10442(8) successfully completed their first year NLT and have been re-submitted for their second and final statutory trials in 1983.

Clones 11305a2 and 11233ab22 were submitted and have been accepted for NLT in 1983.

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

Breeding for potato cyst nematode (PCN) resistance.

During 1982 the assessment of field tolerance of advanced PCN resistant clones continued. In collaboration with ADAS advanced material was trialled at two sites infested with *G. pallida*, one near Cambridge with the co-operation of Dr P. L. Mathias[1] and the other at Nocton near Derby with the co-operation of Mr J. M. Holliday[1]. Clones were also trialled at a site infested with *G. rostochiensis* near Dundee with the co-operation of D. L. Trudgill[2]. At all sites considerable differences were observed in tolerance between clones. The most intolerant clone exhibited a 70% yield reduction in the absence of nematicide compared with 2.4% for the most tolerant clone. As observed in 1981, there is no correlation between PCN resistance and tolerance, again emphasising the importance of screening for tolerance *per se*.

The two most advanced clones 11305a2 and 11233ab22, previously trialled in 1981, again performed satisfactorily.

(M. F. B. Dale)

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[1]ADAS.
[2]Zoology Department.

Virus resistance breeding.

A series of virus resistant crossing schedules was attempted in 1982, using clones identified as duplex for their PVY resistance gene loci. Typically, the schedules were incomplete due to lack of fertility in some clones but in all cases it was possible to obtain seed from crosses or selfs of duplex clones, and in this respect the schedules were extremely successful. In addition, seed was secured from crosses between a range of phenotypically resistant clones of unknown genetic status and PVY and PVX susceptible cultivars for further progeny tests and evaluation in the commercial programme.

Several hundred clones emanating from the 1979 crossing programme involving cv. Maris Piper as a parent reached their second clonal year of field evaluation in 1982 and amongst them 59 were identified as having inherited the H_1 gene conferring resistance to *G. rostochiensis* Ro_1.

(G. R. Mackay, Jean Spence)

Breeding for late blight resistance.

Clones originating from the most recent blight schedule (1979) are now undergoing commercial assessment and have provided the source material for the devlopment of a valuable seedling screen for foliage blight resistance (*viz.* 09015). Preliminary indications are that segregants possessing extremely high levels of horizontal resistance to late blight exist within this population.

(G. R. Mackay, P. D. S. Caligari)

Glasshouse common scab trial.

Single small tubers were placed in 10 cm pots containing sand, naturally infected with *Streptomyces scabies.* This sand was obtained from Archerfield, a site regularly used for field scab trials. Nine cultivars with known susceptibility/resistance were used as the primary requisite of such a test is to give a true prediction of field performance. The indications from this preliminary trial are that although the plants were grown in somewhat artificial conditions, i.e. in pots in a glasshouse, the results correlate well with the established performance of the cultivars.

(P. D. S. Caligari)

09002 *Breed early potato cultivars for early yield and quality in relation to fresh use, crisping and canning.*

The first early cv. Provost (7169(10)), which completed NLT in 1981, is continuing to elicit considerable interest amongst early potato growers, particularly for its table quality.

Clone 9869a9 completed first year NLT and is continuing into its final year of statutory trials in 1983. Another first early, clone 10337de40, was

submitted and accepted for NLT in autumn 1982. 10337de40 is a good quality, high yielding first early clone with a capacity to continue bulking over a long period and has given quite acceptable yields comparable to maincrop cultivars at maturity. It produces attractive long oval tubers which are white skinned with a very faint red/purple eye. This clone has also performed extremely well in Spain and, if the 1982 performance is confirmed in 1983, is a strong contender for Spanish NLT in 1984.

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

09005 *Evaluate advanced potato selections in field trials in Scotland, England and Wales.*

1982 was the third year of joint trials of advanced clones from SCRI, PBI and DANI. The trials contained 22 entries; five control cultivars, nine clones from PBI, three from DANI and five from SCRI. The five SCRI clones were repeat submissions and no new clones were entered into these trials as a result of changes in the trialling system described below. Of the five SCRI entries, 10333ab18 and 10442(8) had been submitted for NLT in 1981 and continued to perform well. Two (11305a2 and 11233ab22) of the remaining three performed sufficiently well to be submitted for Plant Variety Rights and NLT in the autumn. Both of these clones produce good yields of quality tubers and are resistant and tolerant to both *Globodera pallida* and *G. rostochiensis*. They are the first clones to be submitted as potential cultivars which have high levels of comprehensive PCN resistance to both species of the pest.

For the first time, all the clones that had reached the sixth clonal generation (M4) were raised in replicated trials, as opposed to observation plots, at the four ADAS farms with whom we collaborate, namely: Arthur Rickwood EHF, Gleadthorpe EHF, Stockbridge House EHS and Terrington EHF, as well as being grown at The Murrays farm. The trials contained 55 clones and 5 control cultivars grown in two 12-tuber plots at each site. The planting, husbandry and harvesting of the trials was carried out by the ADAS staff while SCRI staff weighed, graded and scored the produce. Several clones were identified as possible candidates for NLT submission and others for retrial in 1983. A few of the 55 clones, which had shown suitable characteristics in our cooking tests in 1981, had been supplied to the Potato Processors' Association. One, 11396ab12, has elicited considerable interest from the crisp manufacturers because it appears to accumulate lower levels of reducing sugars during storage under conditions less stringently controlled than is usually necessary for a crisping cultivar.

Ten clones and six cultivars were grown in first early trials at Trefloyne[1] and Penrice, at Cairnside, Wigtownshire, and at The Murrays farm. Of

[1]University of Wales.

the ten clones, one (10337de40) was submitted for NLT and two others were identified as potential NLT candidates for 1983.

A number of advanced clones either currently in or just completed NLT were supplied, by arrangement with NSDO, to external collaborators, namely: Horberry and Baker (Haxey, Doncaster), H. J. Mason (ADAS, March) and A. and H. Worth and Co. (Holbeach, Lincs). The data they provided usefully supplemented our own.

(P. D. S. Caligari)

Overseas trials.

In 1982, trials were carried out at two sites in Spain by arrangement with Matutano S.A. These comprised some 80 clones which had reached the sixth clonal generation in 1981. The sites were chosen to represent early (Valencia) and maincrop (Burgos) growing areas. Ten clones at Valencia and five clones at Burgos were judged to have sufficient merit to be re-trialled in 1983. In addition to these breeders' trials, eight advanced (pre-NLT and NLT) clones were included in larger scale NSDO trials at Malaga, Valencia, Majorca and Burgos using seed supplied by SCRI. At the three first mentioned, two clones, 10333ab18 and 10337de40, aroused much interest. The latter produced very good yields of very attractive long oval tubers and outyielded all other clones, including controls, in the trial at Malaga. It was amongst the highest yielding clones at the other two sites. Clone 10333ab18 performed well at the short season, early sites in Spain. That it is currently in UK NLT as a maincrop of similar maturity to cv. Pentland Crown, underlines the need for trials in the environment for which the cultivar is ultimately intended. At Burgos, several of the clones were of interest but one, cv. Kirsty (9006(6)), performed particularly well.

For the first time in 1982 a sample of advanced clones from the commercial breeding programme was submitted for trial at Gilat Experimental Station, Israel. The results and observations from these trials also demonstrate the changed behaviour of clones bred and selected in the UK in these different environments. Only 25 clones were grown but five were identified as being worthy of re-trial in 1983. In common with Spain, a sample of all clones reaching their 6th clonal year of assessment in the UK are being supplied for first year observation in 1983, as well as others for specific evaluation in *Verticillium* and *Alternaria* infection trials.

Samples of advanced clones were supplied to Algeria for the first time in 1982 for trial in 1983, by arrangement with Institut de Dévéloppement des Cultures Maraichères, Staoueli.

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

09009 *Establish and manage computerised data bank on clones under selection in the potato breeding programme.*

Development of the Computer Housed Information Package (CHIP) continued and it is now used by the commercial potato breeders, their supporting pathologists and by the cereal breeders. The package has been expanded to incorporate further useful routines which allow the user more control and flexibility in storing and manipulating data. It has been converted into FORTRAN 77 and may be mounted on an APPLE II micro-computer in the near future. Although the micro-computers may lack the storage capacity to handle the larger trials in the early generations of a commercial plant breeding programme, they may be suitable for some of the smaller data bases which are now being used and hence reduce some of the work presently done on the ERCC mainframe machines.

(J. Brown)

09010 *Study biology of potato cyst eelworm including host parasite relationship and the nature of resistance.*

The *in vitro* hatching activity of root diffusates from *S. vernei* (CPC 4078), cv. Pentland Crown, and eleven *S. tuberosum* × *S. vernei* hybrids was compared by sequentially adding diffusate collected over 6 weeks (Ann. Rep. 1981, p.176). The hatch induced by *S. vernei* was 75% of that induced by Pentland Crown. The hybrids produced intermediate hatches, with eight of them significantly less than Pentland Crown. The correlation between percentage total hatch and resistance was positive but weak ($r = 0.6$) due to some of the more resistant clones producing relatively good hatches.

Work continued on the response of *G. pallida* to brief exposure to potato root diffusate (SPBS Ann. Rep. 1976-77, p.52). Treatment with diffusate for 5-10 min each week not only induced a significantly higher hatch (43%) than eggs exposed to tap water only (8% $P<0.001$), but also caused unhatched juveniles to respond more rapidly when treated again with potato root diffusate. When re-treated, peak hatches occurred on the first and second days instead of the fourth and fifth days suggesting that these juveniles had already undergone some changes prior to hatching. More than twice as many eggs were killed by removing liquid from the vials and drying the cysts for a fortnight in an incubator at 20°C, if they had previously been treated with diffusate for 24 h than if they were dried after being soaked only in water. This suggests that a rapid increase in the permeability of the egg membrane is caused by potato root diffusate. The longevity of eggs in the soil may be reduced by such a change.

Selection of the Lindley population of *G. pallida* (Pa_2) maintained under Pentland Crown and two clones with partial resistances of 80% and 90% (SPBS Ann. Rep. 1980-82, p.102) continued for a fifth year. In

1982 the number of eggs/g under Pentland Crown declined to 473.9 while under 8906abc(11) and 8917b(3) numbers remained relatively constant at 116.2 and 27.2 eggs/g respectively. No selection for virulence was apparent. This conclusion was supported by the results of a glasshouse test which compared the performance of populations reared under the three clones with an unselected population. There was, however, selection for increased fecundity under 8917b(3) which was 90% resistant, for this population contained 17.5% more eggs/cyst than those derived from the other clones.

Studies of the selection of *G. pallida* on resistant hybrids might be facilitated if more than one generation of the parasite could be obtained each year. Attempts to break the diapause of *G. pallida* by treating new cysts with potato root diffusate, picrolonic acid and hypochlorites of sodium and calcium have so far proved unsuccessful.

In order to assess the variation in virulence between populations of *G. pallida,* six populations were obtained from ADAS: one each of Pa_2 and Pa_3 and four which gave intermediate responses on the differential clone 62.33.3. Eleven clones derived from *S. vernei* and five derived from *S. andigena* CPC 2802 together with clones 62.33.3 and D47/11 were tested in the glasshouse with all six populations. Analysis of the data based on egg counts at planting and post-harvest indicated that most of the variation in this character could be accounted for by differences between the populations and by the effects of the clones. The interaction between these two factors, although statistically significant, only accounted for approximately 10% of the variation. All the populations ranked the clones in similar order of resistance (Kendall's $W = 0.89$) suggesting that, if the populations sampled are truly representative of UK populations, it is unnecessary to use more than one population in a mass screening programme.

(J. M. S. Forrest, M. S. Phillips, Linda A. Farrer)

09011 *Assess potato breeding material for resistance to potato cyst eelworm. Improve screening techniques.*

In 1982, 767 clones were screened for resistance to *Globodera rostochiensis* (Ro_1), 700 to *G. pallida* (Pa_2) and 57 to *G. pallida* (Pa_1).

In previous years Neo-Tuberosum selections have given more variable results than material from other sources. In an attempt to explain this variation, seed tubers of 40 Neo-Tuberosum clones were obtained from both The Murrays and Blythbank farms and tested against Pa_2 and Ro_1 populations in March and May 1982. There was more variation in results between the two times of testing than between the two sources of tubers, suggesting that the age of the tubers can influence the test results. The least variable results were obtained at the earlier testing date.

Twenty-nine progenies from wild *Solanum* species from the Commonwealth Potato Collection were screened for resistance to *G. rostochiensis* (Ro_1) and *G. pallida* (Pa_2).

(Linda A. Farrer, M. S. Phillips)

09012 *Assess potato breeding material for resistance to and infection with viruses X, Y and leafroll.*

Major gene resistance.

Seedlings of 70 progenies of crosses made for virus resistance were selected for resistance to potato virus Y (PVY) and potato virus X (PVX) by spray inoculation. From 12,000 seedlings inoculated, tubers of 2,300 resistant clones were kept for further assessment of other characters.

Four hundred clones were screened for resistance to various strains of PVY and PVX by sap or graft inoculation. The new cv. Fiona showed resistance to the A strain of PVY, but, contrary to previous results, appeared susceptible to the common strain (Y_0). Further screening will be necessary to resolve this. The new cv. Kirsty showed further evidence of resistance to A, the common and C strains of PVY and the common and B strains of PVX. The cv. Baillie also appeared resistant to the A strain, having shown varied responses in the past, and cv. Sheriff was confirmed as being susceptible to the common X strain but resistant to the B strain of PVX and to all the above Y strains.

Leafroll and PVY trial.

Three hundred and thirty clones were exposed to potato leafroll virus (PLRV) and PVY in a trial at PBI, Cambridge, in 1981. These were grown on and scored in 1982. The incidence of PVY infection was moderate and that of PLRV quite high: in plots of the resistant control cv. Pentland Crown, 4% of the plants became infected with PVY and 51% with PLRV.

The majority of the clones bred for virus resistance showed at least as much resistance as Pentland Crown to PVY, while 35 exceeded it in resistance to PLRV, having scores at least one standard error less than this control.

At least two Neo-Tuberosum clones showed good resistance to PVY and seven showed as much PLRV resistance as Pentland Crown. Several clones of Group Phureja and related material showed good resistance to PVY, and some of these also exhibited a very high degree of leafroll resistance.

ELISA tuber tests.

In the past, the use of enzyme-linked immuno-sorbent assay (ELISA) for testing tubers for PLRV infection was hampered by background reactions of healthy tuber sap giving false positive results. This problem was

aggravated by the genetic diversity of breeders' material, as the background reactions were very variable. One method used by DAFS to alleviate this problem is to treat tuber sap samples with diethyl dithiocarbamic acid (DIECA). We are now testing this on a diverse range of SCRI clones, with promising results.

(Ruth M. Solomon)

09013 *Assess potato breeding material for resistance to soil-borne viruses. Improve screening techniques.*

Potato mop-top virus.

A field trial for resistance to potato mop-top virus (PMTV) was grown at Braco, Perthshire, in 1981. Samples of the harvested tubers were grown and the plants scored for haulm symptoms in 1982; the remaining tubers were scored for primary spraing symptoms. There was little overall symptom expression: spraing occurred in 0 to 33% of the tubers in 30 plots of the susceptible control cv. Arran Pilot, with a mean of 8.1%±8.37. Some susceptible cultivars showed no symptoms. Consequently only two clones out of 34 could be identified as susceptible and it was not possible to identify resistant clones with confidence.

(Ruth M. Solomon)

09014 *Study the biology of common scab, gangrene, skin spot, dry rot, soft rot and powdery scab.*

Soft rot.

Routine susceptibility tests were carried out on 37 clones, modifying the method hitherto used in that tubers were not incubated under nitrogen but laid out in plastic trays under mist nozzles in a constant environment cabinet. The film of water over the tubers provided sufficiently anaerobic conditions for soft rot to become established.

Skin spot.

Tubers of six cultivars inoculated 1, 3 or 6 days after harvest exhibited no significant differences in disease intensity after up to 14 weeks incubation at 4°C. However, there was a slight downward trend in disease levels between tubers inoculated on the 3rd and 6th days. Overall disease levels (5-7 on a 9-point scale) were relatively low and this may have masked any effect of delaying the inoculation.

Dry rot.

Tests carried out on 12 cultivars in two successive years confirmed the generally poor agreement between susceptibility to the two dry rot fungi *Fusarium solani* var. *coeruleum* and *F. sulphureum*. The rank correlation coefficient between the order of resistance to each pathogen was <0.2 in both years, whereas that for the same pathogen was statistically

significant, varying between 0.56 and 0.87. Although cv. Catriona was consistently the most susceptible to both fungi, cv. Arran Pilot and cv. Pentland Crown were considerably more susceptible to *F. sulphureum*, whereas cv. Maris Piper was relatively more susceptible to *F. solani* var. *coeruleum*.

(R. L. Wastie)

09015 *Assess potato breeding material for resistance to fungal diseases. Improve screening techniques.*

Late blight.

In 1982, 743 clones from the commercial and strategic breeding programmes were tested for foliage resistance in the glasshouse. Of commercial programme selections bred for blight resistance, 55 of 80 fifth year and 10 of 22 sixth year clones showed good resistance, scoring 6 or more on the 1-9 scale of increasing resistance, as did 25 of 142 fifth year and 11 of 104 sixth year clones from other crosses.

Advanced clones were assessed in a field trial at Yonderton Farm, Ayrshire. Twelve of 35 early clones and 10 of 45 maincrop clones were at least as resistant as the control cultivars Maris Peer (early), or Stormont Enterprise (maincrop). The results compared fairly well with previous glasshouse assessments, but agreement was better with maincrop than early clones: $r = 0.782$, $p < 0.001$, and $r = 0.620$, $p < 0.001$, respectively. Fourteen of the maincrop clones had also been tested in Ayrshire in 1981 and the two years' results compared well ($r = 0.930$, $p < 0.001$).

Commercial breeding programme clones from the sixth year of selection onwards were assessed for resistance to tuber blight in laboratory tests. Sixty-three of 143 early clones and 142 of 309 maincrop clones scored 7 or more on the 1, 3, 5, 7, 9 scale of increasing resistance. One hundred and seventy of the clones had also been tested in 1981, and 128 received the same or adjacent rating in both years.

The validity of assessing the resistance of progenies by the seed pan test (SPBS Ann. Rep. 1979-80, p.79) was investigated in a field test at Yonderton Farm. Two populations of progenies obtained by crossing resistant and susceptible parents in all combinations were planted; one population represented the survivors from the 1981 seed pan test, while the other had not been screened. There was a high correlation ($r = 0.95$) between the mean field score of the progenies and the seedling score obtained in 1981. The field score was higher and the variance lower, in the selected than in the unselected population.

Progenies identified as resistant or susceptible in the 1981 seedling test were also assessed as adult plants in the glasshouse in 1982. The mean score (1-9 scale) was 4.3 for susceptible progenies compared with 7.6 for those identified as resistant by the seedling test.

The effect on susceptibility of the age of the seedlings at inoculation was also investigated. Pots of seedlings were raised at weekly intervals for 6 weeks and inoculated 3 weeks after the last sowing. Susceptibility decreased with age from 3 to 6 weeks, but there was little difference in the susceptibility of 6, 7 and 8 week old plants.

Gangrene.

During the winter of 1981-82 802 clones were assessed for resistance to gangrene in cornmeal sand tests. A test on 10-tuber samples of 270 commercial programme fifth year selections identified nine very susceptible clones to be discarded. Of 230 sixth year and more advanced selections, 143 scored 7 or more on a 1, 3, 5, 7, 8 scale of increasing resistance. Seventy-three of the clones had also been tested the previous winter; 59 had received the same or adjacent rating in both years.

Common scab.

In 1981 the resistance of 627 clones was assessed in a field trial at Archerfield, near Gullane, East Lothian. Eighty-one of 270 fifth year selections were rated resistant, scoring 7 or more on a 1, 3, 5, 7, 9 scale. This level of resistance was also shown by 88 of 239 more advanced clones which were tested at Scoughall Farm near Whitekirk, East Lothian.

Dry rot.

Ten advanced clones with potential as processing cultivars were assessed for resistance to *Fusarium solani* var. *coeruleum* in winter 1981-82. Two clones were resistant, three susceptible and five of intermediate susceptibility.

Skin spot.

One hundred and thirty-eight clones were tested for resistance to skin spot in 1981-82. Of 86 clones in the seventh year onwards of the commercial breeding programme, 20 scored 7 or more on a 1-9 scale. Sixty-eight out of 79 of these clones had received the same or adjacent score when tested the previous year.

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

09018 *Evaluate Neo-Tuberosum potatoes as parental material for use in breeding cultivars.*

While the purpose of this project is the production of new breeding material for crossing with Tuberosum (i.e. commercial-type) parents, an occasional selection can now be found in Neo-Tuberosum itself which appears worthy of consideration as a cultivar. One such clone, Gl.77B/54, was included in the 1982 first early trials at The Murrays

farm and at Cairnside, Wigtownshire; it yielded well and had attractive and good flavoured tubers but was not considered a commercial prospect because the tubers, though of saleable size, were generally rather too small.

Of 25 clones exposed to leafroll and Y viruses at Cambridge in 1979 as 12-plant units, the incidence of infection being assessed in 1980, 18 were thought worthy of re-exposure as 24-plant units in 1981, results becoming available in 1982. Two clones, Gl.76B/108 and /109, had no plants infected with virus Y in either exposure. Three clones, Gl.76B/55, /60, and /189, had less leafroll infection than cv. Pentland Crown while seven others had about the same incidence of infection as that resistant cultivar.

Of 53 clones exposed to infection with *Verticillium dahliae* at the Gilat Experimental Station, Israel, Gl.77M/72 appeared immune, showing no symptoms and being confirmed to be uninfected by examination of the roots. Six appeared highly resistant in having almost equal yield on infested and uninfested land and showing only mild symptoms; two of these clones were high yielding, indicating tolerance of the hot climate. A number of others showed mild resistance to or tolerance of *Verticillium,* or while susceptible were of interest for their high yields on uninfested land.

From pollinations done in the commercial breeding programme in 1974 as high a proportion of Neo-Tuberosum × Tuberosum hybrids as of the accompanying Tuberosum × Tuberosum progenies survived routine selection up to 1981 by which time the 20,000 initially planted to the field (11,200 of them hybrids) had been reduced to 38 (23 of them hybrids). The 38 were tested in 1981 at The Murrays farm and at three English sites, and at each of the four sites the mean yield of the 23 hybrids exceeded that of the 15 Tuberosum selections. Four of the 38 were retained for further assessment in 1982 and these included two hybrids, one of which is being further assessed in 1983.

In a 1982 trial comparing many progenies using 36 random genotypes per progeny, planted as 3 plots of 12, the finding of Hoopes, Plaisted & Cubillos (1980) that the yield is higher and the quantity of berries is less in Neo-Tuberosum × Tuberosum progenies when the Tuberosum parent is the female was confirmed as regards certain Tuberosum parents, especially cv. Pentland Squire, but not where cv. Maris Piper was involved. For three reciprocal pairs of progenies involving Pentland Squire and the Neo-Tuberosum parents Gl.76B/47, /129 and /214 the mean yield of tubers per 12-plant plot was 21.5 kg where Squire was the female and 18.2 kg where it was the male parent (a difference of 2.4 kg was significant) while the yields of berries were 186 g and 2,077 g respectively. In contrast, for five reciprocal pairs involving Maris Piper and the Neo-Tuberosum parents Gl.76B/129, /146, /214, /220 and /246,

mean tuber yields (18.00 and 18.05 kg) and berry yields (1,213 and 1,247 g) were virtually the same whether Maris Piper was the female or the male parent. Maris Piper is believed to have the cytoplasm of the eelworm resistant andigena introduction C.P.C. 1673 while Pentland Squire is believed to have that of an old British cultivar.

(D. R. Glendinning)

09019 *Breed diploid potatoes and evaluate as potential parents for diploid and tetraploid cultivars.*

Crosses have been undertaken between three diploids with a relatively high frequency of diplandroid pollen grains (51T29 with 8%; 60CS7 with 27%; DB171(11) with 16%) and several 'elite' diploid clones which do not produce diplandroids in order to increase the amount of higher yielding material available for inter-ploidy crossing. One hundred and forty-nine of the resulting seedlings were examined cytologically to determine diplandroid frequency, and 106 of the seedlings were found to produce diplandroids. For effective use in crosses with tetraploid cultivars a level of 2% or more of diplandroid pollen is desirable, and 55 seedlings met this criterion.

The choice of tetraploid parents to be crossed with diploids is important. A cultivar which does not combine well with diploid clones will lead to unacceptably low selection rates among seedlings and loss of hybrid genetic material in which time and effort has been invested. Pilot crosses have so far used 19 cultivars, including both older types such as Arran Consul and Edzell Blue and recent ones such as Desiree and Pentland Squire. As might have been expected the better, modern cultivars have been found to be preferable a parents, although a number of vigorous and highly-yielding hybrids have been obtained with Arran Consul. Ulster Concord has proved marginally the best parent to date as its hybrids with diploids combine good shape and even size with high yield. Pentland Dell has also provided useful hybrids. Desiree does not combine well with diploids, probably because its own tuber shape is not very stable. Also, its colour genes are expressed in an excess of purple and purplish-red seedlings. The recent Irish cultivar Cara has given a very promising range of hybrid seedlings which await field evaluation.

At the tetraploid level two paths are being explored for the development of hybrids to a commercial cultivar level. The initial hybrids can be 'back-crossed' to Tuberosum. It is not possible in every instance to make true back-crosses to the initial cultivar parent, although some success is being achieved with Pentland Dell, Pentland Squire and Maris Piper. Alternatively, the first generation hybrids can be crossed among themselves. If the hybrids are of diverse diploid and tetraploid origin, it may be possible to retain vigour while at the same time combining commercially desirable characters. In the 2AP scheme for instance, it has been possible to combine resistance to several virus diseases.

(C. P. Carroll, M. J. De, Maine)

09020 *Produce, breed and maintain a collection of dihaploid potatoes. Use dihaploids to enhance disease resistance.*

Dihaploids were obtained from the tetraploid offspring of crosses between dihaploids resistant to foliage late blight (*Phytophthora infestans*) and susceptible tetraploids. Twenty-one out of 23 dihaploids tested in leaflet tests and seven out of ten tested as whole plants had the high resistance of their tetraploid parents and dihaploid grandparents. This indicates that blight resistance can be efficiently transferred from dihaploids into tetraploids and efficiently recovered in dihaploids following redihaploidisation. Tests in progress will also show whether resistance to potato cyst nematode (*Globodera pallida*) behaves similarly in these same dihaploids, since the tetraploid parents were also PCN resistant.

Tests on 21 clones obtained from crosses between leafroll resistant dihaploids derived from cv. Pentland Crown and susceptible tetraploids showed that they were more susceptible than their dihaploid parents, all of which had resistance similar to Pentland Crown.

Offspring of a cross between a chromosome-doubled dihaploid, highly resistant to late blight in its tubers, and a susceptible tetraploid were tested for tuber blight resistance. Five out of 16 clones showed no disease symptoms when tested in two successive years and a further four had less than 10% of their tubers infected in any one year.

Experiments so far suggest that, in general, if resistance to pathogens exists at a high level in a dihaploid it can be transferred very efficiently into tetraploid offspring through unreduced (diploid) gametes.

(M. J. De, Maine)

NEW POTATO CULTIVAR

KIRSTY

National List and Plant Varieties Rights – 1982.

Maturity class:	Maincrop, similar to cv. Pentland Crown.
Foliage:	Tall erect, strongly branched, later spreading.
Tubers:	Round to oval, usually a bold sample, numbers moderate. Shallow eyes, white skin, cream flesh.
Cooking quality:	Dry matter medium to high, moderately firm, pale lemon flesh. Superior to cv. Pentland Crown.
Processing:	Crisp colour inferior to cv. Record, less pronounced enzymic browning than Pentland Crown.
Yield:	Consistent high yields of medium to large ware comparable to cv. Pentland Crown; has yielded well in trials in Northern Spain.

Disease resistances*:

Wart	Immune
Blight – foliage	4
tuber	6
Gangrene	6
Skin spot	4
Common scab	5
Potato cyst nematode	Susceptible
Virus X	9
B	9
Y	7
A	9
C	9
Leafroll	8
TRV	Susceptible

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

Summary: A high yielding cultivar with good all-round resistance to major diseases, especially the common viruses, of acceptable quality and some indications of export potential (Northern Spanish results 1982).

SOFT FRUIT BREEDING

D. L. JENNINGS

With the termination of the strawberry breeding programme and closure of the West of Scotland Unit R. J. McNicol transferred to Invergowrie and joined the *Rubus* breeding team, but he will retain responsibility for completing the testing of strawberry selections derived from the former Auchincruive breeding programme. Some of the advanced selections from this programme are already becoming strong candidates for release as new cultivars. In particular, three red fleshed selections appear to meet the processing industry's requirement for cultivars of this type which are adapted to UK production.

A. Dale increased the proportion of his time working on *Ribes* from half to full time, but he resigned in December. His research programme included the screening of black currant selections for frost tolerance and arrangements for the continuation of this important work are not yet complete. R. J. McNicol will continue the work on yield components in raspberry and has started new work on hardiness in *Rubus* and resistance to raspberry cane midge.

Two selections were recommended for release as new cultivars in 1982: one was a black currant, 238/36/19, named Ben Sarek, which is notable for its compact growth habit, yield potential and fruit size and is expected to prove popular as a pick-your-own and garden cultivar; the other was a hybrid *Rubus* (73153C4) which has a different flavour from the Tayberry and can be considered as an alternative choice to this fruit. In addition three advanced black currant selections were recommended for large-scale regional trials; these have already shown considerable promise for yield, frost tolerance and juice quality and it seems likely that one or more of them will eventually be released as cultivars.

Some other notable results reported this year include further evidence for two unusual forms of plant resistance to pests or disease. In one, there is further evidence for a situation where resistance to two unrelated pathogens is conferred by the same genes. This is apparently true of raspberry cane resistances to *Botrytis cinerea* and *Didymella applanata* derived from three distinct sources. The other relates to resistance to the raspberry cane midge in hybrids of raspberry with *R. crataegifolius*: these hybrids provide relatively few natural cane splits suitable for oviposition and when splits occur an active wound periderm causes them to heal so quickly that larvae are trapped and embedded within the stem tissues.

03001 *Strawberries: breeding and associated genetic studies.*

Field planting of the last selections from the Auchincruive strawberry programme was almost complete by December. They will be further assessed at Invergowrie over several years to determine their cultivar potential. Among advanced selections, GU76, ET30 and EW30 were notable for their good performance in trial plots throughout the UK. Yields at one site were respectively 40, 30 and 26% higher than cv. Cambridge Favourite. EW30 ripens a week later than C. Favourite and its large fruit of very high dessert quality makes it a good prospect for a new cultivar.

Assessments of processed samples were again made on fruit of selections ET115A and WC64. The results supported previous observations that they give a high quality product when frozen or canned without added colouring matter. This was mainly due to their easy decapping, firm and intensely red-coloured fruits. ET115A is also suitable for the fresh market.

Three SCRI seedlings, GU76, EW30 and DK60 have been submitted for the next NFT multicentre trial.

(R. J. McNicol)

03006 *Cane fruit: breeding and associated studies.*

High yields were reported from regional trials in England and Scotland for the new SCRI cultivars Glen Moy and Glen Prosen, though at some centres the yield of Glen Moy was reduced by damage caused by frosts at flowering time. The frosts which damaged Glen Moy in 1981 occurred when lateral development was at an early stage and stimulated the development of replacement secondary laterals which later carried a full crop, but the frosts in 1982 were too late to stimulate this development and the only compensation was the production of larger fruit. Among the selections in the NFT, 731/53 was notable for its high fruit numbers per lateral and gave one of the highest yields despite its moderate vigour; 7515C5 was notable for its excellent fruit quality as well as good yield, and 741B11 had excellent fruit quality but only moderate yield, apparently because the stock is a mixture of plants carrying three or four different alleles of gene L_1. The original selection carried a dominant allele, but one of the mutant variants, which has the phenotype of a recessive, was much superior to it for fruit size and yield potential. Root cuttings were taken to propagate individual plants of 741B11 to study this variation. If the good performance is repeated the best of them will be re-submitted to the NFT.

Seven new selections were chosen for propagation for a new trial to be planted at the end of 1983.

Yield studies.

For several reasons growth in 1982 was poor in families grown for selection of plants with high expression of yield components, particularly high numbers of fruit per lateral or high numbers of nodes per cane and hence potential for high numbers of laterals. As a result, few plants developed high numbers of fruit per lateral but it was possible to select plants whose laterals had high numbers of flowers, and though many plants had high numbers of nodes per cane this was a consequence of the short cane growth. Selection for a capacity to produce high numbers of nodes independently of cane height has proved effective only in vigorous plants, so work with this characteristic was postponed.

(D. L. Jennings, R. J. McNicol, Eleanor Carmichael)

Genotype x environment studies.

In a comparative study of the growth of four American and four British cultivars at SCRI and Abbotsford, British Columbia, it was observed that the lateral lengths of certain cultivars tended to be much longer at Abbotsford. Difference in the time of flower-bud initiation might be one of the causes of this, and so the date when flower initiation could first be detected was determined for bud samples of four cultivars taken from each site at weekly intervals. In each cultivar flower-bud initiation started in the terminal parts of the canes and was always earlier in the SCRI samples. At SCRI it was seen first in Glen Clova, followed by Glen Prosen and Meeker and then Haida while at Abbotsford the order was Glen Clova, Haida, Glen Prosen, Meeker. The differences between SCRI and Abbotsford samples were greater for the three late cultivars.

Another difference between the two sites was that three of the four North American cultivars studied set a lower percentage of drupelets in fruits at SCRI. It was concluded that drupelet set in these cultivars was more affected by the lower temperatures prevailing at flowering time at SCRI, and that cultivars bred in Britain have greater tolerance of low temperatures at this stage.

(A. Dale, H. A. Daubeny[1], Barbara M. M. Tulloch)

Hardiness in raspberries.

Recent experience indicates that SCRI raspberry breeding material is very variable in the winter hardiness of canes and the spring hardiness of flowers and developing laterals. Work was therefore begun to devise techniques for assessing hardiness under controlled conditions, using pot plants for tests of spring hardiness and portions of stems bearing buds for tests of winter hardiness. Preliminary results were encouraging and material was prepared for larger-scale experiments in 1983.

(R. J. McNicol)

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[1]Agriculture Canada Research Station, Vancouver, Canada.

Disease and pest resistance.

Resistance to botrytis fruit rot was assessed in 66 genotypes, 35 and 31 of which had previously shown resistance and susceptibility respectively to *Botrytis cinerea* in their canes. Highly significant differences in fruit resistance occurred between individual genotypes, but there was no overall difference between the two groups denoted by the difference in cane resistance. Most of the genotypes had soft fruit but several of the resistant ones were noted for the firmness of their fruit. It has previously been observed that the factors which confer cane resistance do not contribute detectable fruit resistance to genotypes with soft fruit texture. However, the genotypes were from 12 families whose parents were included in the experiment; and the correlation between the mean fruit resistance of progenies and the mean of their parents was high ($r = 0.70$; d.f. = 10), showing that the resistance was highly heritable.

Preliminary results have been given (Ann. Rep. 1981, p.60) of experiments to study the inheritance of cane resistance to *B. cinerea* and *Didymella applanata*. These results, based upon the lengths of lesions in autumn 1981, showed entirely additive inheritance and there was a high correlation between the two resistances. The same lesions were studied again in spring 1982 to measure the lengths of lesion still visible ('silvered') and to assess the amount of sporulation present. The results support the preliminary conclusions reported and principal components analyses of the three assessments of each disease show that 78% of the variation in one group of families and 64% in another can be accounted for by a vector which denotes resistance to both pathogens at both times of recording. A second vector denotes greater resistance to one pathogen than to the other but accounts for only 15 and 22% of the variation in the two groups of families. Further analyses showed that the variation described by this vector was largely associated with families in which most of the segregates were susceptible to both diseases but had exceptionally severe symptoms of *B. cinerea*, and that some of it was associated with backcross material derived from *Rubus coreanus*. Hence, with the possible exception of the *R. coreanus* derivatives there was no evidence that any of the resistance operated against one disease more than the other.

In assessments of resistance to *Leptosphaeria coniothyrium* using mycelial inoculations, varying resistance was found among both F_2 and first backcross hybrids of *R. pileatus*, and 23 apparently resistant backcross hybrids were retained for further study. In these experiments there was unusually high variation in lesion length within genotypes; it is possible that this was because the inoculations were done later than usual, on 23 August, as resistance is known to increase as the canes mature. The families tested also segregated for resistance to *B. cinerea,* but there was no correlation between resistance to the two diseases.

(D. L. Jennings, Eleanor Carmichael)

Very few midge larvae were found in a survey of canes of F_2 *R. crataegifolius* × red raspberry hybrids exposed to natural infestation by cane midge (*Resseliella theobaldi*), apparently because the non-peeling nature of the canes greatly reduced the number of sites suitable for oviposition. When suitable oviposition sites were provided by mechanical wounding, new tissues were rapidly produced as a response to the wound and often trapped larvae within the cane tissues. Further histological studies supported the findings reported previously and indicated that resistance to the pest is conferred by the ability to produce abundant wound periderm. This characteristic has been transferred from *R. crataegifolius* and preliminary assessments indicate that it has been retained in segregates of new families produced by backcrossing some of the F_2 hybrids to raspberry. Further work is planned to determine whether these segregates have effective resistance.

(R. J. McNicol)

The cultivars Latham, Viking and Cuthbert are immune from raspberry vein chlorosis virus and studies have continued on the inheritance of this immunity in selfed and crossbred progenies of Viking, Cuthbert and the susceptible cv. Malling Delight. Much of the evidence supports the hypothesis that immunity is conferred by a single recessive gene, but there was an inconsistency in the occurrence of three susceptible segregates in a family of 20 obtained by selfing Cuthbert. The study is therefore being continued with studies on additional families including some related to the black raspberry (*R. occidentalis*) which has also been found to be immune.

(D. L. Jennings, A. T. Jones[1])

03008 *Cane Fruit: breed early erect blackberries and hybrid* Rubus *berries.*

The second generation blackberry × raspberry hybrid 73153C4, obtained by crossing the Tayberry with one of its sibs, has given high yields at NFT Brogdale and has shown less winter injury than the Tayberry. Its flavour is less aromatic than that of the Tayberry and it is preferred by many but not all consumers. Because of this preference the NFT Raspberry Panel recommended that it should be released as a new hybrid cultivar and an application for Plant Breeder's Rights has been made.

The severe winter frosts killed a high proportion of the canes of blackberries in the tetraploid families, but selections from family 77135 were notable for their good survival, as in previous years. Selections carrying the dominant gene for spinelessness and an early fruiting selection from Ireland (CLB11) were among those showing particularly poor survival. Newly established hexaploid families raised from seed

[1]Virology Department.

recently introduced from Oregon survived well at a different site. Although the observations are not comparable this is an encouraging result because most of this material carries the dominant gene for spinelessness and is being used to produce spine-free Tayberry-like hybrids. A further series of hexaploid families was raised for this objective, mostly of crosses between the Tayberry and Tayberry derivatives carrying the introduced dominant gene. New progenies at the tetraploid level were raised to transfer the gene to the hardy blackberry selections mentioned above, and hybrids between tetraploid raspberries and tetraploid blackberries were produced in the first stage of an attempt to transfer dominant spinelessness to raspberries.

Preliminary work was begun to devise laboratory procedures for assessing blackberry hardiness. Portions of stems bearing buds were frozen slowly to various temperatures down to −31°C and the effects on the tissues assessed by measuring the conductivity of exuded leachates after freezing. This work gave results in accord with field assessment of hardiness, particularly in respect of the superior hardiness of a selection from family 77135 and the non-hardiness of CLB11.

(D. L. Jennings, R. J. McNicol, Eleanor Carmichael)

03009 *Bush fruit: breed black currants for northern regions of the UK.*

SCRI 238/36/19 (cv. Goliath × cv. Ojebyn) o.p. – now named Ben Sarek – was recommended by the NFT Black Currant Panel for commercial release. It is particulary suitable for pick-your-own purposes because of its high yields and regularity of cropping (Ann. Rep. 1981, p.63). Three of the top-yielding, late flowering and frost tolerant SCRI hybrids in trial at Brogdale were recommended for regional growers' trials.

Regional trials and commercial assessments.

Ben Sarek in its seventh year of cropping at Luddington EHS outyielded cultivars Ben More, Ben Lomond, Baldwin and Black Reward. Over the entire period of the trial its mean annual yield (15.8 t/ha) was nearly twice that of Baldwin (8.5 t/ha). Ben More was second in order of yield in 1982, and also in mean annual yield over the 7-year period.

At Brogdale EHS, in a trial of 36 cultivars and hybrids in its fourth year of cropping, the five top yielding SCRI hybrids outyielded Ben Lomond (16.2 t/ha) and five others outyielded Baldwin (7.6 t/ha). The two which gave the best combination of yield and juice processing quality were P8/12/7 (Ben More × Ben Lomond) and P9/8/7 (a complex Ben Lomond hybrid). In an adjacent trial, an overnight frost on 5 May reduced the expected yield of Ben More in its fifth year of cropping by about half (to 7.8 t/ha). The frost occurred 9 days after the first flowers had opened by which time Ben More had almost certainly lost most of its frost hardiness. Ben Lomond yielded 14.8 and Baldwin 4.0 t/ha.

Two year's results from controlled frost tests at SCRI together with four year's yield data from Brogdale indicate that P8/12/7 is exceptional for its combination of high frost tolerances, high yield, regularity of cropping and intense juice colour. However, it is not superior to Ben More for plant habit. A flavour trial in 1981 rated P8/12/7 slightly lower than Baldwin, but this result may be atypical.

Four regional growers' trials with up to 250 plants each of three SCRI selections, including P8/12/7 and P9/8/7, were planted in November under the aegis of ADAS; Baldwin and Ben More were planted as standards. These trials will assess the adaptability of P8/12/7 to different soil types and its suitability for machine harvesting.

In co-operation with NSDO and Beecham Products Ltd., 550 plants each of six cultivars and 10 SCRI selections, including P8/12/7 and P9/8/7, were planted in Norfolk to provide large samples of juice for processing and analyses by Beechams, and to assess their suitability for machine harvesting and mechanised pruning. Another plot of leading SCRI selections for machine harvesting tests was established at Blairgowrie, Perthshire.

(M. M. Anderson)

Frost tolerance.

In February, results from controlled frost tests with cut shoots supported the conclusion from 1981 tests that Baldwin is less winter hardy than Ben Lomond and Ben More. This indicates a relationship between winter hardiness and spring frost tolerance, but in 1981 this relationship may have been because dehardening and growth started earlier in Baldwin (Ann. Rep. 1981, p.64). Thus account must be taken of dormancy status when comparing cultivars for their tolerance of winter frost, because they are at their most hardy when they are fully dormant. Each cultivar was hardy enough to survive a natural winter frost, and able to withstand deeper frosts when pre-conditioned at $-5°C$ for 2 days.

In a dehardening/rehardening experiment, cut shoots of the same three cultivars were frosted in March/April after pre-conditioning treatments designed to reharden them. Most of the variation in the percentage of flower buds that survived was accounted for by the number of days the shoots grew at 15°C, the number of days they were held at 2°C before frosting, and by the frost temperature used. The number of flower buds that survived was inversely proportional to the time they had grown at 15°C, and to the number of degrees of frost applied. The flower buds were able to reharden slightly at 2°C, but this response was related to the hardiness of the plants when they were subjected to the lower temperatures; they regained most of this hardiness within 1-2 days.

In February, when the plants were still winter hardy, the buds could be rehardened to withstand up to a further 5°C of frost, but in March/April when they had dehardened appreciably they could only be rehardened to

withstand a further 2°C. Thus, provided that cultivars are frosted at defined growth stages they are likely to be ranked in the same order for spring frost tolerance regardless of the weather preceding the test.

(A. Dale, Nina Heiberg[1])

SCRI black currant selections differ appreciably in the extent to which their frost hardiness is lost by April and May. Controlled freezing tests for the second year in succession showed that P8/12/7 (Ben More × Ben Lomond), and two 238/36/12 × Ben Lomond selections were able to survive −3.8°C for longer after the first flowers had opened than was Ben Lomond.

(A. Dale, Barbara M. M. Tulloch)

Commercial and breeding value of arctic genotypes.

Experience to date of the frost and cold tolerance selections derived from arctic genotypes suggests that they are capable of mean yields of more than twice that of non-frost-protected Baldwin under UK conditions. SCRI P8/12/7, P9/11/13 and P9/11/14 (238/36/12 × Ben Lomond) have shown substantial improvements in frost tolerance on Ben Lomond and Ben More. Further improvements in one or more frost tolerance components are now sought from recently acquired cultivars which survived the severe 1978 winter freeze in the USSR, and from frost tolerant selections bred in Sweden.

Poor plant form and weak branches which reduce yield stability still present problems in breeding from arctic genotypes and their progeny, but the means of resolving them are now available.

(M. M. Anderson)

Branch strength and flexibility.

The stiffness of black currant shoots depends on the length and diameter of the shoot – a short or thick one is more resistant to bending – and on the composition and structure of the wood. The contribution of wood structure may be quantified by Young's modulus, which measures elasticity.

A technique was developed in which the weight required to give a deflection of 25 mm was determined for weights hung at different distances along a horizontally held shoot. A graph was plotted of this weight against the fourth power of the mean diameter divided by the cube of the distance of the weight from the fulcrum, and the slope was determined. Young's modulus was calculated by multiplying the slope by 13.5 units GN/square metre.

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[1]Agricultural University of Norway, Aas-NLH.

The slope ranged from 0.07 for a shoot of Ben Lomond to 0.52 for a shoot of a *R. sanguineum* hybrid. The value of Young's modulus for cell wall material given in the literature is 10 GN/square metre, and the results obtained were within this order of magnitude. They showed a good linear relationship between the derived variate and the weight. The intercept was always non-significant. The regressions were recalculated using only three points per line, taken at the base, tip and near the middle of the shoot. These agreed well with the slopes calculated from the full set of points.

The technique appears to be a practicable method to differentiate between the contribution to stiffness of the diameter of the shoot and that of its mechanical properties.

Three selections which have good plant form and strong but flexible branches, a rare combination in *R. nigrum* selections, were selected in a third backcross black currant × red currant family. One of them was propagated to provide parental plants for crosses with P8/12/7 and 243/7 selections to produce progenies which combine the outstanding qualities of these parents.

(Barbara M. M. Tulloch, P. Smith[1])

Juice quality.

The quality was assessed of 210 juice samples from the 1981 season and 257 from the 1982 season. The samples were adjusted to standard specific gravity and then diluted to 5% V/V at pH1. Their optical densities were measured at E515 in a 2 mm cell in an SP6-300 Pye Unicam spectrophotometer, and measurements were made of ascorbic acid content, %soluble solids, titratable acidity, and juice yield per 100 g fruit. The E515 values of 13% of the samples exceeded that of Ben Lomond in both 1981 and 1982. Ascorbic acid content in mg/100 g juice ranged from 70 to 307 in 1981, and from 59 to 373 in 1982.

In two contrasting seasons, 243/7 (cv. Seabrook's Black × cv. Janslunda) × (cv. Anger von Oeffelt × cv. Stahanovka), Ben Lomond and Westra were the parents of most of the selections rated superior for juice colour and/or ascorbic acid content. This group included the highly productive, frost tolerant Ben Lomond hybrids P8/12/7, P9/8/7/, P9/11/13 and P9/11/14. Hybrids of (Westra × 7/189) × 243/7 were especially notable for their combination of intense juice colour and high ascorbic acid content. A useful addition to this group was third backcross black currant × red currant hybrids selected primarily for their plant habit and branch strength. Results to date suggest a scope for improvement over Baldwin of 200% for E515 value and 50% for ascorbic acid content.

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[1]Data Processing Department w.e.f. 1.10.82.

Flavour.

Fruit from two groups of selections harvested in 1981 were assessed for juice flavour by a testing panel at Beecham Products (Research and Development). The first group of 19 included samples from 11 Ben Lomond selections and M48/2 (Goliath × Baldwin), a 243/7 selection, Baldwin, Ben Lomond and Ben More. The second group of 44 included samples from 30 243/7 selections, 8 Ben Lomond selections, 5 cv. Sunderbyn II selections, and 2 cv. Edina selections. Samples of cultivars Baldwin, Ben More, Black Reward and Westra provided standards for comparison.

In the first group, no sample scored as well for flavour as the Baldwin control (rated 5.0). The highest ratings (4.6-4.8) were achieved by M48/2, P9/8/7 and P8/12/7 and the lowest rating by Ben More (3.8). In the second group, the quantity of the Scottish-grown sample of Baldwin was insufficient to act as a tasting control and it was necessary to use a standard factory-produced juice which was rated 5.0. The flavour ratings of the samples in the second group were also low with only one exceeding a score of 4.0; the Scottish-grown sample of Baldwin was rated 3.3. The flavours of most of the juices was described as pleasant and fruity but lacking in essential black currant character. In some the flavour was described as green or vegetable-like, totally lacking in astringency or 'leafiness' and reminiscent of the flavour resulting from the use of unripe fruit.

The reason why these flavour ratings are so much at variance with past experience is uncertain. Seasonal or environmental factors which affect variables other than those measured may be involved.

(M. M. Anderson, Judith Thomson)

NEW BLACK CURRANT CULTIVAR
BEN SAREK

The Institute and the NSDO have applied for Plant Breeders' Rights for Ben Sarek, bred at SCRI.

A stock is being propagated by NSDO and 1-year-old bushes are expected to be available for commercial propagation in winter 1983/84.

Breeder's number: 238/36/19.

Origin	(Goliath × Ojebyn) o.p.
Habit	Moderately vigorous but forming a small bush at maturity. Branches slightly spreading and tending to spread outwards under the weight of fruit. Two-year-old and older bushes are characterised by their high harvest index and short internodes.
Fruit	Berries are large and soft and should be picked soon after they are ripe. They do not 'hang' as long as Baldwin.

Season of flowering Early, similar to cv. Baldwin.

Tolerance of spring frost-injury Very high.

Season of ripening 7-10 days earlier than Baldwin.

Productivity Usually exceeds Baldwin.

Diseases and pests Resistant to American gooseberry mildew but not to leaf spot, gall mite or reversion diseases.

The name 'Sarek' (a mountain in Norrland, Sweden) was chosen by Mrs Gunny Larssen, Experimental Division of North Swedish Horticulture, Röbäcksdalen, Umeå at the invitation of the breeder in recognition of her work over many years in collecting and trialling black currants from the Swedish wild. These wild ecotypes form an invaluable addition to the pool of black currant germplasm as they provide both frost and cold tolerance attributes which are rare in European black currant cultivars.

TISSUE CULTURE AND CYTOLOGY

I. H. McNAUGHTON

A small Tissue Culture and Cytology Unit was initiated during the period of this report. A main aim of the Unit is to develop *in vitro* techniques and put them into practice as an aid to plant breeders. Central facilities for *in vitro* culture work, part of the plan for the new laboratory block at Mylnefield, have already been set up, on a modest scale, at Pentlandfield. The remit in cytology is to provide a service for the plant breeding departments. This aspect of the work has been resurrected with the appointment of two new members of staff and is expected to become increasingly important with the development of techniques such as pollen irradiation, as a means of gene transfer, which requires cytological monitoring.

07001 *Exploit interspecific and intergeneric crosses as sources of variation for brassica and radicole (Raphanobrassica) breeding.*

Particular success was achieved this year in both the *Brassica* ovary and embryo *in vitro* culture programmes, leading to the synthesis of a high number of artificial *B. napus* plants. Crossing involved a large range of *B. campestris* and *B. oleracea* cultivars at both the diploid and tetraploid levels.

Following the recommendations made by N. Inomata, Japan, who developed the ovary culture technique, only *B. campestris* was used as female parent and ovary culture was restricted to diploid cultivars. Following bud pollination, 6-day-old developing ovaries were removed and cultured *in vitro* on modified White's medium with increased vitamins. Ovaries, two per 30 ml solid medium, remained in culture at 22°C, 16 h day length, under low light intensity until the siliquae began to split as the developing embryos matured and enlarged. In many cases, the ovaries contained several viable naked embryos that had developed to the 'walking stick' stage and were easily transferred to an embryo culture medium. They remained in this medium until a healthy root and shoot system formed. They were then transferred to a 50:50 mixture of peat and perlite and placed in a mist propagator. Eventually they were weaned to glasshouse conditions.

B. campestris (2n = 20, aa) forms were crossed with *B. oleracea* (2n = 18, cc) and hybrids (2n = 19, ac) raised by embryo culture. It is intended to micropropagate these hybrids, which are effectively haploid

B. napus (2n = 38, aacc), for mutagenic studies and for induction of chromosome doubling by colchicine treatment.

Further artificial *B. napus* plants were produced directly by embryo culture following 4x *B. campestris* × 4x *B. oleracea* crosses. Artificial *B. napus* forms, obtained earlier by embryo culture were maintained by bud-selfing and by isolating plants in insect-proof cages with blow-fly pollinators.

Anther culture.

Anther culture to obtain haploid *B. napus* from swede cultivars and breeding lines was attempted on a modest scale, approx. 5,000 anthers being cultured on an agar based medium using the method described by Keller and Armstrong (1978) for oil-seed rape. Embryogenesis was not induced, although good growth rate of anthers was obtained. Callusing of filament tissue, difficult to remove completely prior to culture, was a problem. This could be obviated by free pollen culture.

Pollen irradiation.

Attempts to obtain cultivars of the inter-generic hybrid *Raphanobrassica* (radicole) directly has been terminated, mainly due to its low seed fertility and low dry matter content. Radicole lines have shown good resistance to club-root disease (caused by *Plasmodiophora brassicae*), powdery mildew (*Erysiphe cruciferarum*), downy mildew (*Peronospora parasitica*) and sugar-beet eelworm (*Heterodora schachtii*). It may be possible to transfer genes conferring these valuable resistances by pollen irradiation. In a pilot experiment to ascertain irradiation levels appropriate to *Raphanus* pollen, crosses were made within *Raphanus* using pollen irradiated at 50, 100, 150 and 200 grays (radiation from a cobalt source). Good seed germination was obtained and plants resulted from even the highest dose, although leaf malformations were noted. Sampling of ovaries at an intermediate stage of development gave evidence of embryo abortion and suggested that the frequency of M_1 plants could be raised by embryo culture. This result needs to be substantiated by further experiments.

Storage of potato germplasm.

In vitro storage of potatoes offers several important advantages over field growing and conventional storage *viz.* 1. Clones can be maintained in a healthy condition; 2. Material will not be lost due to pests or pathogens; 3. Obviating the considerable annual labour in planting, lifting and conventionally storing; 4. Storage requirements are much reduced; 5. The transport of material is facilitated both by reduced costs and by satisfying international phytosanitary regulations.

A start has been made with *in vitro* storage of 24 clones currently used as differentials for late blight pathotyping and a number of clones from

the breeders' museum collection. Explants are being stored in a liquid medium on filter paper bridges in test tubes kept at low temperature and low light intensity. It is hoped that cultures may be maintained for at least 2 years using this method.

The prospect of using *in vitro* cultured potato plants, for bacteriological studies and for blight tests by the Potato Breeding Department, is being investigated. Potatoes grew particularly well in liquid culture, providing plantlets which might be suitable for easy inoculation by bacteria. Under high light intensity good leaf production suggested that blight tests *in vitro* might be feasible.

(I. H. McNaughton, Jill E. Middlefell Williams)

Cytology.

The post of ASO was filled in March whilst the SO post remained vacant until November. The work of the laboratory has, as a result, been largely restricted to routine screening of potato breeding material.

This was firstly for the production of tetraploid material from the cross *phureja* ($2n = 2x = 24$) by *tuberosum* ($2n = 4x = 48$). Useful tetraploid material can be identified cytologically and used for further crossing schemes, for example with commercial *tuberosum* material. Ploidy levels are checked, by mitotic counts, for each hybrid generation produced to ensure that the tetraploid level is maintained. Secondly, help was given with the production of primary dihaploids from known dihaploid inducing crosses. Fertile dihaploids may then be useful for breeding for traits controlled by major genes, at the diploid level, so avoiding complexities of tetrasomic inheritance. Both tasks required large numbers of chromosome counts (860) and pollen fertility estimates (1,200). Potential pollen parents of *phureja* were also screened for dimorphism for pollen size, to assess the proportion of diploandroid pollen.

A small number of pollen fertility checks were made for the brassica breeders and a few chromosome counts made of barley root-tips.

(E. Borrino)

MYCOLOGY AND BACTERIOLOGY

R. A. FOX

Interim findings from several research projects have tended to raise rather than resolve problems. The nature of chocolate spot disease of beans, complicated by the intimate association between *Botrytis fabae* and an endogenous pectolytic bacterium, has become further confused by the finding that when very young conida of *Botrytis cinerea* are inoculated to bean leaves, this fungus behaves in the aggressive fashion previously associated only with *B. fabae*. Moreover, the joint efforts of a number of workers in different places have failed to resolve the nomenclatural problem of the pectolytic bacterium which has been variously allocated to the genera *Erwinia, Pseudomonas* and *Alcaligenes*. Another taxonomic and pathological problem has been raised by studies on potato roots where one of the most prevalent fungi, *Verticillium tricorpus,* appears not to merit fully the specific epiphyte used and has raised doubts here and elsewhere on the supposed clear differences between that species, *Verticillium albo-atrum* and *Verticillium dahliae*.

The interactions, importance and role of infections, either covert or overt, of potato leaves by *B. cinerea* and their cryptic infection by the gangrene fungus, *Phoma exigua* var. *foveata,* require further studies on host-pathogen interaction and such studies are also required before we can understand the new and novel observations on the interactions of potato and *Phytophthora infestans*.

Continuing field experiments on cavity spot of carrot have revealed an unexpected beneficial response following the application of metalaxyl that cannot be attributed to the control of any identifiable fungus. The epidemiological picture of the association between species of *Erwinia* and potato becomes more complex each year although the rate of identification of new potential sources of the bacteria must diminish if for no better reason than that there are few ecological niches left where the bacteria have not been found. However, this diversity emphasises the close relationship of erwinias with other species within the coliform group the ubiquity of which is further reflected in what has been learned in the last decade of the distribution of *Erwinia* spp.

Studies on raspberry flower and fruit infection by *B. cinerea,* during the brief harvesting season over several years, have shown that the hypothesis of latent infection within the fruit plug, initiated during flowering and analogous with latent infection in strawberry fruit, must be

rejected. Moreover, although the dying floral parts are important targets for fungicide sprays, benefit also accrues from later sprays applied at all stages of ripening, a finding again contrary to suppositions associated with the concept of ineradicable latent infection within the fruit. The interesting relationship between raspberry cv. Glen Clova and *Thielaviopsis basicola,* the black root rot fungus of a number of crops in warm environments, appears to be no more than a benign association; despite extensive colonisation of the root surface, growth remains unaffected under experimental conditions.

SOIL MICROBIOLOGY AND ROOT DISEASE

02017 *Biology of potato gangrene.*

Effect of different soil environments on expression of tuber disease.

When the effects of wet or very dry soil conditions on gangrene incidence in tubers were examined in glasshouse-grown plants raised from tubers inoculated with *Phoma exigua* var. *foveata,* the highest disease levels were in progeny tubers from the wet treatment, a result in conflict with evidence from field experiments where disease levels tend to be higher following dry rather than wet seasons (Ann. Rep. 1981, p.75). The experiment was repeated in 1982 using more plant replicates but only one soil temperature regime and one harvest date.

Progeny tubers were again more numerous and larger following the wet treatment where the mother tubers showed least decay. When sectioned, some mother tubers appeared wet and glassy and rotted areas were black, granular and delimited by a thick corky zone within which bright yellow crystals were often evident which, when microscopically examined, appeared to be identical with those found in culture plates of *P. exigua* var. *foveata.* These anthraquinone crystals have been observed in tubers once before and their presence may be associated with a decrease in pH known to enhance their production in culture, and which would be an expected consequence of waterlogging, restricted aeration, and rotted roots seen at harvest.

The mean root weight at harvest from plants in the dry regime was 115 g but it was only 57 g for the wet regime where the haulm was dead at harvest although it was still green and vigorous in the dry treatment. No stem lesions or pycnidia were evident at harvest and, when cultured on agar, stem sections from only one and two plants out of 10 from the wet and dry treatments respectively yielded the pathogen. Root and stolon isolations showed that three and five plants respectively from the wet treatment had infected roots and stolons contrasted with one and four for the dry treatment. Six of 10 plants from both treatments had some part of the underground system affected but the overall frequency was highest in tissues from the wet treatment. However, the incidence of induced gangrene in the daughter tubers following inflicted standard

wounds and cold storage was unrelated to these findings being highest in tubers from the dry regime with 91% rots compared to 68% rots from the wet regime – a reversal of the 1981 result that may be related to the relative immaturity, when wounded, of tubers from the dry treatment.

Effect of different soil environments on fungal flora of potatoes.
The occurrence of fungi in below-ground stems, stolons and roots of glasshouse-grown plants was surveyed using standard isolation techniques. The range of fungi obtained from plants grown in either very wet or very dry soil environments was similar but there were marked differences in species frequencies.

The 'early dying' or black dot fungus, *Colletotrichm coccodes* was most frequently found with incidences of 55, 44 and 35% in stems, roots and stolons respectively from the dry environment but only 7.5, 12.5 and 11.5% respectively from the dry environment. In contrast, *Cylindrocarpon destructans,* a common root surface fungus, was significantly more common in the less-decayed plants from the dry than the wet treatments, the incidences for roots and stolons being 15 and 42% and 5 and 15% respectively, although the incidence in stem sections was similar at 12%. The wet treatment also resulted in reduced frequencies of *Rhizoctonia solani,* particularly in stems and in the stolons, *Polyscytalum pustulans* in all tissues, and *Phoma eupyrena* in stems and stolons. In contrast, the incidence of *P. exigua* var. *foveata* was higher in the wet treatment but at a low overall incidence.

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

Cryptic lesions in leaves.
Symptomless infection of potato leaves by *P. exigua* var. *foveata* and *Botrytis cinerea,* previously recorded (Ann. Rep. 1981, p.76), was again found in glasshouse-grown cv. Pentland Crown, developing from seed tubers infected with *P. exigua* var. *foveata.* Small, nearly circular chlorotic patches resembling blight lesions developed on some leaves and from these, after surface sterilisation, *B. cinerea* was consistently, and *P. exigua* var. *foveata* was infrequently isolated. Apparently healthy leaves of the cultivars Pentland Crown and Maris Piper were inoculated singly or dually with spore suspensions of *B. cinerea* and *P. exigua* var. *foveata* in July. Chlorotic zones were apparent 8 weeks later following inoculation with *B. cinerea* or with both fungi but not where *P. exigua* var. *foveata* alone had been used. Nevertheless, after surface sterilisation, symptomless leaves yielded the gangrene fungus from zones where it had been inoculated and it was also recovered relatively more frequently from both the single and dual inoculation sites and it seems likely, because of its rapid growth rate, that in the past the grey mould fungus may have obscured the detection of cryptic infection by the gangrene fungus.

(H. M. Wilson)

02024 *Autecology of the strawberry red core fungus.*

Oospore germination.

Experiments on the effects of high temperature on germination of oospores of *Phytophthora fragariae* (Ann. Rep. 1981, p.77) were continued. Oospores were placed on 1% distilled water agar (DWA) in petri dishes and held either continuously at 15°C, or at 25 and 30°C for 1, 3, 6, 10 or 15 days before being transferred to 15°C. When held continuously at 15°C, 50% of the spores became active and 37% formed germ tubes, most of the active spores having been so classified within 6 days from the start of the experiment. When held at 25°C for 10 days or less, only 7-16% of the spores became active, again within the first 6 days, but when transferred to 15°C more became active to give totals ranging from 38-43% by the end of the experiment. Only 24% of the spores held at 25°C for 15 days became active.

Only one spore became active at 30%C but, again, more did so when transferred to 15%C. The longer the spores had been held at 30°C, the greater the adverse effect on their potential activity, the figures being 51, 50, 43, 39, 36 and 24% for the control, 1, 3, 6, 10 and 15 days at 30%C respectively. Moreover, the initiation of activity after transfer to 15°C was proportionately delayed with increasing exposure to 30°C. Temperatures above 25°C not only inhibited oospore germination, but so affected the non-germinated spores that their germination was both reduced and delayed when they were exposed to favourable temperatures.

To study the effect of osmotic potential on germination, NaCl was incorporated into 1% DWA to give a range of potentials from −0.25 to −10 bar. At potentials down to −2.5 bar, 57-64% of the spores became active with 41-48% forming germ tubes; at lower potentials germination was slowed and fewer spores formed germ tubes, but even at −10 bar, 41% of the spores became active during the 3-week duration of the experiment, although only 7% formed germ tubes. Similar results were obtained with KCl, mannitol and sucrose and at potentials as low as −15 bars a few spores germinated and formed limited germ tubes.

Captafol and dichlofluanid had little effect on the early phases of germination at concentrations up to 1,000 μg ml a.i., but germ tube formation was markedly affected by low concentrations. In 0, 1.0, 3.0 and 10 μg ml captafol, 33, 26, 0.5 and 0% respectively of the spores formed germ tubes: dichlofluanid was better tolerated, 4% of the spores forming germ tubes at 10 μg ml. In the controls, germinating spores frequently developed sporangia but they did not do so even in the lowest concentration, 1.0% μg ml, of both fungicides. Instead they formed limited mycelia which were much more branched than those in the controls and it proved much easier to establish single spore isolates from them than it was from colonies on the control plates.

Oospore infectivity.

In an attempt to relate germination *in vitro* with infectivity *in vivo,* two lots of oospores of *P. fragariae* were used in germination tests and to inoculate well-rooted runners of *Fragaria vesca* clone VSI growing singly in pots of UC compost.

Batches of 10, 20, 40 and 80 oospores were each expressed singly into a hole *ca.* 15-20 mm deep made in the compost in which each runner was growing and the plants kept under conditions suitable for red core development. Plants showing symptoms were removed after 4 wk and checked for red steles and oospores, the remainder being scored 2 wk later. The proportion of oospores in lot 1 that were classed as active after 6 wk was only 11% compared to 39% in lot 2 and the corresponding figures for germ tube formation were 7 and 25%. These differences were not, however, reflected in their infectivity the number of plants with symptoms after 6 wk being 30 and 32 of a possible 40 for lot 1 and 2 respectively. However, it was noteworthy that despite the low levels of activity and germ tube formation of lot 1, half of the test plants developed symptoms at the lowest inoculum level of only 10 spores per plant.

Root tip bait tests.

Root tip bait tests were done in October 1982 on field-grown plants of three strawberry cultivars purported to differ in susceptibility to red core disease; Cambridge Favourite, Cambridge Vigour, and Saladin. The plants were grown in three blocks. Two were infested with *P. fragariae*; the plants in one were not treated but in the other they were treated with the fungicide Aliette. The third adjacent block was initially uninfested but some plants in it had symptoms when samples were taken indicating that the fungus had spread between blocks. All tests were positive, demonstrating that regardless of cultivar or fungicide treatment, infection had become so widespread that the highly sensitive root tip bait test did not distinguish between them.

Selective media for soil sampling.

In attempts to develop selective media for detecting and isolating *P. fragariae* directly from soil or water, it was assumed that the fungus would be present as zoospores either produced by germinating oospores or from sporangia on infected roots. Zoospores were not therefore produced aseptically and the suspensions inoculated to trial media in petri dishes were contaminated with other fungi and bacteria.

Four basal media were tested; a sucrose-mineral salts medium containing 30 μg ml ß-sistosterol (SMA), corn meal agar (CMA), oatmeal agar clarified by centrifugation before addition of agar (OMA), and French bean agar similarly clarified (FBA). SMA, CMA and OMA all

supported satisfactory growth of zoospores and contamination was well controlled by the inclusion per ml of; rifamycin 30 μg, nystatin 10 μg, and benomyl 10 μg. Nystatin was used in preference to pimaricin because it did not suppress zoospore cyst germination. Although the fungus was recovered from contaminated zoospore suspensions it has not yet been isolated from water used to flood samples of naturally infested field soil.

Soil sampling, Mylnefield/Auchincruive.

An experiment to monitor long term survival of *P. fragariae* in field soil has been established in an infested field at Mylnefield and in the former red core screening field at Auchincruive. The plots, kept fallow since October 1981, have been sampled every 2-3 months, and after sieving and moisture content determinations, portions of soil samples were baited with plants of the alpine strawberry Baron Solemacher to assess their inoculum levels. The remaining portions were adjusted to 50% moisture holding capacity and one part baited and the remainder stored at −1°C. The stored samples collected over any one year will be baited at the same time in each of 2 successive years in an attempt to distinguish between fluctuations in the efficiency of the bait test caused by environmental fluctuations in the glasshouse and true seasonal changes of inoculum levels in the soil.

To date, the fungus has been detected in all samples taken over the last 15 months, as well as in the first three samples stored at −1°C.

(J. M. Duncan)

02013 *Biology of root diseases in field peas and beans.*

Biology of Botrytis fabae *in bean.*

Following inoculation of bean leaves with conidia of *B. fabae* in a glasshouse, bacterial growth during the development of chocolate spot lesions was controlled with antibiotics. Using Paton's pectate gel, pectolytic bacteria were not detected in comminuted tissue from these lesions, but in the absence of antibiotics there were 4.7×10^7 pectolytic bacteria per g lesion tissue. The mean numbers of pectolytic bacteria isolated from pieces of lamina 3×3 mm with and without a non-aggressive chocolate spot lesion from a commercial bean crop after a prolonged spell of dry weather during summer were 8.5 and 9.6 respectively.

Twenty isolates were sub-cultured and all consisted of oxidase positive, catalase positive motile rods which gave similar, but not identical, results when inoculated onto multi-test plates. One isolate was grown in liquid culture, washed and injected into healthy bean leaflets kept at a high humidity. No lesions developed, suggesting that this bacterium is not a primary pathogen of field bean leaves. Large amounts of both polygalacturonic acid trans-eliminase and pectin methyl trans-

eliminase were produced by this isolate in liquid culture. Polygalacturonase, however, could not be detected in culture filtrates suggesting that trans-eliminases produced by bacteria play a role in the development of chocolate spot lesions.

Leaflets were inoculated with dry spores and lesions recorded after exposure to different relative humidities at two temperatures. Extensive lesions developed when the relative humidity was between 92 and 100%, but lesions were absent when it was 86% or less; the results were similar at both 10 and 22°C. The equilibrium moisture content (m.c.), on a wet weight basis, of conidia on clean glass slides was determined gravimetrically at various humidities at 10 and at 22°C. Temperature had little effect on spore m.c. and the mean at the two temperatures increased only slightly, from 19.8 to 26.2% water with increasing humidity between 45 and 86% r.h. Above 86% r.h. it increased sharply reaching 70.8% water at 100% r.h. Temperature had little effect also on the percentage of spores which had germinated after 6 days on slides. All spores remained ungerminated at 45 to 92% r.h., while at 95, 98 and 100% r.h. 1.1, 1.7 and 43.1% respectively had germinated suggesting that a low spore m.c. may inhibit germination under dry conditions. Either sucrose or KCl was added to distilled water agar to control its osmotic potential, giving a range of agars with osmotic potentials from *ca.* 0 to *ca.* −50 bar. The percentage of conidia which had germinated 1 day after scattering them over the agar surface decreased as the somotic potential decreased. At *ca.* −5, −10, −20 and −50 bar 93.8, 96.9, 96.0 and 25.8% of conidia respectively had germinated on agar containing sucrose, while on agar with similar osmotic potentials, but containing KCl, 88.5, 36.6, 21.4 and 0.0% of condida had germinated. These results indicate that the presence of sugar may extend the range of water potential, and hence spore m.c., under which germination can occur.

In a similar field experiment to that carried out in 1981, plants of two field bean cultivars sown during March, were sprayed to run-off with 0.15% chlorothalonil every 2 weeks on five occasions during summer. Plants were harvested in August when most of the leaves had fallen off. Spraying with fungicide had no effect on the yield of oven-dry seeds of either cultivar, perhaps relecting the low disease levels observed in local bean crops during 1982.

B. Cinerea is generally considered to cause only limited lesions on bean leaves. The effect of age of conidia on lesion aggression was investigated by inoculating leaflets with spores from cultures grown on agar for different periods. From a total of 30 inoculation sites per treatment, there were 29, 1, 1 and 0 black spreading lesions 4 days after inoculation with spores from 6, 9, 13 and 17-day old cultures respectively, demonstrating that *B. cinerea* can induce the development of aggressive lesions.

Benomyl-tolerant *B. cinerea* was frequently the only fungus recovered from extensive chocolate spot lesions from a benomyl-treated field plot.

To test whether spraying with benomyl increased susceptibility to *B. cinerea* infection, plants were sprayed to run-off with either benomyl (as 0.1% w/v Benlate, du Pont 50% a.i.) or water alone. On the following day they were inoculated with conidia of *B. cinerea* and kept at a high humidity. After 2 and 4 days lesions were similar in size and frequency on plants of both treatments.

(J. G. Harrison)

02010 *Seed quality-soil interactions and their effects on seedling growth.*

Pathogenicity of Fusarium nivale *on barley.*

Seeds of barley cv. Golden Promise harvested at Invergowrie in 1981 were inoculated with *Fusarium nivale* by steeping them in a suspension containing 6.3×10^4 spores for 1 h and drying in air overnight. A similar quantity of seed was soaked in water as a control. Baytan (Bayer Ltd) a dust preparation of triadimenol and fuberidazole containing 250 g and 30 g a.i./kg respectively was applied to half of the inoculated and non-inoculated seeds at the rate of 2 g/kg seed. Seeds from each of the four treatments were sown in a latin square design with an Oyjord drill in plots 10 m long $\times$ 1.7 m wide at Invergowrie on 22 March.

Mean seedling emergence counted on 15 April was 405/m^2 and was unaffected by inoculation or fungicides. Seeds and plant stems were placed on potato-sucrose agar (PSA), incubated at 15°C and the presence of *F. nivale* determined by colony characteristics after 6-7 days. Before sowing the fungus was present on 46 and 4% of the inoculated and non-inoculated seeds respectively which were not treated with fungicide and from 2 and 0.5% respectively after treatment. In contrast, on 22 April it was isolated from 23.5 and 20.5% of surface-sterilized stem bases of seedlings from inoculated and non-inoculated seeds not treated with fungicide and from 9.0 and 6.5% of seedlings from seeds which had been treated with fungicide. By 29 July the fungus was detected in 22.5% of stem bases of mature plants from inoculated, non-fungicide treated seeds and in 6.5% of plants from non-inoculated, non-fungicide treated seeds but not in plants from any of the Baytan treated seeds. Mean grain yield at 15% m.c. was 481 g/m^2 with no significant differences between treatments and the average incidence of *F. nivale* on surface sterilized seeds was 5.9% with no relation to incidence on stem bases.

The contrast between frequency of isolation from seeds and seedlings indicated that infection from soil-borne inoculum had taken place and that fungicide treatment effectively controlled the fungus.

Laboratory experiments.

Seeds of barley sown in UC compost to which sand-maize meal cultures of several isolates of *F. nivale* had been incorporated (100 g/kg) produced seedlings with lesions on both coleoptiles and seminal roots after 14 days

incubation at 10°C with artificial illumination. Inoculation did not cause seedling death but shoot length (coleoptile and first leaf) was reduced by <46%. Plating dissected surface sterilized seedlings on PSA showed that the fungus was present in areas of the coleptile and root closest to the seed and that the first leaf was not infected. The fungus was always isolated from brown lesions but could also be found in adjacent tissue which was not discoloured.

Seeds were inoculated by dipping into suspensions containing 1×10^3 to 1×10^7 spores/ml and sowing directly into UC compost. After 14 days at 10°C seeds inoculated with 1×10^3 spores/ml produced seedlings with no symptoms and the fungus could not be isolated from them. At higher spore concentrations lesion severity and frequency of isolation of the fungus were related to inoculum level.

The effect of periods of low temperature on symptom development was investigated by sowing seeds in UC compost after dipping in a suspension of 1×10^6 spores/ml or in water. After 7 days at 10°C pots were transferred to 2°C or −2°C for 6 and 2 days respectively and returned to 10°C, while some pots were kept continuously at 10°C. Seedlings were examined for symptoms when shoots of those from non-inoculated seeds were *ca.* 100 mm long. Seedlings from inoculated seeds kept at 10°C continuously developed lesions on the coleoptiles and roots and the shoots were 12% shorter than those from uninoculated seeds. Exposure to 2°C decreased lesion severity but shoots from inoculated seeds were 25% shorter than those from controls. Treatment at −2°C had severe effects on the seedlings from inoculated seed. Coleoptiles failed to develop from 64% of seeds and the remainder were severely stunted or deformed. Roots bore severe lesions and were <50% of the length of those from controls. Coleoptiles grew normally from uninoculated seeds and although some were discoloured, *F. nivale* was not isolated from them.

Radial growth of *F. nivale* on PSA was 10 mm/day at 20°C and 0.55 mm/day at −1°C.

These investigations confirm the pathogenicity of *F. nivale* at low temperatures and the potential for damaging overwintering cereal plants.

(D. A. Perry)

Observations on *F. nivale* grown on glass fibre tapes and buried in field soil showed that spores and mycelia survived longer at 5 and 10°C than at 20°C. Soil-borne infection could be detected using disease-free barley seeds as baits and plating coleoptiles on PSA.

(Mediha Al-Hashimi)

02025 *Rhizosphere and allied phenomena affecting plant health.*

Incidence of selected fungi in potato roots following continuous cultivation.

At intervals from 22 July to 23 September, roots were sampled from plants of cv. Maris Piper growing in plots where this cultivar had been grown for none, one, two or three successive seasons previously. Root segments were washed, surface sterilized and plated on to low nutrient agar containing antibiotics. The following fungi were identified either directly or after further culturing on diagnostic media: *Polyscytalum pustulans, Rhizoctonia solani, Colletotrichum coccodes, Cylindrocarpon destructans,* and *Verticillium* spp.

The overall mean frequency of detection of *P. pustulans* rose from 22% at the first sampling date to 32% 1 month later and remained at that level until the last sample. At each sampling date the previous cropping history significantly affected the frequency of the detection; following none, one, two and three previous crops the overall mean incidence was 18, 31, 33 and 38% respectively, the most marked difference always being that between the first and second season crop indicating the ability of the fungus to overwinter either in the soil or in debris from the previous crop.

R. solani was also detected more often as the season advanced but it was generally infrequent, apparently localised within plots, and its incidence varied from one sampling date to another. Like *P. pustulans,* previous cropping with potato induced a cumulative effect and in samples from the first to the third succession of potato crops the overall mean incidence increased from approximately zero to 13% but it fell to 6% with the fourth season crop. The apparently anomalous decrease may be explained by a phenomenon similar to that of the well-known take-all decline in cereals. It has also been observed with *R. solani* on potatoes in the Netherlands where declines in the incidences of Rhizoctonia stem canker and black scurf have been associated with increases in antagonistic soil populations with increasing numbers of potato cultivations in new polders.

The overall frequency of detection of *Verticillium* spp. was high and the within-season variations observed were as likely to reflect rapid rates of production and death of conidia as affected by variations in soil conditions rather than within-season multiplications or past cropping history. Surprisingly, *Verticillium albo-atrum,* the common cause of potato early-dying or wilt in milder climates was not recorded although it has been in other seasons; the corresponding warm climate pathogen, *Verticillium dahliae* was recorded at low frequencies that increased with the number of previous years' potato cropping as would be expected from the known persistence of its micro-sclerotia. Similarly, there was a progressive increase in the relatively high detection rate of *Verticillium*

tricorpus whereas the low numbers of *Verticillium nubilim* decreased in relation to the number of past potato crops. *V. tricorpus* has been recorded as a common tuber-borne fungus in potato seed stocks but not as occurring in the soil, but it is widely considered to be non-pathogenic. Perhaps not surprisingly, nearly 90% of the isolates assignable to *Verticillium* were initially categorised as *V. tricorpus* but detailed study and check identifictions by the CMI suggested that no less than 75% of the isolates must, for the time being, be considered as no more than '*tricorpus*-like.'

C. coccodes, another root fungus associated with premature senescence especially in warm climates, showed a clear relationship, as has been found before both in the glasshouse and in the fields at Invergowrie, between incidence and time of sampling the figures ranging from approximately 10% at the first harvest to 20% at the last. Again, the overall mean incidence was clearly related to the members of previous potato crops.

As expected, the frequency of occurreance of *C. destructans,* a ubiquitous root surface coloniser, was higher than that of any other single fungus. A decrease in numbers was paralleled by increased numbers of *C. coccodes* which accords with previous findings that his latter fungus can suppress others.

The overall effects of these and other fungi were recorded both by scoring the haulm for senescence and measuring plot yields. When the foliage was scored on the last sampling date on a scale of 1 dead, to 5 fully alive the scores were 1.3, 1.4, 1.0 and 1.0 for 0, 1, 2 and 3 years previous cropping of potato and the corresponding yields expressed as a percentage of a single season in potatoes were 100, 98, 85 and 87% respectively.

Causes and effects cannot yet be identified but it is planned to investigate them in other experiments using combinations of selective pesticides. Experiments in the plots described here will be continued using micropropagated plants to separate the effects of soil and tuber-borne pathogens and of genotype-determined susceptibilities.

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

PLANT AND PATHOGEN PHYSIOLOGY

02026 *The nature and implications of quiescent fungal and bacterial infections.*

Rishitin/nutrient interaction.

The sensitivity of *Erwinia carotovora* ssp. *atroseptica* to the phytoalexin rishitin can be altered by changes in the composition of the nutrient medium *in vitro* (Ann. Rep. 1981, p.81). This work has been continued by studying the interaction of rishitin with a total of 15 nutrients and cations which represent the major soluble components of

potato tubers. For example, 30 min after the addition of 250 μg rishitin ml to bacteria suspended in 20 mM sucrose only 0.7% of the bacteria remained viable compared to 4.7% in 5 mM arginine, 14.8% asparagine, 34% in mM Mg SO_4 and 91% in 5 mM $CaSO_4$. Respiration of the bacteria was continuously monitored over the 30 min assay period. A model of the bacterial respiration was developed in order to provide additional information on population dynamics which could not be obtained from a relatively few data points derived from viable counts. The model contained parameters relating to initial oxygen concentration (A), initial respiration rate (B), relative growth rate (C), proportion of tolerant cells (D) and the relative death rate (E). Thus at any time after the addition of rishitin, the oxygen concentration (Y).,

$$= A + B \left[\frac{D}{C}(1-e^{Cx}) + \frac{1-D}{C-E}(1-e^{(C-E)x}) \right]$$

Thus, where bacteria have similar growth rates in two different treatments (e.g. sucrose and glutamine), the number of viable bacteria remaining is determined by the killing parameters D and E. However, for bacteria suspended in either glucose or asparagine, where the combined killing parameters (1-D)E are similar, the numbers of surviving bacteria is determined by the growth rate. This model, together with direct measurements of viability changes, will be further used to determine the extent to which the soluble nutrients within a potato tuber could be manipulated to increase its resistance to this bacteria.

(G. D. Lyon, J. C. Cowan[1])

Polygalacturonic acid lyase.

Earlier work has shown that polygalacturonic acid lyase, when purified from culture filtrates of a single isolate of *E. carotovora* ssp. *carotovora*. elicits the accumulation of phytoalexins in soybean cotyledons. Using a large number of isolates, obtained from a range of plant species in different countries, the elicitor activity of dialysed culture filtrates of ssp. *carotovora* grown in a liquid medium containing pectin was measured. Results suggest that in these culture filtrates there is a poor correlation between phytoalexin elicitor activity and the level of polygalacturonic acid lyase. Therefore, other high molecular weight components are also present in the culture filtrates which affect elicitor activity.

(G. D. Lyon)

02015 *Disorders of vegetables.*

Cavity spot of carrots. Field Experiment.

Carrots, cv. Red Cored Chantenay, were sown on 27 April at East Seaton Farm, Arbroath, on imperfectly drained sandy loam of the

[1]Data Processing Department.

Balrownie series where previous carrot crops had been severely affected by cavity spot. They were grown in single rows 0.75 m apart at a high population density and the treatments applied in a 5×5 latin square to 2-row plots 5 m long were (1) calcium peroxide granules, 2-4 mm diam. (Laporte Industries Ltd) applied pre-sowing at 20 g/m^2; (2) calcium peroxide granules, 1.4-2.0 mm diam. applied 24 June in furrows alongside rows at 15 g/m of row; (3) foliage sprayed with metalaxyl at 125 mg a.i. in 200 ml water/m^2 on 24 June; (4) soil between carrot rows cultivated mechanically to a depth of 100 mm three times during the growing season; (5) soil rolled post-sowing. Herbicide and insecticide applications followed commercial practice. Carrots were harvested on 21 October, washed and graded into roots 20-32 mm and <32 mm crown diameter. The percentages of roots with slight, moderate and severe lesions in both grades were recorded for each treatment.

In the canning-size grade (20-32 mm), the incidence if slight lesions was high ($\bar{x}$ = 41.7%) and unaffected by treatment while moderate and severe lesions were significantly less in the calcium peroxide mid-season treatment (10.1%) and following metalaxyl spray (6.3%) than in the calcium peroxide pre-sowing (16.2%), inter-row cultivations (13.1%) and rolling (14.4%) treatments. Similar trends were recorded in the large root grade.

Following the response obtained to metalaxyl, plating on several appropriate agar media and baiting in apple and pine needle tissue failed to isolate any *Pythium* or *Phytophthora* spp. which may have been pathogenic. *Mycocentrospora acerina, Cylindrocarpon destructans, Mucor* spp., *Rhizoctonia* sp. were most frequently isolated from lesions and all grew on agar media containing <1 g/l metalaxyl.

(D. A. Perry, A. Horgan[1])

Induction of carrot root lesions.

The toxicity to carrot roots of salicylic acid increased as the pH of the solution was lowered and lesions were induced by 1 mM solution at pH3. Salicylaldehyde was not toxic and the structural isomers of salicylic acid, m-hydroxybenzoic and p-hydroxybenzoic acids were not toxic at concentrations <10 mM. Slurries of 100 g field soil were amended with 1 g glucose, 1 g $Ca(NO_3)_2$, 0.5 g $Ca(NO_3)_2$ + 0.5 g glucose, 1 g cinnamic acid and 1 g caffeic acid and incubated anaerobically for 14 days. Only the supernatant from the glucose amendment was toxic to carrot roots.

(M. R. Groom[2])

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[1]ESCA.

[2]MAFF.

02018 *Diseases of potato tubers.*

Susceptibility of tubers to infection by E. carotovora.

Continued investigations into the relative susceptibility of tubers of 30 cultivars to decay following inoculation with *E. carotovora* ssp. *atroseptica* (Eca) using the infectivity-titration procedure described previously (Ann. Rep. 1981, p.83) confirmed that they were more susceptible after harvest in October than after 5 months storage at 5°C. Among the susceptible cultivars were Pentland Javelin, Pentland Meteor, Arran Comet and King Edward with ED 50s of <10 cells of Eca in October rising to 10^3 cells in March, while Cara, Croft, Golden Wonder and Vanessa were resistant, with ED 50s of 10^6 cells in March. Most cultivars maintained their susceptibility ranking from October to March which was similar to that found in 1981.

Preliminary results of a study on the virulence of four strains of *E. carotovora* ssp. *carotovora* (Ecc) and four strains of Eca to tubers of cv. Pentland Crown at 22°C using the infectivity-titration procedure showed that ability to cause decay varied and was not related to their identity; for example, on Eca strain was most virulent with an ED 50 of 5×10^1 cells, while an Ecc strain was least virulent with an ED 50 of 2×10^4 cells.

Potato tuber susceptibility to decay is known to increase when the oxygen concentration is reduced at temperatures <30°C (Ann. Rep. 1981, p.83). However, susceptibility to Ecc was equally high under both aerobic and anaerobic conditions at 35°C, a temperature at which Eca does not grow.

Susceptibility of tubers to *E. carotovora* may be related to their Ca content. Ca concentrations and distribution in tubers of 19 cultivars grown in the same field at SCRI were determined by atomic absorption spectometry at MISR. On average, four times more Ca was present in the peel (ca.2 mm) than at the vascular region and no difference in levels was detected between the heel and rose ends of tubers of all cultivars. With the exception of two cultivars, the ranking of the other 17 on the basis of Ca level was in close agreement with that based on tuber susceptibility to decay. The levels of Ca ranged from 740 mg/kg dry weight peel in the resistant cultivars Pentland Croft, Cara and Stormont Enterprise, to 340 mg/kg in the susceptible cultivars Maris Piper, Bintje and Pentland Crown. The two exceptions were cv. Maris Bard rated as intermediate in resistance but with a Ca level of 240 mg/kg and cv. Pentland Javelin rated as susceptible but with an intermediate Ca level of 596 mg/kg. These results justify more work to clarify the role of Ca in tuber resistance to decay which might lead to the development of a rapid method for screening breeding lines for resistance.

(R. Lowe, M. C. M. Pérombelon)

02027 *Studies of plant pathogens.*

Biology of E. carotovora *on potato leaves.*

Erwinia carotovora ssp. *carotovora* (Ecc) multiplied on wet leaves at *ca.* 100% r.h. on plants at 17°C in growth chambers and to a lesser extent on dry leaves if the r.h. was about 100%. The maximum number of erwinias enumerated on wet healthy leaves was $10^5/cm^2$ and numbers were not significantly higher on senescent leaves on which high numbers of other micro-organisms occurred. Fewer erwinias were detected on green leaves maintained wet by continuous misting either because the bacteria were washed off or due to a dilution of nutrients on the leaf surface.

When the epiphytic flora of potato plants was monitored in the field populations of bacteria and yeasts increased towards the end of the growing season when leaves were more frequently wet for longer periods because of rain and dew. There were on average ten times more bacteria than yeasts but the former declined temporarily by a tenth immediately following the application of fungicides to control blight. Representative samples of the bacteria were classified into seven groups on the basis of Gram reaction, morphology and three biochemical tests although two groups of Gram −ve, motile rods, oxidase− and catalase+ predominated at all times. One was white and gave a negative reaction to Hugh and Leifson's O-F test and the other was cream and positive in the O-F test.

(N. Ross, P. Blakeman[1], M. C. M. Pérombelon)

Survival of E. carotovora *in soil and water.*

The monthly surveys to detect the ssp. *carotovora* (Ecc) and *atroseptica* (Eca) in rhizosphere soil of weeds and crops in fields were continued at Invergowrie and on two commercial farms.

Although the number of contaminated soil samples fell sharply from a peak of 45% at all three sites in late autumn 1981 as found in the previous survey (Ann. Rep. 1981, pp.83-84), the bacteria were detected at a low level (*ca.* 3%) throughout the year except that on one farm the contamination level rose to 43% in October. Soil populations of *E. carotovora* (Ec) in fields on which potatoes were grown in 1981 were high after harvest but had fallen to low levels by February 1982. Although populations in most fields were low, the bacteria were present in a high proportion of water samples taken from waterlogged areas in the fields after heavy rain in autumn at the three sites. Furthermore, over 60% of rhizosphere soil samples from brassica crops at Invergowrie were positive at the end of the year and the ability of Ec to survive in this environment was confirmed by further sampling on other farms. Whereas Ecc and Eca were present in equal numbers in soil in 1981, over 95% of the isolates in 1982 were Ecc.

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[1]Botany Department, University of Aberdeen.

Monitoring Ec populations in the Alyth Burn and its main tributary streams in Perthshire was continued during the year and the results were in broad agreement with those obtained previously (Ann. Rep. 1981, pp.83-84). Only the lower reaches of the river where it flows through arable land were contaminated throughout the year. Thus, from January to May $<10^2$ erwinias/1 were present but subsequently the numbers gradually increased to a maximum of 7×10^3/1 in October and fell to 6×10^2/1 by December. Where the river flows through grazing land, the bacteria were rarely detected before May. Thereafter detection was more frequent and the numbers ranged from 10^1 to 10^3/1 until November when they were again rarely detected and then in numbers $<10^2$/1. The bacteria were never detected at sampling sites near the river source in moorland. A similar pattern was found when the South Esk river and River Isla before its confluence with the Alyth Burn were sampled in July and October but the numbers of Ec present were a tenth of those found in the Alyth Burn possibly because these rivers flow through less intensively cultivated land. Of 345 isolates of Ec identified to sub species level 96% were Ecc which is about one fifth more than in 1981.

Samples of water from several field drains on arable land on commercial farms contained low numbers (<50/1) of Ec in spring and early summer irrespective of the present or past cropping history. The numbers increased in August-September to 10^3-10^4/1 and decreased during the rest of the year. The bacteria were not detected in drainage water from grazing land until September when the numbers present rarely exceeded 10^2/1.

The pH of water from the Alyth Burn ranged from 7.2-7.8 and that from the field drains was half a unit higher. River and drainage water temperature was <5°C in winter and between 10-15°C in summer. The total numbers of bacteria in the rivers ranged between 10^3 to 10^4/ml at all sampling points with higher numbers present during the summer months.

Twenty-five strains of Ecc and Eca from different sources including the river water survived better in 0.001M phosphate buffer at pH5.5 than at pH7.5 and at 15° than at 5°C. Survival of washed cells of Ecc and Eca in unbuffered distilled water at pH6 and at 10°C was <1 wk when the density was 10^3 cells/ml but when the density was 10^7 cells/ml the bacteria survived for several months in un-diminished numbers after an initial fall in numbers within the first week. The bacteria multiplied and survived for <1 wk in filter sterilised soil extract obtained by mixing soil and water in a 1:2 ratio but failed to grow and died within 48 h in filter sterilised river water.

(M. C. M. Pérombelon, Lizbeth J. Hyman)

Pectic enzymes production by E. carotovora.

Alterations in the pectic enzymes produced by one strain of Ecc and one of Eca were obtained by nitroso-guanidine mutagensis. Polygalacturonate transeliminase (PL) and polygalacturonase (PG) activities of 28 mutants cultured for 24 h in pectate broth at 20° and 30°C were determined by spectrophotometry and viscometry respectively. Loss of activity ranged from 0 to 100% for either one or the other enzyme, or for both enzymes and mutants were classified into three groups: PL + ve PG + ve, PL − ve PG + ve and PL − ve PG − ve, the − ve referring to loss of some activity and the + ve to 100% activity.

When 10^7 cells of mutants with enzyme activity loss <80% were inoculated into tubers and incubated for 5 days in 10% 0_2, 90% N_2 at 22°C, PL − ve caused less decay than PG − ve strains and, PL − ve PG − ve strains caused no decay.

(R. Lowe, M. C. M. Pérombelon)

Genetic mapping of E. carotovora *sub sp.* carotovora.

Although the frequency of gene transfer mediated by plasmid R68::Mu C+△ 445-7 in *E. carotovora* ssp. *carotovora* strain 193 (Mu) to multiple auxotrophs of strain 193 was low (Ann. Rep. 1978, p.82), a linkage map with 15 ordered markers and two loosely mapped markers has been constructed. Two chromosomal transfer systems were involved simultaneously during conjugation, a non-polar transfer induced by plasmid R68 and a polar mechanism requiring the co-integrated plasmid in addition to a chromosomal Mu prophage. Hence, difficulties were experienced when mapping markers distal from the origin (thyA1::Mu). However, by combining these data with those obtained using plasmid F′ lacTc which was even less efficient in effecting chromosomal mobilisa tion, it was possible to construct a single circular linkage map of strain 193. When this map was compared with those of other species in the *Enterobacteriaceae,* including the genus *Erwinia,* a large 10 min chromosomal inversion found in *Salmonella typhimurium* compared to *Escherischia coli* was also found in Ecc. Two other inversions also noted in Ecc relative to *E. coli* and *S. typhimurium* in the region which includes *Str A* and *rif* are also found in available linkage maps of other *Erwinia* spp.

(K. Forbes, E. Reeve[1], M. C. M. Pérombelon)

Cloning in E. carotovora.

Work has begun to develop a cloning system in *E. carotovora* ssp. *carotovora* (Ecc) which could be applied to the study of genes coding for pathogenic characters using a well characterised promiscuous plasmid vector, pKT210, found to be stable when introduced into Ecc. Using

[1]Institute of Animal Genetics, Edinburgh.

purified preparations of Ecc-modified pKT210 DNA, preliminary attempts to transform a wild type strain of Ecc by the $CaCl_2$ method were unsuccessful. Future work will include the use of pKT210 as a shuttle vector. Recombinant plasmids will be constructed *in vitro* and transformed into *Escherichia coli* and following characterisation the plasmid will be mobilised into Ecc for further study.

(J. Hinton, E. Reeve[1], M. C. M. Pérombelon)

Pectolytic Clostridium *spp.*

Comparisons of the properties of the collection of *Clostridium* spp. (Ann. Rep. SHRI 1980, pp.79-80 and SCRI 1981, p.85) with reference cultures of *Cl. butyricum, Cl. beijerinckii, Cl. rubrum* and *Cl. felsineum* from the National Collection of Industrial Bacteria failed to reveal sufficient similarity positively to identify any of them. *Cl. felsineum* was the only pectolytic species in the reference cultures, while *Cl. butyricum* and *Cl. beijerinckii* were most similar in morphology and colony characteristics to several of the isolated strains but continued sub-culturing in polypectate-containing media failed to demonstrate any adaptive ability to form pectolytic enzymes.

At least half of the 56 pectolytic Clostridia were capable of growing satisfactorily in a glucose-containing liquid medium at 10°C. A representative selection of 12 of the low temperature tolerant isolates also liquefied calcium pectate and rotted potato disks at 10°C showing that they did not require high temperatures for pectolytic activity.

(D. A. Perry)

Production of metalaxyl tolerant isolates of Phytophthora cactorum.

A single zoospore isolate of *P. cactorum,* the cause of strawberry crown rot, has been used in a study of metalaxyl tolerance. Zoospore suspensions were produced from cultures growing on french bean agar by flooding them with sterile distilled water or sterile 0.005 M $Ca(NO_3)_2$ solution, incubating them at 12°C for 1.5 h, and then decanting the liquid which contained large numbers of zoospores. Portions of the suspension were pipetted into empty sterile plastic petri dishes and V-8 juice was added to promote encystment. The encysted spores, which mostly adhered to the bottom of the petri dishes, were then either treated with ethylmethane sulphonate (120 μg ml) or irradiated with uv light (253 nm) for varying periods of time, before the liquid in the dishes was replaced with a thin layer of cooled V-8 agar. The plates were incubated at 20°C until growth was visible; a thicker layer of V-8 agar containing metalaxyl at 100 μg ml was poured over the first layer and the plates were incubated again at 20°C. Hyphae which grew through the fungicide layer were excised and sub-cultured on fresh media before making single

[1]Institute of Animal Genetics, Edinburgh.

zoospore isolates from them. Ten isolates showing increased tolerance to metalaxyl have been obtained and, by a similar procedure, streptomycin-tolerant isolates have been selected. Some of the metalaxyl-tolerant isolates have been grown in liquid culture in which they form abundant oospores and single-oospores progeny from them are being examined to study the inheritance of tolerance to metalaxyl.

(J. M. Duncan)

09028 *Study mechanisms of genetic variability in* Phytophthora infestans *and the evolution of new pathogenic types.*

Samples of *Phytophthora infestans* received from various parts of Scotland and England reflected the recent change from race 4 to race 1,3,4 as the basic, common race. The former was obtained from only one location in Scotland. Among the samples from elsewhere race 1,3,4, race 1,3,4,7,10, race 1,3,4,7,10,11, and race 1,2,4,10 were identified.

Resistance to metalaxyl was not associated with any particular race.

(Jean F. Malcolmson)

EPIDEMIOLOGY AND ETIOLOGY

02003 *Shoot disorders of cane and bush fruits.*

Cane diseases of raspberry.

Cane blight.

A fruit catching system developed at the SIAE for their raspberry harvester test rig and designed to minimise the wounding of young canes and the consequent risk of infection by *Leptosphaeria coniothyrium,* substantially reduced the incidence and severity of vascular lesions compared with the catching system of the Littau harvester when young canes were inoculated with the pathogen (Ann. Rep. 1981, pp.85-86). However, under conditions of high levels of natural inoculum or a drastic inoculation method lesions developed on many canes at pressure marks caused by the spring-loaded rubber belts of the SIAE rig. These have now been modified to reduce the pressure they apply to the young canes. The effect of the modifications was evaluated in a replicated field trial by inoculating young canes of cv. Malling Jewel with mycelium of *L. coniothyrium* isolate 902 (IMI 190198) on the belt marks immediately after a single harvest on 21 July 1982. As controls, canes in plots not harvested mechanically were wounded by scalpel or left unwounded before inoculation. Other treatments to assess the level of natural infection of wounds or belt marks were included in the experiment. The incidence and severity of vascular lesions at inoculations are to be assessed in 1983.

(B. Williamson)

Spur blight.

Inoculation experiments in the field and glasshouse have suggested that *Didymella applanata* inhibits axillary bud development and lateral shoot growth if the subtending leaf is infected in early July, but inoculations in mid-August were ineffective (Ann. Rep. 1981, pp.87-88). The effect of leaf infection on bud growth was again studied. At weekly intervals from 15 June to 1 September the petiole of the leaf at the 15th nodes of young canes of the cultivar Malling Jewel and Glen Clova was wounded by scalpel and inoculated with mycelium of *D. applanata* isolate 188; as controls leaflets were removed to simulate defoliation by *D. applanata* and buds of healthy undamaged leaves were also assessed. The primary axillary buds were measured on 8 and 9 March 1982 and the lateral shoots assessed as emerged or failed on 7 May.

In Malling Jewel buds at inoculated nodes were shorter than those at delaminated nodes which, in turn, were shorter than those untreated. The buds at the nodes whose petioles had been inoculated on 22 June 1981 had the shortest buds in March 1982 and petioles inoculated later produced progressively longer buds; the buds at delaminated nodes showed no such trend. In Glen Clova buds at nodes given either treatment had a similar length but were shorter than those of the unwounded controls. Significantly fewer primary laterals grew in May 1982 at inoculated nodes in both cultivars; in Malling Jewel fewer laterals grew when petioles were inoculated before 28 July but no time-related trend was observed in Glen Clova. Most buds at the delaminated nodes and unwounded controls produced laterals. In Malling Jewel the length of buds at the inoculated nodes was highly correlated wth the proportion of those which produced laterals ($r = 0.85$; d.f. $= 9$) but not in Glen Clova.

The results demonstrate how a single isolate of *D. applanata* may be used to evaluate its effect on axillary buds at the best stage of plant growth to identify tolerant genotypes, or to assess the virulence of isolates of the fungus. Studies on natural infection have indicated that Glen Clova is more tolerant of *D. applanata* than Malling Jewel (Ann. Rep. SHRI 1978, pp.85-86) and these inoculation experiments support this assessment of the cultivars. The experiment also suggests that chemical control of spur blight might be effective in Scotland if applied between mid June and late July.

(B. Williamson, A. Dale[1])

Under Scottish conditions cultivars become infected by *D. applanata* mainly at nodes in the non-cropping area at the base of canes, but in British Columbia (BC) the majority of nodes on canes up to 155 cm (tipping height) of susceptible cultivars, bred either in N. America or in the United Kingdom (UK), are infected.

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[1]Soft Fruit Breeding Department.

Because environmental differences between the above two important raspberry growing areas probably influence susceptibility of canes to *D. applanata*, the effect of temperature was examined by separating a single population of one-year-old plants of Malling Jewel into two groups early in their second year. One group was grown outside without protection, the other within an unheated glasshouse. On the 27 July the petiole at the 15th node and the internode above the 17th node were wounded by scalpel and inoculated with mycelium of *D. applanata*. Eight isolates of UK origin and a non-inoculated control were used in the experiment. Both groups of plants were then separated into three environments; outside unprotected, in an unheated glasshouse, or in a glasshouse at 20°C. The lengths of internodal lesions were measured on 27 August. In October the plants under glass were hardened-off and moved outside. The length of primary axillary buds subtended by inoculated petioles were measured on 28 November.

Canes produced in an unheated glasshouse before inoculation were more susceptible than those grown outside; longer lesions were produced at 20°C than in unheated glasshouse or outside. The buds on canes grown outside were significantly shorter than those from the unheated glasshouse but the post-inoculation environments did not significantly reduce bud growth. Inoculation usually reduced the rate of bud growth compared to the control and when assessed by their effects on petioles and canes there were significant differences in virulence between isolates.

This experiment suggests that warmer growing conditions may induce more aggressive spur blight lesions which reduce the growth rate of buds before winter dormancy is imposed.

Cultivars bred in the UK have ranked differently for resistance to spur blight when grown in BC as did Canadian cultivars when grown in the UK. These differences at the two raspberry growing centres may be due to local isolates having differential virulence or it may be attributed to cultivar x environment interactions which influence cane vigour and maturation rates, factors known to influence spur blight.

The virulence of five isolates of *D. applanata* (three from BC, two from UK) on the cultivars Williamette, Leo and Glen Prosen was compared by inoculating mycelium to scalpel wounds on four internodes above the 15th, 17th 19th and 21st node from soil level on 3 August. The plants were grown under quarantine conditions in a sealed growth cabinet under lights for 16 h/day (15°C day, 11°C night) in August and 14 h/day (13°C day, 10°C night) in September. The length of lesions, measured on 15 September, differed significantly on the three cultivars, the longest occurring on Glen Prosen; the virulence of isolates also differed, the BC isolates producing longer lesions than UK isolates with a significant cultivar x isolate interaction attributed mainly to a UK isolate.

These experiments show that temperature, cultivar and isolate genotype all affect the severity of spur blight, and emphasise the need for regional fruit trials close to large centres of raspberry growing to test the field resistance of new selections and cultivars.

(H. S. Pepin[1], B. Williamson)

Raspberry yellow rust.

Teliospores of *Phragmidium rubi-idaei,* the only overwintering stage of the fungus, are produced on ageing uredinia on the underside of leaves. Most infected leaves are incorporated into the soil and decompose before spring although some remain trapped between old cane stubs at the base of the plant. As in rose rust, teliospores may be dispersed from leaves and adhere to the canes.

The surface of overwintering canes of cv. Malling Delight at Pen-y-ffridd Field Station[2], Bangor, was sampled by pressing adhesive tape to canes at heights of 20, 75, 110 and 160 cm from soil level, where, respectively, 199, 70, 60 and 21 teliospores/cm^2 were found. Thus, the overwintering canes may be an important source of inoculum with the teliospores well placed to eject basidiospores close to young foliage in spring.

Teliospores, on leaves stored in gauze bags suspended in a plantation during winter to complete their dormancy requirement, were used to study the effect of light and temperature on their germination and ability to produce promycelia and basidiospores on agar. In darkness at 15°C, 40% of them germinated readily to produce promycelia, of which 95% developed basidiospores after 48 hrs, but <5% germinated in light of 250, 400, 650, 1,100 and 1,800 lux. Germination occurred between 6 and 25°C, the optimum 15-17°C; between 12 and 22°C, germination began within 2 h in darkness.

Further information on resistance of red raspberry to *P. rubi-idaei* was sought after finding resistance to Scottish strains in N. American cultivars (Ann. Rep. 1981, pp.86-87). Bait plants of seven cultivars arranged in a randomised block within a rust-infected Glen Clova plantation in Grampian Region in 1981 were overwintered and the young canes produced in spring 1982 were assessed for resistance at the aeciospore and teliospore stages. An identical set of bait plants were wintered in a rust-infected plantation of Malling Delight at Pen-y-ffridd and their infection studied to the urediniospore stage.

The N. American cultivars Latham, Chief and Boyne were completely resistant at all stages of the rust life cycle and Meeker was very resistant at both sites. In June at the aecial stage at the Scottish site, Malling Jewel was more severely infected (12.6 aecia/leaf) than Glen Clova or Malling Delight (8.9 and 5.1 aecia/leaf respectively) but at the teliospore

[1]Agriculture Canada, British Columbia.
[2]University College of North Wales.

stage in October the ranking of cultivars for infection reversed, Malling Delight and Glen Clova being more severely affected (21.0 and 8.7 teliosori/cm^2 leaf) than Malling Jewel (1.1 teliosori/cm^2).

At Pen-y-ffridd the bait plants were assessed weekly during the aeciospore and urediniospore stages. Aecia were observed first on 15 April on the upper surface of leaves, their rate of development was similar on Malling Delight, Glen Clova and Malling Jewel. However, aecia were not observed on Meeker until 12 July and the infection was slight whereas it was then at its maximum on Malling Delight, Glen Clova and Malling Jewel. Uredinia first appeared in mid-July in Malling Delight, Glen Clova and Malling Jewel with 42, 27 and 1% leaves infected but only 1% of leaves of Meeker were infected by 21 July. Infection continued to increase and by 18 September 96 and 91% of leaves of Glen Clova and Malling Delight had uredinia but there was only 56 and 13% infection on Malling Jewel and Meeker respectively.

The results from bait plants suggest that a resistance mechanism operates in Malling Jewel after the aecial stage which may explain why Malling Jewel has never been severely attacked in commercial plantations.

(Vivienne M. Anthony, B. Williamson)

Clathridium corticola *on blackberry.*

The thornless blackberry selection 126RA8 showed conspicuous silver lesions with a chestnut brown margin at the nodes in May 1982 following severe winter injury that killed the canes. The fungus *Clathridium corticola* (conidial state *Coryneopsis rubi*) (IMI 268825) was isolated from erumpent black acervuli formed on the silvered epidermis.

(B. Williamson)

Raspberry root disorders.

(a) *Contamination of raspberry root stocks by* Thielaviopsis basicola.

Samples of compost containing roots and taken from containers in which mother plants of cv. Glen Clova were growing in the glasshouse, were infected with the black rot fungus *T. basicola* (Ann. Rep. 1981, p.89). Refrigerated roots stored prior to propagation, and compost surrounding root stocks of ten different clones of Glen Clova derived from four mother plants, and roots of ten clones from seven cv. Malling Jewel plants and one clone from a cv. Malling Promise mother plant, were tested for infection using carrot baits. Each compost sample was distributed between five petri dishes, moistened, and ten sterile carrot discs buried in each dish. After 7 days incubation at room temperature the 50 bait discs were washed, transferred to dishes containing moist filter paper, five discs to each dish and the number that developed typical black chlamydospores recorded after a further 4-7 days incubation.

All Glen Clova material was found to be infected; four clones from stock 207 were severely contaminated the number of infected baits ranging from 30-40; compost from a further two stocks (111F and 103B2) each caused 30 of 50 infections and for samples from the remaining stocks the numbers ranged from 3-23. No infection was detected in the Malling Promise sample and only 2 of the 10 stocks of Malling Jewel were slightly affected with 1 (stock 202C) and 10 (stock 204A2) discs infected.

Despite the high populations of *T. basicola* apparently present in many samples of compost the roots themselves appeared healthy.

(b) *Effect of* T. basicola *on growth of raspberry plants.*

The results cited above and those of experiments in two previous years demonstrated that all stocks of Glen Clova examined are contaminated by *T. basicola,* and previous attempts to demonstrate pathogenicity of the fungus were invalidated because, not surprisingly, control plants were also infected. Root stocks of Glen Clova were therefore surface sterilised in 0.1% HgCl before use to propagated shoots which were then potted in steam sterilized compost to produce plants for further study. Negative results from attempts to culture the fungus from samples of the mercury dipped roots showed that the treatment had been effective. Twenty young plants were inoculated with *T. basicola* by pouring conidial suspensions on to the surface of the compost in each pot and corresponding quantities of sterile water were added to the control plants; the latter were separated from the former by a distance of not less than 5 m. After 5 days the dispersion of the inoculum through the root system was checked using samples of compost taken from the drainage holes of 10 pots chosen at random, together with parallel samples from the uninoculated plots, and these were tested with carrot bait discs. The inoculated pot samples induced characteristic black rots with chlamydospores but no evidence of *T. basicola* was found on discs from the control plots.

The height of the canes was measured at weekly intervals on 6 dates following inocuation, the plants harvested after 7 wk and the fresh weights of the roots recorded. Ten root samples from each of 10 random plants in each treatment were tested for infection using carrot baits and 99 of 100 and only 1 of 100 from the infested and non-infested plants respectively developed black rot. However, no black rot symptoms were observed on the root systems of the inoculated plants and neither cane height nor root weight were significantly affected by inoculation.

Although *T. basicola* is known as a serious root pathogen on a wide range of crops it appears to be little more than a benign surface coloniser of raspberry roots with a particular affinity for cv. Glen Clova which when infected remains apparently healthy and grows as well as uninfested plants.

(c) *Effect of temperature on growth of* T. basicola in vitro.

T. basicola is pathogenic on plants usually cultivated in warm rather than temperate climates but it is apparently well adapted locally to the raspberry.

To test the possibility that local isolates might be variants with lower-than-normal temperature optima than that characteristic for the species elsewhere, *T. basicola* was isolated, using carrot baits, from refrigerated compost around roots of two stocks of Glen Clova. The cultures were transferred to V8-juice agar in petri dishes and their growth rates determined when incubated at 15, 20, 25 and 30°C. The two isolates were morphologically identical and both grew fastest at 25°C. Growth at 30°C became self-restricting, presumably because of staling products, the colonies extending no further than two-thirds of the diameter of the plates. Growth was slow but constant at 15°C and after 9 days exceeded that of the other temperature treatments presumably due to lower concentrations of staling products in the agar.

A growth optimum of *ca.* 25°C is similar to that reported in the literature so that the raspberry strains examined are not atypical of the species. The results also show that moderately cool conditions should not inhibit the spread of the fungus on root systems.

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

02022 *Harvest disorders of soft fruit.*

Effect of fungicide sprays on infection of raspberry fruits and flower by Botrytis cinerea.

The best control of *B. cinerea* in raspberry cv. Malling Jewel as assessed by isolating and culturing the fungus, was obtained by dichlofluanid sprays applied early rather than late during the period of fruit development (Ann. Rep. 1981, p.89). This year two spray programmes were tested each based on between one and six applications applied at approximately 5 day intervals starting at flower-opening on 4 June and ending on 30 June, 1 week before the berries ripened with picking commencing on 7 July. The method of tagging flowers, sampling fruit and culturing on agar were all similar to those described previously (Ann. Rep. 1981, p.89).

In the first programme the treatments provided increasing intervals between the final spray and harvest by stopping spraying after either the first, second, third, fourth or fifth application. The increasing intervals resulted in corresponding increases in the incidence of *B. cinerea* ranging from 11% in berries from canes which had received six sprays to 34% for canes which had been sprayed only once, 5 wk before harvest. The incidence in the control unsprayed fruits was 96% indicating that either a single spray substantially decreases effective fungal inoculum and/or that residues may persist to provide some protection to the maturing berries.

The first spray, applied at the open flower stage, was probably effective in preventing the cryptic infection found to occur in spent stamens, their filaments and those of the styles.

The persistence of dichlofluanid during the later part of the fruiting season when levels of airborne inoculum became high because of the presence of moribund fruit, was estimated by measuring the level of *B. cinerea* incidence in a second sample of ripe fruit picked from the six-spray plot 2 wk after the first harvest. These fruit would have received their first spray at the tight-closed bud stage rather than at flowering and their last spray during the mid-green fruit stage. Although the incidence at 43% was a marked increase over the 11% noted above it was still an improvement over the effective 100% incidence found in fruits from unsprayed canes.

The second spray programme was a mirror image of the first. Again, fruit received either six, five, four, three, two or one sprays only by successively delaying the date of the first spray in each treatment. The greater the interval before the first spray the higher the incidence of *B. cinerea* in the ripe berries ranging, again, from 11% where canes received six sprays to 65% in fruit which had had a single spray 1 week before harvest. The relatively high incidence of 65% reflects the inaccessibility of cryptic infection established not only in the spent anthers, their filaments and those of the styles but also in the collar tissue sited at the base of the anther filaments at the top of the fruit. Three sprays before harvest gave an incidence of 38% similar to that achieved in the other programme by a single spray at flowering emphasising the importance of early control of inoculum sources and infection.

Effect of dichlofluanid on the level of cryptic infection by B. cinerea *in green fruit.*

During the two spray programmes reported above intermediate samples of young developing fruit were picked to assess the level of *B. cinerea* infection in flowers and young fruit at the time of spray applications. Twenty green fruit from each of the 12 treatment plots were picked immediately before the second, fourth and sixth spray applications, surface sterilized and cultured on agar. Only 22% were infected at the petal drop stage when the first spray application was due but 80% of the green fruit were infected by the time the last spray was due and by harvest, 1 week later, the incidence in ripe fruit was 65%. The effect of the final spray therefore was to reduce incidence by 15%. Following a single early spray the amount of infected fruit was 9% after 5 days, 25% after 14 days, 25% after 26 days and 34% after 37 days when the fruit was ripe. Fruit picked from unsprayed canes on the same dates had levels of 22, 63, 80 and 96% respectively demonstrating the rapid build-up of *B. cinerea* population and infection levels. As expected, the incidence of *B. cinerea* in intermediate samples receiving more than one spray was

inversely proportional to the number of sprays, the decrease being greater in the earlier rather than later sprayed fruit samples.

Effect of dichlofluanid on the incidence of Cladosporium herbarum *in green fruit.*

The incidence of *C. herbarum,* a saprophyte often associated with post-harvest decay, was consistently over 90% in surface sterlized fruit samples collected from unsprayed canes. Even very young, green fruit picked early in the season showed similar levels of incidence and there was no evidence that these poulations of *C. herbarum* on and in the fruit had any inhibitory or associative effect with *B. cinerea* infection. Following various fungicide spray programmes the patterns of incidence and their alterations were similar to those found for *B. cinerea,* but because of its ubiquity the incidence of *C. herbarum* never fell below 50%. Again, a single spray applied early was more effective rather than those applied late and increasing the spray frequency proportionately decreased the incidence of *C. herbarum* in green fruit. Its incidence in ripe fruit was not recorded.

Site of B. cinerea *infection in ripe fruit.*

Fruit samples collected between 7-12 July, developing from flowers tagged on 3 June, were surface sterilized and aseptically separated into druplet shells and plugs before being cultured on plates. The plug included the attached collar of sepals and withered stamens and their filaments. Of the unsprayed berries, 96% were infected and there was also 96% infection of the core tissue and 50% of the shells. In contrast 42% of the cores and 65% of the shells of sprayed fruits yielded botrytis. In further samples of fruit in which the shell, plug and husk (sepals plus stamens) were plated separately, all berries from unsprayed plots yielded *B. cinerea* from some part and 88, 86 and 12% of the shells, husks and plugs respectively were infected indicating that the plugs *per se* tend to remain free of infection. Of samples picked from the six-spray plots there was 46% overall infection with 40 and 18% in the shells and husks respectively and only 1% for the plugs demonstrating again not only the relative innocuousness of the plug as a potential source of infection of the husk but the importance of the collar tissue as a potential source of infection and fungicide spray target.

Relationship between cryptic B. cinerea *infection and post-harvest decay.*

The efficacy of fungicide sprays in 1981 and 1982 were assessed by examining their effects on cryptic infection after surface sterilizing fruit to remove superficial infection; this was done to reduce within-treatment variability by eliminating chance concentrations of surface inoculum. However, commercial assessment of the effectiveness of fungicides, spray programmes, method of application and cultivar resistance is simply the

extent of post-harvest decay in ripe fruits and it was necessary to relate this to figures obtained by isolation techniques.

Berries harvested on 12 and 21 July were placed without surface-sterilization on damp cotton wool in individual cavities in plastic trays, enclosed in polythene and stored in diffuse light at room temperature (22-25°C) until they decayed. The level of decay so induced in the first harvested sample was much higher than the incidence of infection estimated from isolation techniques. The effect of increasing the frequency of successive sprays was to decrease the proportion of decayed fruit (80-95% following one spray; 18-42% following six successive sprays) but the results were variable and did not correlate with the incidence detected by culture. When the single spray was applied late in the season, 80% of the fruits could be induced to rot as opposed to 95% of the unsprayed fruit, whereas for fruit sprayed once and early the induced incidence at 95% was as high as that in the control. Corresponding samples which were cultured gave incidences of 65% for the late spray and 34% for the early sprays but a similar incidence, 96% for unsprayed fruit. The apparent reversal of results points to a rapid build-up of surface inoculum following spraying, that that build-up was not affected by persistence of spray residues, that it was not measured using cultural techniques, and that it was probably responsible for inducing as much if not more post-harvest decay than any established cryptic infection. The results emphasise the importance of a late pre-harvest spray. Results from the second fruit harvest did not give comparable results owing to relatively high levels of *Rhizopus* spp. inducing decay during the whole fruit incubation period. Nevertheless, it was still evident that spraying had some effect in reducing decay and, despite its ubiquity, *C. herbarum* was never apparent on the decaying fruit.

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

02005 *Analysis of and screening for resistance to diseases of soft fruit. Red core of Strawberry.*

The measurement of the depression in yield and berry size due to disease in three pairs of cultivars susceptible, moderately susceptible, and slightly susceptible to root infection (determined by standardised tests in a controlled environment) was continued for the third year in plots of single plant rows.

As in previous years, there was no indication, on the basis of annual results, that factors other than susceptibility were involved in the depression in yield as both cultivars in each category showed similar percentage decreases. However, there was a substantial difference in the berry size of cultivars in the susceptible category, the decrease in Cambridge Favourite (65%) being almost twice that in Redgauntlet (34%).

The frequency of isolates of *Phytophthora fragariae* with high virulence to Saladin, a resistant cultivar recently introduced to commercial cultivation, was investigated using an improved method of isolating the pathogen from field samples. Isolates obtained in 1981 from young runners in plots of Saladin or Cambridge Favourite planted in 1979 at SCRI, Invergowrie were evaluated in standardised tests in a controlled environment. Fourteen out of 28 isolates from Saladin and three out of 29 from Cambridge Favourite were highly virulent to Saladin.

(Isabel G. Montgomerie, Diana M. Kennedy)

As the need for identification became less frequent, the maintenance of stocks of nine differential cultivars used to characterise physiological races, either in the glasshouse or as micropropagated clones derived from meristems, was wasteful of space and labour. The feasibility of decreasing the frequency of transferring micropropagated clones was investigated by storage at 5°C in nutrient agar (Murashige & Skoog) containing 2, 4, 6 and 8% sucrose. After 25 weeks, the single plant cultures were transferred to 26°C for 10 weeks when the numbers of plantlets generated were determined. Similar numbers were produced in agar containing 2, 4 or 6% sucrose but significantly fewer were formed in agar containing 8% sucrose. Contrary to results obtained by other workers who found that cold storage required higher levels of sugar, strawberry plantlets in agar containing 6 to 8% sucrose were necrotic and unsuitable for further propagation.

(Isabel G. Montgomerie, Alison M. Campbell)

Verticillium *wilt of strawberry.*

Three breeder's selections were assessed in the glasshouse for susceptibility to *Verticillium* wilt (*V. dahliae* and *V. albo atrum*) together with the susceptible cultivar Cambridge Vigour and the tolerant cultivars Redgauntlet and Talisman. 69GU76 was as susceptible as Cambridge Vigour, 71ED30 was as tolerant as Redgauntlet and 69EW30 gave an intermediate response.

(Diana M. Kennedy)

Verticillium *wilt of raspberry.*

In further screening tests to evaluate the susceptibility of *Rubus* genotypes to *Verticillium dahliae,* a mycelial slurry and a conidial suspension were used separately to infect plants, and susceptibility was assessed by measuring the percentage length of cane with wilted leaves. The black raspberry cultivars ranked higher in susceptibility than the red raspberry cultivars and a black x raspberry cross included in one test was intermediate.

(Diana M. Kennedy)

02019 *Gangrene, blackleg and soft rot and contamination of VTSC seed potato stocks.*

Blackleg etiology: field studies.

The relative susceptibility to blackleg of six cultivars, in addition to the 12 tested in 1981 (Ann. Rep. 1981, p. 91), was examined in replicated plots each planted with 90 seed tubers inoculated by vacuum infiltration in suspensions containing 10^3 or 10^6 cells/ml of Eca. The average blackleg incidence rose from 0.9% in early July to 4.8% in early August after which little further increase occurred. Mean disease incidence was six times less than in 1981 and was associated with below average rainfall during May to September which was about a third less than in the previous year. Seed tubers inoculated with low and high cell concentrations produced 0.8 and 10.1% diseased plants respectively in September. Seed with the high inoculum level yielded 20% less than those with the low inoculum level irrespective of the blackleg incidence.

With the exception of Wilja, the relative susceptibility of the 12 cultivars tested in 1981 was confirmed. Although susceptibility groups could not be as clearly defined as before because of the lower disease levels, the 18 cultivars could be divided into three groups based on the percentage of diseased plants grown from seed inoculated with the higher number of bacteria. Cultivars Pentland Crown, Wilja, Pentland Squire, Pentland Dell, Maris Piper, Pentland Javelin, and Desiree were classed as resistant with 0 to 2.6% diseased plants, cultivars Guardian, Pentland Hawk, Cara, Record, Pentland Lustre, and Pentland Raven were intermediate (4.2 to 11.6%) and cultivars King Edward, Maris Bard, Bintje and Estima were susceptible (17.4 to 32.1%). Most cultivars were consistently resistant or susceptible but the ranking of others was variable possibly because their resistance was affected by environmental factors. For example, the unexpected classification of cultivars such as King Edward (reported to be resistant) as susceptible and Wilja as resistant may be explained in terms of their reactions to water stress. Thus, plants of Wilja became senescent very early, while those of King Edward were still green in September possibly biaising disease expression.

(M. C. M. Pérombelon, R. Lowe)

Sources and pathways of contamination by E. carotovora.

Field plots of 12 micropropagated plants of cv. Desiree were sprayed weekly with 250 ml streptomycin solution containing 0.2 g/l a.i., commencing at the end of either June, July or August. The presence of *E. carotovora* on leaves, progeny tubers and in rhizospheres was determined by enrichment techniques. The bacteria were detected in soil and on tubers in mid August irrespective of the spraying regime but they were not detected on leaves until mid-September when the haulm of a potato crop in the same field was pulverised. Streptomycin treatment had no effect on leaf or rhizosphere populations but tubers of plants which

had been sprayed from July were less contaminated than those from plants sprayed later.

The relative contributions of mother tubers and leaves to contamination of progeny tubers was examined using different antibiotic marker strains of *E. carotovora* inoculated in tubers partially rotted before burial at tuber level in July and sprayed on leaves in August and September. Contamination of the leaves, rhizosphere soil and progeny tubers by *E. carotovora* was followed by sampling every 10 days starting in early August and the bacteria (marker strains and wildtypes) identified. Leaves from plants sprayed with bacteria remained contaminated until the end of the growing season and those of non-sprayed plants were not contaminated until September when *ca.* 75% of the isolates were of the wild type. Because of the prolonged dry summer the inoculated placement tubers failed to decay further and bacteria were not detected on the progeny tubers. *E. carotovora* was not detected in the soil in July but later in August the leaf marker strain was found to predominate in leaf sprayed plots and wild type erwinias in non-sprayed plots. Contamination of progeny tubers became widespread in September and was greater in sprayed than in non-sprayed plots. The occurrence of leaf marker strain and wild type was similar to that found on leaves and soil.

An investigation on the effect of spraying leaves with bactericidal chemicals on leaf and progeny tuber contamination was continued (Ann. Rep. 1981, p.83). Copper oxychloride (Cuprokylt, Universal Crop Protection Ltd.) or an experimental bactericide (CGA 78039, Ciba-Geigy Ltd.) were sprayed at a concentration of 1.6 g/l and 5.0 g/l respectively at the rate of 250 ml per 12 erwinia-free micropropagated plants every 2 weeks starting in August by which time both the rhizosphere soil and progeny tubers were already contaminated. The level of tuber contamination was not thereafter affected by the treatments. Although erwinias were not detected on the leaves when spraying started, they were found in September and for the rest of the growing season irrespective of treatments. The retention and efficiency of the chemicals was probably too low at the frequency of application used compared with the twice weekly rate in 1981 and which, moreover, was commenced 4 wk earlier. When Cuprokylt and Fubol 58WP – the latter is non-toxic to erwinias – were applied by a farmer to his crops, starting at an early date on 1 July, and thereafter on 8 and 23 July and 9 August, the contamination level of progeny tubers from plants sprayed with Cuprokylt was lower than that from plots sprayed with Fubol when examined on 19 August prior to harvest.

(J. G. Elphinstone, M. C. M. Pérombelon)

Contamination of VTSC stocks by E. carotovora.

The annual survey of VTSC stocks in the process of multiplication was continued on three commercial farms. The average tuber contamination

of clones/stocks in their first three multiplication years ranged between 24 to 34% and 90% in later multiplication years on two farms, whereas it was 25% throughout the five multiplication years on the third farm. Contamination of clones of a given stock often varied from being high to undetectable. On two of the farms Ecc predominated over Eca by 2 to 3:1 and was infrequent on the third.

The test used to detect tuber contamination is very sensitive but it is difficult to obtain a representative sample of tubers. Because it can determine only the presence or absence of the pathogen, it cannot be used to assess the likelihood of tuber decay in storage or of the incidence of blackleg which may develop in the field. An attempt is being made to develop a quantitative technique to process replicated lots of 10-15 tubers rapidly using a commercial potato peeler.

(M. C. M. Pérombelon, Lizabeth J. Hyman)

A comparative study of blackleg epidemiology in Scotland and in Israel.

A joint project was initiated in 1981 with support from the Potato Marketing Board, between SCRI and the Volcani Center, Israel, to study blackleg epidemiology in crops grown at SCRI, Invergowrie, and in Israel in the spring and autumn cropping seasons. About 1.5 tonnes of VTSC grade of cv. Desiree and cv. Pentland Crown known to be free of *E. carotovora* were inoculated with suspensions of Ecc and Eca by vacuum infiltration soon after harvest in September 1981. Some of the seed were retained at Invergowrie and planted in April 1982 and the rest was shipped to Israel and planted in February 1982 in two different climatic conditions at Gilat and Bet Shean Experimental Stations. Blanking or non-emergence in plots of Pentland Crown planted with inoculated seed was 20% at Bet Shean, which has a hot dry climate, and 5% at Gilat which is less hot and more moist. Desiree was not affected and emergence of both cultivars was complete at Invergowrie. Blackleg incidence in Desiree and Pentland Crown in Israel was twice and eight times respectively that observed at Invergowrie, reversing the ranking normally observed in Scotland. More disease was caused by Eca than by Ecc in both countries.

Daughter tuber contamination did not occur at Invergowrie during the growing season probably because the very dry soil conditions inhibited decay of mother tubers. In contrast, mother tubers rotted quickly and the progeny tubers were contaminated throughout the growing season at both sites in Israel. The numbers of erwinias per tuber were *ca.* 10^3 less than those on the seed tubers and may have originated not only from the mother tubers but also from the irrigation water, applied twice a week, which frequently contained 10^3 to 10^6 erwinias/l. Most of the isolates obtained from irrigation water were Ecc but *E. chrysanthemi* was also present.

When progeny tubers from this experiment were planted in August at Gilat and in October at Bet Shean blackleg was absent. Blanking level was low except in Pentland Crown at Gilat when it was 7.5% and was attributed to failure of the eyes to sprout. Stem density was lower than in the spring crops and Pentland Crown crops at Gilat were poorest with a stem population of <2 per plant.

(V. M. Lumb, M. C. M. Pérombelon)

09029 *Study mechanisms of quantitative resistance to potato late blight and identify resistant parental material.*

In studies with scanning electron microscope (SEM) the hyphae of *Phytophthora infestans* observed in potato leaf tissue were all intercellular. However, abundant haustoria were formed by some isolates in the mesophyll cells of certain clones but not in others. It was noted that this formation of haustoria was always associated with clones known to have a high level of field resistance.

The SEM studies revealed that few sporangia adhered to the leaf surface of some resistant clones while on others many sporangia adhered and released zoospores but the latter were slow to encyst and germinate compared with those on fully susceptible clones.

The presence of cells filled with crystals were an interesting feature of the mesophyll of potato leaves revealed by the SEM. These cells appeared to have a regular distribution, they occurred adjacent to the palisade and they were present in old, young, healthy and blighted leaves of several clones. When examined by X-ray microanalysis they were shown to have a high Ca content. Similar analysis of crystals which occur in the pores of marginal stomata of leaves showed a high K content.

(Jean F. Malcolmson)

PLANT PROTECTION

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

Raspberry yellow rust reduced by vigour control and biennial cropping.

Compared with infection levels of young canes on untreated plots, removal of the first flush of young canes by spraying dinoseb-in-oil or by cutting, substantially reduced infection of replacement canes by *Phragmidium rubi-idaei* at the aecial stage and substantiated general observations that rust was less serious in commercial plantings of Glen Clova (Ann. Rep. 1981, pp.93-94) where cane vigour had been controlled with dinoseb-in-oil.

The effect of time of removal of the first flush of young canes on rust infection was studied in Malling Delight at Pen-y-ffridd Field Station[1], Bangor, and in Fife, Scotland. Young canes were cut at both sites when

[1]University College of North Wales

10, 20 and 60 cm tall. Cutting young canes at Pen-y-ffridd at 20 cm reduced infection at the aecial stage from 8.2 aecia/cane in controls to 3.6 on replacement canes. In Fife, the same treatment did not reduce infection. However, on both sites after canes had been cut at 60 cm infection was reduced markedly (86% of canes infected in controls to 6% in Fife; 100 to 19% infected canes at Pen-y-ffridd).

The biennial cropping system for raspberry management requires that in the vegetative phase only young canes are present and in the following fruiting year their growth is discouraged by removing several flushes of cane to prevent competition. Teliospores of *P. Rubi-idaei* have been shown to overwinter on fruiting canes, but the viability and infectivity of these spores and their relative contribution to the inoculum received by young canes was unknown. A biennial cropping treatment was therefore included in the rust trials; all fruiting canes and old cane stubs were removed at Pen-y-ffridd and four flushes of young canes were removed on 22 April, 7 and 25 May and 11 June in Fife. At Pen-y-ffridd fewer young canes were affected by rust at the aecial stage on plots where all fruiting canes were removed than in the controls. However, infection of lateral shoots on fruiting canes was no less than on controls in plots where young canes had been removed throughout spring. These results emphasise the role of overwintering canes as sources of inoculum for cane and foliage diseases and indicate the benefits which might accrue from biennial cropping for control of diseases.

(Vivienne M. Anthony, B. Williamson)

Chemical control of cane blight.

Benomyl has been the most efficient fungicide for control of cane blight (*Leptosphaeria coniothyrium*) in machine-harvested raspberries. It has increased yields in a heavily infected plantation of cv. Malling Jewel when sprayed once pre- plus twice post-harvest (SHRI Ann. Rep. 1980, p.86) or in mixed programmes with triforine or triadimefon (Ann. Rep. 1981, pp.94-95).

Benomyl was applied in 1981 on four spray dates in various combinations to give five programmes which might indicate the time during machine-harvesting when sprays may be most effective; pre-harvest (16 July), mid-harvest (24 July) and post-harvest on 7 and 26 August. A non-benomyl control was included. All plots were sprayed during the blossom period with dichlofluanid, a contact fungicide which has not increased yields by controlling cane blight. A random sample of 20 canes per plot were assessed for vascular lesions between 27 January and 5 February 1982 after dead, broken and small canes had been removed and potential fruiting canes 'tied-in.' The proportion of dead fruiting canes was assessed on 19 May.

The catching-plates of the Littau harvester wounded *ca.* 60% of canes and *ca.* 49% of wounded canes were infected in the non-benomyl

control plots. The flexible beater bars wounded canes rarely and infection of bar wounds was negligible. The incidence of vascular lesions at plate wounds was not reduced significantly by any benomyl programme but girdling of canes by lesions was significantly less than the control after the full four-spray programme.

To assess if the apparent failure of benomyl to control cane blight may have been due to the appearance of benomyl-tolerant strains of *L. coniothyrium* after four years' trials on this site spores from benomyl-treated plots were spread on 2% malt extract agar containing 8, 40, 200 and 1,000 ppm benomyl made from the same batch of fungicide used to spray plots in 1981. No tolerant strains were found.

(B. Williamson)

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

The interaction of disease severity and yield was studied for the second year in cv. Cambridge Favourite in single plant rows. Differences in disease severity (% number of diseaed roots) in April between metalaxyl treatments were again non-significant but some differences in yield were significant. Plots which received a total of 2.81 kg a.i./ha in band sprays applied in August, November and February produced significantly more fruit than those which received a single spray with 0.625 kg a.i./ha in September. However, the difference between the three spray treatment and a single spray with 1.25 kg a.i./ha in September was non-significant. There were no significant differences in either disease control or yield between sprays containing 0.025 or 0.05% a.i. metalaxyl. The rank order of treatments for decreasing disease severity did not reflect their rank order for increasing plant size and yield as in the first year but increased plant size in June was associated with increased yield and berry size in July.

In another experiment on Cambridge Favourite planted in April 1981, a band spray of fosetyl-Al (LS 74 783) in March 1982 in addition to a spray in September 1981 did not decrease the proportion of main roots which were diseased in May 1982. Although total yield and berry size were both greater than in the single spray plots these increases were not significant. A fungicide containing a mixture of metalaxyl (10% a.i.) and mancozeb (48% a.i.) applied as a band spray containing 0.05% a.i. metalaxyl significantly decreased disease severity and inceased yield and berry size. Captafol applied at a rate of 2,500 l/ha containing 0.6% a.i. was not phytotoxic and disease control and yield were similar to those in plots sprayed at the recommended rate of 7,500 l/ha containing 0.2% a.i. Nitrochalk applied in March 1982 at 100 kg/ha had no effect on the proportion of main roots which were diseased in plants lifted in May but total yield and berry size were consistently greater than from untreated plots though the increases were not statistically significant.

Pre-plant root soaks for 4 h in fosetyl-Al have been accompanied by a range of symptoms varying from zero to 5% plant mortality in field experiments planted in the spring. Phytotoxicity was eliminated by decreasing the concentration from 0.3 to 0.2% a.i. but this reduced efficacy. The interaction of treatment (0.3% a.i. fosetyl-Al) with plant size and post-planting environment was examined when small, medium and large runners of Cambridge Favourite were planted in April 1982 either in the field or in pots of compost in an unheated glasshouse. Treatments consisted of soaking roots for 0, 0.25, 0.5, 1.0, 4.0 h; totally immersing plants for 1 h; or applying a band spray as soon as plants were established.

Six per cent of plants in the field and 12% of those in the glasshouse eventually died but neither size nor treatment had a significant effect on mortality. Plants which survived in the field grew larger after treatment with fosetyl-Al but in the glasshouse those soaked for 0.5 and 4.0 h were smaller than untreated plants. Four months after planting the effectiveness of any residual fungicide was tested by drenching each plant *in situ* with a zoospore suspension. After 14 days incubation there were no significant differences in disease severity between initial plant sizes or between treatments in the field. In the glasshouse, the large plants were less severely diseased than the small or medium ones and these differences were significant. This may have been due to a greater uptake of chemical or to more roots having aged and become less susceptible in the larger plants.

(Isabel G. Montgomerie, Diana M. Kennedy)

Biological control.

Actinomycetes which had decreased the severity of red core when incorporated into a peat/sand compost in a controlled environment were multiplied on sterilised maize and added to planting holes in the field in April 1981. When plants were lifted 1 year later there was no significant difference in disease severity between treated and untreated plants although fungicides decreased it in the same infested site.

(Isabel G. Montgomerie, Diana M. Kennedy)

02020 *Development of histological and histochemical techniques.*

The embedding compound LR White Resin is now available in three hardness grades and investigations have continued into its suitability for use in routine sectioning where fine detail is required. The soft grade has greatly reduced problems of wrinkling and curling both during sectioning and mounting, but fixation still causes problems because of slow penetration in large pieces of tissue. Promising results have been obtained by checking the purity of glutaraldehyde and increasing its concentration to 6% in Pipes buffer whilst holding the specimens at −18°C for 7-10 days. Problems of static electricity and curling when

sectioning with glass knives can be successfully reduced by coating knife edges with PTFE applied from an aerosol spray and then cutting sections dry. A heavy microtome (e.g. Reichert-Jung, 1140 Autocut) is superior to a lightweight model and better sections can be cut manually compared to those cut with the microtome on automatic action. An acetone-based floating solution, with a proprietary surfactant such as Photoflood enhances the flatness and gives more uniform spread of sections on the slide.

Barley seeds present a continuing challenge because of peripheral wrinkling due, in part, to the rapid absorption of water by the endosperm from the flotation solutions that results in uneven expansion of the section. However, this effect can be reduced by using clove oil as the final stain solvent and excellent detail was seen in sections cut at 1.5 μ.

Most of the published staining schedules for plant tissue can be used with IR White Resin which does not absorb most stains although certain triphenyl-methane dyes have an affinity for it, but this property can be used to advantage as an indicator of resin penetration into the sectioned tissue and to facilitate negative staining for interference microscopy. When used in LR embedded tissues, Coomassie Brilliant Blue in acidified solution has proved excellent for rapid identification of plasmodesmata, middle lamellae and other cell wall connections. Simple histochemical tests can readily be done, and for these staining schedules ascending and descending alcohol series are not required and most schedules can be used in under 10 minutes. Piccolyte, a resin mountant, has proved to be the best of 20 commercially available mountants tested; it is clear and rapid drying and sections may be examined under oil immersion within 5 minutes of mounting. The resin has a very low autoflourescence and does not interfere with immunofluorescent labelling, vital staining of spores, or the use of fluorochromes.

(H. M. Wilson)

02021 *Immunofluorescent techniques in histology.*

Antisera for typing Erwinia carotovora *ssp.* atroseptica.

Pretreatment of cells of *Erwinia carotovora* ssp. *atroseptica* with glutaraldehyde (Ann. Rep. 1981, pp.101-2) removed undesirable reactions in rabbits, but consistently resulted in inadequate low titres that were further reduced by adsorption to remove non-specificity. Attempts to overcome this problem by concentrating antisera by polyacrylamide gel resulted in a slight improvement but necessitated using much larger quantities of serum. Glutaraldehyde pretreatment has now been discontinued in favour of using fresh, washed and sonicated cells.

(H. M. Wilson)

ZOOLOGY

D. L. TRUDGILL

A new technique of drilling granular systemic insecticides/nematicides in bands in the side of potato ridges at crop emergence was tested. Effective control of aphids was obtained with aldicarb but control of spraing in the tubers, due to tobacco rattle virus transmitted by trichodorid nematodes, was less good than that obtained with similar amounts of aldicarb applied at planting.

The tolerance of potato cultivars to damage by potato cyst nematodes (PCN) was examined in a further series of trials and Maris Piper proved relatively tolerant at all sites infested with *Globodera rostochiensis* (the species with yellow females). Cara was consistently tolerant at all sites, including those infested with *G. pallida* (the species with white females) to which it is not resistant. In contrast Pentland Dell was relatively intolerant, especially when drought stressed. Several other cultivars or clones gave more variable results, indicating that at some sites PCN damage is interacting with other factors.

Studies on the spread of potato leafroll virus (PLRV) in 1981 showed that over 70% of the spread occurred before 30 June and that relatively small numbers of aphids on the crop in June were responsible for a disproportionately large amount of PLRV spread. These results emphasise the importance of early rogueing and the value of granular insecticides applied at planting in years when the incidence of PLRV is high and aphids are expected to arrive early.

Other findings of particular interest include the conclusion that a severe, virus-like mottling of the leaves in two raspberry plantations was due to raspberry mite (*Phyllocoptes gracilis*); that some nematode species differ in their susceptibility to various nematicidal compounds, and that control using liquid fumigants can be improved by incorporating a small amount of dazomet in the soil surface; evidence that *Macrosiphum euphorbiae* may be a significant vector of PLRV; and an indication that carbohydrates may be involved in the specific retention of viruses within their nematode vectors.

NEMATOLOGY

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

Tolerance of potato cultivars to damage by potato cyst nematodes (Globodera rostochiensis *and* G. pallida).

In co-operation with the Scottish Colleges of Agriculture and ADAS, field trials have been undertaken over several years comparing the tolerance of different potato cultivars to damage by potato cyst nematodes (PCN).

In 18 such trials at sites infested with *G. rostochiensis* Maris Piper proved consistently more tolerant than Pentland Crown yielding more in untreated nematode-infested soil and producing smaller yield increases in response to nematicide treatments.

In trials at six sites infested with *G. pallida* to which Maris Piper is not resistant, the tolerance of Maris Piper was shown to be lessened; in the untreated plots it yielded less than Pentland Crown and produced yield increases as large in plots treated with the nematicide.

Of the other cultivars which have been extensively tested Pentland Dell has tended to be relatively intolerant of both species of PCN especially when drought stressed, whereas Cara has been consistently tolerant, even at sites infested with *G. pallida* to which it is not resistant.

When the results for several trials are compared there are inconsistencies with some potato cultivars. The cultivars Maris Anchor and Corsair were strikingly intolerant in a trial in 1979, a result which has not been repeated in several later trials. In three trials in 1982 the PCN resistant clone 11305 was one of the most tolerant cultivars in two and one of the least tolerant in the third. Similarly, in two trials clone A27/20 was comparatively tolerant in one and intolerant in the other. The results also reveal apparent differences between sites in the relative damage caused by PCN, and hence response to nematicide treatments. For example oxamyl (Vydate, 55 kg/ha) produced a larger increase in the yield of Pentland Dell, from 0.4 to 1.0 kg/plant, at a site moderately infested (41 eggs/g soil) than at a heavily infested site (250 eggs/g soil) where the yield increase was from 1.7 to 2.0 kg/plant.

Interpretation of the results from tolerance trials is also complicated by differences in yield potential between potato cultivars and by problems associated with the definition of tolerance. However, an analysis of recent results indicates that yield potential is as important or even more important than tolerance, in determining the yield of untreated potatoes at moderately infested sites. Therefore, in breeding new potato cultivars and selecting those to be grown on PCN infested land it seems logical to give high yield potential priority over tolerance.

(D. L. Trudgill).

*Root-knot nematodes (*Meloidogyne *spp.).*

Further experiments were made on a Scottish population of *Meloidogyne ardenensis* to determine how it is adapted to survive in our relatively cool conditions.

Studies *in vitro* demonstrated that the eggs of *M. ardenensis* were tolerant of cold conditions, hatching as readily at 5 as at 20°C. In comparison the eggs of four polulations of *M. hapla* had much higher temperature optima for hatch, ranging between 20 and 27°C.

Using tomato as a host it was shown that *M. ardenensis* and three populations of *M. hapla* had different temperature requirements for reproduction, and that temperature affected the amount of damage they caused. At 15 and 18°C *M. ardenensis* invaded and developed in tomato roots and an inoculum of 4,000 eggs per 600 g soil significantly reduced top growth. Two of the three populations of *M. hapla* that were tested did not invade tomato at 15°C and top growth was unaffected at 15 and 18°C, even in pots inoculated with 8,000 eggs. At 21 and 24°C no invasion or development of *M. ardenensis* was observed but relatively small inocula (1,000 and 2,000 eggs/600 g soil) of *M. hapla* caused significant reductions in plant growth.

The host range of *M. ardenensis* was also examined but was found to be relatively restricted and not to include any important arable crops grown in Scotland. In contrast two English populations of *M. hapla* had wide host ranges but three tomato cultivars (Rossol, Nemared and Small Fry) were found to be very resistant.

(Z. A. Stephan)

Effect of control of L. elongatus *in a grass/clover sward.*

In two field trials, treatments of dichloropropane (Telone II, 225 l/ha) decreased the pre-planting numbers of *L. Elongatus* by *ca.* 90%. However, under a good host (grass/clover) the numbers in the treated plots in the first experiment increased elevenfold to 473/200 g soil over 4 years, and five-fold to 62/200 g over 3 years in the second experiment. In the untreated plots two and threefold increases over the same periods gave means of 810 and 386 *L. elongatus*/200 g soil, for the two experiments respectively.

The higher reproduction rate in the treated plots was probably due to reduced competition, resulting from fewer nematodes and better plant growth, and to differences in the sward composition. In the first year the dry matter yield of the treated plots was increased by *ca.* 1.6 t/ha compared with the untreated, but the proportion of clover in the sward was reduced from 35% in the untreated plots to 15% in the treated plots. In the second year, the treated plots tended to yield less than the untreated, perhaps as a consequence of the differences in clover content.

(B. Boag)

The effect of *L. elongatus* on newly sown grass was also studied in pots (5×2.75 cm) which had added a range of between 0 and 64 nematodes per pot. Each treatment was replicated 20 times, 10 of which were

watered with oxamyl solution (Vydate L, 5ppm a.i.). After 44 days the initial population had been decreased 50% in the oxamyl treated pots whereas the population in the untreated pots had remained constant or slightly increased. The numbers of nematode-induced feeding galls on the grass roots were related to the inoculum level in the untreated pots but few galls were present on the oxamyl treated plants. The treatments had no effect on the growth of the grass.

(B. Boag, Irene E. Geoghegan)

Ecology of Rotylenchus robustus *and two trichodorid spp.*

An experiment was started in 1980 which examined the effect of fallowing or growing grass or Scots pine, with and without a pre-planting fumigation with dichloropropene (225 l/ha), on the numbers and distribution of *Rotylenchus robustus* and of *Trichodorus primitivus* and *Paratrichodorus pachydermus.*

After 30 months the numbers of all species in the untreated plots had remained almost constant under fallow, but had increased three- to five-fold under grass, and slightly less under Scots pine (especially the *R. robustus*). Fumigation with dichloropropene killed about 95% of the nematodes. In those plots subsequently cropped the numbers remaining after fumigation increased more rapidly than those in the unfumigated plots. However, because the initial populations in the unfumigated plots were larger, the total numbers of nematodes at 30 months were more than in treated plots.

The ratio of *T. primitivus* to *P. pachydermus* was initially 2:1 but at 30 months the proportion of *T. primitivus* had increased markedly in the fallow and grass plots although it had remained unchanged under pine.

(T. J. W. Alphey, B. Boag)

05003 *Chemical control of virus vector and other plant parasitic nematodes.*

Combined liquid and solid fumigants for the control of soil inhabiting nematodes.

The products available for controlling nematodes by soil fumigation include liquids such as dichloropropene (Telone II) and metham sodium (Vond Metam), and prills such as dazomet (Basamid). The liquid fumigants are injected at depth (12-20 cm) and release a toxic gas which diffuses through the soil. At the soil surface, where the gas escapes to the atmosphere the concentration is frequently insufficient to give good nematode control. A study was therefore made to determine whether the effectiveness of a liquid fumigant, injected by a Rumptstad Combiject, could be improved by incorporating a small amount of dazomet into the upper layer of the soil.

The dazomet was applied at 0, 12.5, 25, 50 and 100 kg/ha broadcast on to the soil surface immediately prior to the injection of metham sodium (Vond Metam, 300 l/ha). An adjacent area was treated with dichloropropene (Telone II, 225 l/ha) together with surface applied dazomet (50 kg/ha). Examination of the effect of the various treatments 30 wk after fumigation showed that the numbers of migratory nematodes between 0 and 40 cm depth were decreased by all treatments. In comparison with the pre-treatment numbers, the largest decrease (98%) was produced in the dichloropropene + dazomet plots. In plots treated with metham sodium alone the control was poor (31%), probably due to the soil being too cold and wet at the time of treatment. The addition of dazomet at 12.5 kg/ha failed to improve control by metham sodium, whereas dazomet at 25, 50 and 100 kg/ha significantly and progressively enhanced control, reducing nematode numbers by 67, 68 and 84% respectively.

(T. J. W. Alphey)

Control of TRV spraing in potato by aldicarb applied as a side dressing.

Aldicarb (Temik 10G) applied at planting controls spraing disease of potato tubers caused by tobacco rattle virus transmitted by trichodorid nematodes. Aldicarb largely acts by disorganising nematode behaviour rather than by killing, and has a relatively short persistence. Consequently relatively large amounts of aldicarb have to be applied at planting to ensure that sufficient chemical is present later in the growing season to prevent the newly forming tubers being infected. An experiment was therefore made, using a newly developed side-banding machine, to test whether control could be improved by delaying the application of the aldicarb until the time of tuber intitiation.

At harvest, aldicarb (128 and 86 g/100m row) applied in the furrow at planting decreased the incidence of spraing from 74.7% in the untreated to 4.3 and 3% respectively. A lower rate (43 g/100m row) was not so effective, the incidence of spraing being 14.5%. Aldicarb applied at 70 or 35 g/100m row as two side-bands in the potato drills at tuber depth was not as effective as similar amounts applied at planting, the incidence of spraing at harvest being decreased only to 17.6 and 38.8% respectively. These results point to the importance of thorough mixing of the aldicarb into the soil for maximum effectiveness.

(T. J. W. Alphey)

Differential effectiveness of nematicides.

Field studies have indicated that some nematode species may differ in their susceptibility to some nematicidal chemicals. This was tested in a replicated pot experiment using different soils, predominantly infested with *Longidorus elongatus, Rotylenchus robustus, Pratylenchus crenatus* or a mixture of *Trichodorus cylindricus* and *T. similis.*

Four chemicals were tested, each being incorporated into the soil immediately prior to planting a ryegrass/clover mixture. In pots sampled 22 and 66 wk after treatment *P. crenatus* was found to have been controlled by aldicarb (Temik 10G, applied at field-equivalent rate of 34 kg/ha) and oxamyl (Vydate, 56 kg/ha) but not by benomyl (Benlate, 45 kg/ha), and with quintozene (Botrilex, 448 kg/ha) the numbers increased. Good control of *L. elongatus* was obtained at 22 wk with all chemicals but only quintozene prevented numbers increasing between 22 and 66 wk. The numbers of *R. robustus* after 22 wk were decreased by oxamyl and quintozene but again only quintozene prevented numbers increasing after 66 wk. In the soil infested with the trichodorid nematodes only aldicarb decreased their numbers 22 wk after treatment but after 66 wk numbers in the aldicarb and the quintozene treatments were significantly less than in the untreated controls. Trichodorid numbers in benomyl treatments increased between 22 and 66 wk. A significant ($P = 0.001$) interaction between chemicals and nematode species was found.

(T. J. W. Alphey)

Effect of rotary cultivation on plant parasitic nematodes.

It has long been known that the numbers of some species of nematodes (especially trichodorids) are decreased by cultivation. To learn more about this the effect of rotavation on the populations of migratory plant parasitic nematodes was studied at two sites in eastern Scotland.

The results showed that rotary cultivations did not greatly reduce nematode numbers until they had been repeated several times. When this was done the numbers of most species were reduced and differences were observed between species in their survival. The species, and the percentage of the original population to survive 16 passes of a rotary cultivator were: *Pratylenchus neglectus* (64%), *Rotylenchus goodeyi* (41%), *Paratylenchus microdorus* (40%), *R. robustus* (28%), *Longidorus elongatus* (18%) and trichodorid spp. (9%). Some plots were irrigated prior to rotavation but this had no significant effect on the numbers of nematodes killed except at one site where it enhanced the kill of trichodorid species.

(B. Boag, Irene E. Geoghegan)

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

Total reproductive capacity and longevity of individual female Xiphinema diversicaudatum.

In the field, populations of *X. diversicaudatum* rarely increase more than ten-fold each year. However, a pot test indicated that their reproductive capacity is considerably greater than this; individual females from a Scottish population of *X. diversicaudatum* lived for 60 weeks on

strawberry, *Fragaria×ananassa* cv. Cambridge Favourite and produced eggs over a 36 wk period. At a constant temperature of 18°C an egg was laid on average every 1.7 days and the total egg laying capacity was in excess of 150 eggs per female. No periodicity occurred in the production of eggs in contrast with the field where seasonal effects are apparent.

(D. J. F. Brown, M. I. Coiro[1])

Status of some plants as hosts for four populations of Xiphinema index.

Xiphinema index is an important vector of viruses, especially to grape. Until recently it was thought to have a narrow host range. However, in a pot test five of eight plant species tested were hosts for four populations of *X. index.**

Non-hosts were *(ryegrass), Ribes nigrum* (black currant cv. Ben Lomond) and *Rubus idaeus* (raspberry cv. Malling Jewel). Hosts for *X. index* were *Fragaria×ananassa* (strawberry cv. Cambridge Favourite), *Ficus carica* (fig), *Petunia hybrida, Solanum demisum* and *Lycopersicon esculentum* (tomato). On *L. esculentum* some variation was observed between populations in their reproduction, cv. Haubners Vollendung was a better host for *X. index* from France and the USA than for populations from Israel and Italy. Also, significantly fewer *X. index* from Israel than from France survived and produced progeny on strawberry. All four populations reproduced and developed more rapidly on fig than on strawberry, one generation taking less than 12 wk at 18°C.

(D. J. F. Brown, M. I. Coiro[1])

Xiphinema limbeense *n. sp. from Malawi.*

Soil samples collected from the type location for *Xiphinema malawiense* (Ann. Rep. 1981, p.128) were found to contain specimens of a second species which has been named *Xiphinema limbeense* n. sp. *X. limbeense* n. sp. resembles *X. malawiense* and *X. coxi* but may be distinguished by tail length and shape, spear length and mainly by the structure of the pseudo Z organ.

(D. J. F. Brown, M. Luc[2], V. W. Saka[3])

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

Transmission of arabis mosaic and strawberry latent ringspot viruses by populations of* Xiphinema diversicaudatum.*

A previous study (Ann. Rep. 1980, p.117) showed that populations of *X. diversicaudatum* from France, Italy and Scotland differed in the rates with which they transmitted serologically distinct strains of strawberry

*Held under DAFS licence.

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latent ringspot virus (SLRV). This study was extended in 1982 to include populations of *X. diversicaudatum* from seven European countries, New Zealand and the United States of America, and two serologically distinct strains of AMV (AMV-T, British type strain; AMV-W, British woodland strain).

Using groups of two or five nematodes per pot it was calculated that of the 12 populations tested most transmitted AMV-T efficiently with more than 80% of the nematodes acting as vectors. However, nematodes from Italy, Spain and France were much less efficient vectors, only 2 to 15% of the nematodes tested transmitting virus. AMV-W was transmitted with about one-third the frequency of AMV-T and was also poorly transmitted by the French, Spanish and Italian nematodes. A similar pattern of results was obtained with the type–strain of SLRV (SLRV-T) whereas an SLRV isolate from peach in Italy was transmitted only rarely and then mostly by nematodes from the Italian population.

(D. J. F. Brown)

Feeding by Longidorus elongatus.

Studies on the feeding behaviour of virus vector nematodes in agar culture have been continued.

L. elongatus feeding on ryegrass (*Lolium perenne*) was observed to feed exclusively at the root-tip. Shortly after feeding commenced the root ceased growing and the tip started to swell to form a gall. Once a feeding site was selected the root-tip was penetrated by rapid thrusts with the stylet. Penetration ceased when the stylet-tip was several cells deep and the stylet almost fully protracted. Following penetration there was a period of inactivity lasting about 30 min; during this period occasional ripple-like movements were observed on the walls of the oesophageal pump, adjacent to a large gland cell, and the nematodes were thought to be injecting saliva into the plant root. After the initial period of inactivity, ingestion commenced and continued for long periods without pause (more than 3 h in one instance) and with the stylet-tip in the same cell. During most feeds there were two or three long periods of ingestion separated by short (2 min) periods of inactivity during which the nematodes were thought to be salivating once again. Following the periods of inactivity the rate of pumping of the oesophageal pump temporarily increased.

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

Morphological and histochemical changes occurring in root-tip galls induced by Longidorus elongatus.

Galls induced by *L. elongatus* were only fed upon for 10-12 days at 18°C, and passed through distinct stages after which they collapsed and became necrotic. In the initial stage hypertrophy occurred and the cells contained enlarged nuclei and nucleoli, a greater proportion of cytoplasm

and increased concentrations of protein. This stage was followed by hyperplasia when cells divided once or twice. In the third stage, secondary hypertrophy occurred and many cells became hypertrophied with enlarged, amoeboid shaped nuclei and nucleoli. The total RNA and protein content of root-tip galls increased approximately 1.6 times at this stage of development, 6-8 days after feeding had started. During the next stage galls were usually fed-upon by several nematodes and cell contents were progressively removed leading to the eventual collapse of the gall.

During this last stage, where *L. elongatus* had been feeding there were large areas of empty cells in which the interconnecting walls were perforated by numerous holes. These holes are probably made by the action of the saliva injected by the feeding nematodes. It has been calculated that one nematode may remove the contents of more than 40 cells during one feed and the formation of the holes facilitates the removal of cell contents at some distance from the stylet tip.

(B. S. Griffiths, W. M. Robertson, D. L. Trudgill)

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

Function of the oesophageal bulb in Longidorus *and* Xiphinema.

Calculations of the changes in cross-sectional area of an idealised pump chamber as it opens have shown that the increase in area is almost linear up to an apical angle of about 90° but the efficiency of opening rapidly declines thereafter.

Transverse sections through the oesophageal pump chamber in the closed position show that one of the three rays is shorter than the others. The cuticular appendages of the shorter sides are also larger giving the muscles greater leverage to open that side of the pump. It is thought that this asymmetry is necessary for priming the pump at the start of ingestion and implies that once normal pumping speed is achieved, the pump chamber never fully closes on each pump cycle. From observations on feeding nematodes it is estimated that the volume ingested with each contraction of the pump is between 25 and 50% of the total volume of the pump chamber.

(W. M. Robertson, Pauline B. Topham[1])

Carbohydrate histochemistry.

The mechanism by which virus particles are retained within their nematode vectors is unknown, but it is thought that carbohydrates may be involved.

The periodic acid-thiosemicarbozide-silver proteinate reaction was used to test for the presence of carbohydrates at sites of virus retention within vector species in three nematode genera.

[1]Data Processing Department.

In *Xiphinema diversicaudatum* and *X. index* the lining of the food canal within the odontosphore was found to stain in localised patches. The odontostyle of *Longidorus elongatus* and *L. macrosoma* both stained intensely and the lining of the oesophageal lumen of *Paratrichodorus pachydermus* also stained. The staining of the oesophageal lining in the *Xiphinema* and *Paratrichodorus* species is confined to a very thin layer which cannot be resolved in the light microscope. However, the periodic acid-Schiff reaction stains the odontostyle for light microscopy.

(W. M. Robertson)

Carbohydrate residues on the body wall of Xiphinema index.

The location of carbohydrate moieties on the outer cuticle of *Xiphinema index* was examined by electron microscopy using several different reagents: (a) the periodic-thiosemicarbazide-silver proteinate reaction was used as a general stain for carbohydrates, and in sectioned material it stained the canal system and deeper layers of the cuticle as well as the outer surface; (b) cationized ferritin at pH2.5, which identifies carboxyl and sulfate groups, was used to identify sialic acid residues and also labelled parts of the canal system, the deeper layers and outer surface when applied to ultrathin cryosections; (c) ferritin-goat and anti rabbit IgG coupled to a DNP ligand was used to label either sialyl or galactosyl/N-acetyl-D-galactosaminyl residues; (d) ferritin hydrazide, a new reagent for the ultrastructural localization of glyco-conjugates. Reagents (c) (with appropriate antisera) and (d) were applied only to the outer surfaces of the cuticle and showed that sialic acid residues were concentrated mainly on the outer-body wall of the head, the lips, oral opening, amphid apertures and outer surface of protruded odontostyles. Ferritin distribution was not altered by pretreatment with neuraminidase. Galactose oxidase treatments revealed galactose/N-acetyl-D-galactosamine residues along the entire body wall. These results confirmed earlier findings obtained by fluorescence microscopy.

(Y. Spiegel[1], W. M. Robertson, S. Himmelhoch[2], B. M. Zuckerman[3])

ENTOMOLOGY

05013 *Control of aphids and virus diseases of potatoes, raspberries and bulbous ornamentals.*

Potato.

There is much indirect evidence that in years when aphids migrate early from winter hosts, small numbers in the crop before rogueing can be responsible for much of the spread of potato leafroll virus (PLRV). In 1981 results were obtained which showed that small numbers of aphids early in the growing season were more potent vectors than larger numbers later on.

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[2]Weizmann Institute, Rehovot, Israel.
[3]University of Massachusetts, Amherst, USA.

Aphids were expected to arrive early after a mild winter and a replicated experiment was made to test the effect of the time of rogueing on the spread of PLRV in plots of FS1 cv. Maris Piper. This was done by including, in two rows in each plot, 10 PLRV-infected cv. Desiree plants to give an initial PLRV infection level of 3.7%. Plots were rogued at progressively later dates on 12 June, 30 June or 20 July, and there was a control in which the infectors were not rogued. At each rogueing the appropriate Desiree infectors were cut at ground level and the foliage placed directly into large polythene bags; the mother tubers and any daughter tubers were also removed. The possibility that aphids can transmit PLRV from current season (primary) infected plants was also tested by replacing each of the rogued Desiree infectors with an FS1 Maris Piper plant of comparable size that had been grown in a cold glasshouse.

After haulm destruction in early September a sample of six tubers was taken from the four plants that had been immediate neighbours of each infected Desiree plant and six tubers were also sampled from each Maris Piper replacement plant. In 1982 these tubers were grown to assess the proportion that were infected with PLRV.

Regular sampling in 1981 showed that the crop was colonised by a few aphids in early June but numbers did not increase as much as in some previous years and remained low throughout June. In July and through August the numbers of *Myzus persicae* increased slightly to about 18 aphids/plant. The number of *Macrosiphum euphorbiae* increased to over 600/plant in early July, when top roll symptoms were common, but declined rapidly due to the production of large numbers of alatae and the effects of fungal epizootics.

The percentage of tubers infected with PLRV was least in plots in which the infectors were rogued earliest (13%) and greatest in plots which were not rogued (61%). However, the increase in tuber infection was not linear with time. There was relatively more spread up to 30 June (43% infected) when aphid numbers were still low than there was up to 20 July (51% infected) when aphids were more numerous. Significantly more infected tubers came from the plants in the same row as the infector than from plants in the adjacent rows. These results highlight the importance of applying granular insecticides at planting to protect seed-potato crops in years when aphids are likely to arrive before PLRV infected plants show symptoms and can be removed by rogueing.

In the Maris Piper plants that replaced the infectors on 12 June 10.5% of the daughter tubers were infected with PLRV, 21.9% were infected in those replacing infectors on 30 June and 4.2% in those replacing infectors removed on 20 July. These results suggest that the plants replacing infectors rogued on 30 June were colonised by the most effective vectors but it is not known what proportion of these aphids had

originally colonised the rogued infectors or had moved from primary sources of infection in adjacent plants.

(J. A. T. Woodford, S. C. Gordon, D. L. Trudgill)

The effect of plant age on transmission of potato leafroll virus (PLRV).

Older potato plants are more resistant to PLRV infection than younger plants. To test if they are also poorer sources of PLRV, nymphs of *M. persicae* were fed on excised leaves of potato plants (cv. Maris Piper) grown from infected tubers in the glasshouse, or collected from plants showing secondary leaf roll symptoms in the field. Batches of three large nymphs were transferred to indicator plants (2-3 wk old *Physalis floridana*) for 5 days. Ten indicator plants were used for each leaf zone in each experiment.

With leaves collected in June from 9-10wk old infected plants in the field, PLRV was transmitted in 89% of 160 tests. Transmissions in July from 12-14 wk old plants decreased to 61%, but still averaged 58% from senescing plants in August, 16-17 wk after planting. There was little overall variation in the frequency of transmission from different aged leaves from similar aged infectors. In the tests with glasshouse grown plants the frequency of transmissions was more variable. Overall, transmissions decreased from 92% using 3 wk old infectors to 12% with 9 wk old plants, but there were as many transmissions in two experiments with 10 wk old plants as there were from plants 6 wk old. Transmissions were equally frequent from all leaf zones of 3 wk old plants but in older plants PLRV was usually transmitted more often from lower or middle leaves than the upper leaves.

(J. A. T. Woodford)

Transmission of potato leafroll virus (PLRV) by Macrosiphum euphorbiae.

In laboratory experiments *M. euphorbiae* is an inefficient vector of PLRV compared with *M. persicae*. However, most of the laboratory experiments have used only a few clones of *M. euphorbiae* and these have been tested on indicator plants which are not particularly suitable as food plants for this species. In glasshouse tests *M. euphorbiae* collected from PLRV-infected plants in the field, transmitted the virus to 9 out of 77 young plants of FS1 cv. Maris Piper. The upper leaves on some stems of plants that were infected in early July developed a mild chlorosis and upright habit in mid August which ELISA tests confirmed to be symptoms of primary infection by PLRV.

On *Physalis floridana,* which is frequently used as an indicator plant for PLRV, we obtained no transmission by *M. euphorbiae* in 180 separate tests. In comparison, *Myzus persicae* transmitted PLRV to 66 out of 88 *P. floridana* plants in this experiment.

Macrosiphum euphorbiae also transmitted PLRV to mature potato plants in a field experiment. Groups of 15 *M. euphorbiae* collected from PLRV-infected plants in the field were caged for 1 week (7-14 July) on a mature leaf on 40 plants of FS1 Maris Piper. Twenty of these plants had been treated at planting (10 April) with thiofanox. Groups of 15 *M. persicae* reared on PLRV-infected potatoes were similarly caged for the same period on 20 treated and 20 untreated FS1 Maris Piper in the same plots. No aphids survived on treated plants but there were large increases in the numbers of aphids caged on untreated plants. All the caged plants were then sprayed to run-off with pirimicarb. Tubers from 4 out of 20 untreated plants caged with *M. euphorbiae* and 17 out of 20 untreated plants caged with *M. persicae* were infected with PLRV. Controls consisting of 200 tubers from neighbouring uninoculated plants produced 0.5% infected plants. Thiofanox prevented any transmission by *M. euphorbiae* but, as in a previous experiment (Ann. Rep. 1981, pp.134-135) it did not completely prevent transmission by viruliferous *M. persicae*. Nine out of the 20 treated plants caged with *M. persicae* produced infected tubers. None of the 200 control tubers from neighbouring uninoculated plants was infected.

(J. A. T. Woodford, S. C. Gordon, H. Barker[1])

Effectiveness of granular insecticides applied as side dressings to emerging potato crops.

Although granular insecticides applied at planting can control aphids on potato for up to 16 wk, delaying application until plant emergence may present several advantages including more time to assess the probable risk of early aphid attack, and also enhance persistence whilst using lower doses. In 1982 two field trials were made to compare the effectiveness with which aphids were controlled by granular pesticides applied in-furrow at planting or as side dressings at crop emergence.

The first observations were made in a farm crop of cv. Pentland Hawk described on page 140 of this Annual Report. Aphids arrived late and populations remained low on all plots. All the rates of aldicarb (Temik 10G) decreased the numbers of *M. persicae* and *M. euphorbiae* in August but the numbers were too low to detect differences between the chemical treatments.

In the second trial an experimental planting of FS1 cv. Maris Piper was divided into four blocks each of seven treatments; aldicarb 10% a.i. applied at planting in-furrow at 86 g/100 m or 43 g/100 m; thiofanox 5% a.i. (Dacamox 5G) applied at planting at 112 g/100 m or 56 g/100 m; aldicarb applied as two side bands into the potato drills at tuber depth 6wk after planting at 35 g/100 m; thiofanox similarly applied 6 wk after planting at 56 g/100 m; and untreated.

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[1]Virology Department.

Aphids were uncommon until mid-July but all the chemical treatments decreased numbers significantly. The only difference detected amongst the insecticide treatments was that significantly more *M. euphorbiae* developed on plots treated at planting with thiofanox at 56 g/100 m than on plots treated at planting with the higher rates of thiofanox or aldicarb, or side dressed with aldicarb at 35 g/100 m.

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

05008 *Ecology of aphids infesting potatoes, raspberry and bulbous ornamentals.*

Direct aphid damage to potato.

In recent years large populations of *M. euphorbiae* have developed on unprotected potato crops at SCRI and top roll symptoms have often been observed. In 1982 a field trial was planted to investigate the susceptibility to *M. euphorbiae*, and to top roll, of the potato cultivars Désirée, Corsair, Kennebec, Maris Piper, Maris Anchor, Pentland Dell, and clone 9559. These were arranged in a latin square layout in which half of each main plot was split for an insecticide treatment at planting (thiofanox granules, 5% a.i. 112 g/100 m).

M. euphorbiae was less abundant in 1982 than in the previous 5 years. Populations peaked in early August on all treatments except for Maris Piper where the peak occurred 1 week earlier with significantly more *M. euphorbiae* on Maris Piper than on the other cultivars and clone 9559 ($P<0.05$). Top roll appeared in 21% of the untreated Maris Piper plants and 2.5% of the Maris Piper plants treated with thiofanox; the number of Maris Piper plants with symptoms decreased in August. Although the maximum population of *M. euphorbiae* on Maris Anchor exceeded that on Maris Piper no top roll symptoms developed on Maris Anchor. However, Pentland Dell, which supported fewer *M. euphorbiae* in late July/early August, appeared to be very susceptible to top roll, with 9.5% of untreated plants showing symptoms. No cultivar or clone showed any significant difference in yield between insecticide-treated and untreated plants.

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

05001 *Ecology and control of horticultural and agricultural pests.*

Pests of hybrid Rubus.

Examination of several Tayberry plantations in eastern Scotland has revealed the presence of several pests. As previously reported (Ann. Rep. 1981, p.112), *Sitobion fragariae* was the only important aphid species found. In plantations where raspberry beetle (*Byturus tomentosus*) was not controlled their numbers increased rapidly and severe fruit damage resulted. As with raspberry the larvae tunnel into the plug and browse on the ripening drupelets. The damaged plug decays rapidly and makes the fruit unmarketable.

A severe virus-like mottling of leaves and multi-branched primocanes was observed in two plantations. Viruses are now thought not to be involved and it is thought to be caused by raspberry leaf and bud mite (*Phyllocoptes gracilis*) as large numbers have been recovered from damaged leaves and the application of the acaricide vamidothion (0.56 l a.i./1,100 l/ha) in early May significantly reduced mite numbers and the symptoms (see Virology p.190). Mites also caused damage to another plantation where large numbers of the two spotted mite (*Tetranychus urticae*) caused bronzing to leaves of primocanes in August.

Loganberry cane fly (*Pegomya rubivora*) were responsible for damage to primocanes at two sites in Tayside. The upper portions of the canes had wilted and become brittle at a point 15-20 cm from the growing tip. Larvae were recovered from tunnels girdling the canes at the point of wilting. A secondary bud below this point subsequently assumed the role of the terminal bud.

(S. C. Gordon)

Air-assisted spraying.

Fenitrothion, a contact insecticide, applied by a low velocity air-assisted sprayer at medium volume (350 l/ha) has controlled the large raspberry aphid (*Amphorophora idaei*) as efficiently as a conventional hydraulic sprayer delivering 2,000 l/ha (Ann. Rep. 1981, p.132), the volume recommended by chemical manufacturers for most pesticides used on raspberries.

In 1982, the value of air-assisted spraying to reduce costs by decreasing the spray volume required to achieve adequate pest or disease control was again studied. Treatments included cross-flow sprayer treatments using air velocities of 11.3 and 12.9 m/sec to apply fenitrothion at the rate of 0.55 l a.i./ha in 350 l of water/ha and conventional hydraulic sprayer treatments of 2,000 and 1,000 l of water/ha (the latter volume being achieved commercially more easily than the former). When the spray was applied in early July few aphids were present (33.7 per five canes in unsprayed plots) and although all sprayed plots had fewer aphids than the controls, there were no significant differences between sprayers.

(S. C. Gordon, B. Williamson[1])

Control of clay coloured weevil.

Laboratory experiments to find a replacement for DDT to control clay coloured weevil (*Otiorhynchus singularis*) on raspberry have continued.

Candidate insecticides were applied to pots containing soil, raspberry foliage and adult weevils. The sprays were applied during the daytime when the adult weevils which are nocturnal feeders were sheltering in the

[1]Mycology & Bacteriology Department.

soil. The insecticides tested were azinphos-methyl mixture, chlorpyrifos, DDT, fenitrothion and triazophos. The azinphos-methyl mixture was also tested on exposed weevils to simulate spraying after dark when most weevils emerge from the soil. Only two treatments, azinphos-methyl mixture, applied to exposed weevils, and DDT, applied to the soil and foliage, significantly reduced feeding damage on the test foliage. This suggests that to control adult clay coloured weevils an insecticide should either have a similar mode of action and persistence to that of DDT (properties which might be damaging to the environment), or should be sprayed after dark when the weevils are active and liable to be hit by spray droplets.

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

PHYSIOLOGY AND CROP PRODUCTION

P. D. WAISTER

The simple model of growth and development of the potato crop, described in last year's Report, identified important gaps in our knowledge of the factors controlling time to emergence, rate of development of leaves in the period before canopy closure, and efficiency of utilisation of light by the canopy. Progress has been made in investigations of each of these areas, so that the model can now be developed further, although still at an empirical level. Dr Bruce Marshall has been appointed to the post of mathematical modeller.

Herbicide evaluation continues to provide essential data for the development of improved weed control systems for horticultural and arable crops. It now appears that one of the major remaining problems, that of control of perennial grass weeds in broad leaved crops, may be solved by a new group of herbicides. Experiments over the last few years have shown that a range of crops have adequate tolerance of these chemicals at the rates required for grass control.

Changes are imminent in the project classification scheme and the expanding programme on potato crop and plant physiology will eventually be reported under new project titles. However, this year the reports appear under the vegetable crop project numbers 01030 and 01049.

CROP ENVIRONMENT

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

Potato light interception and growth.

Irrigation was provided this year in an experiment to compare the growth of three cultivars of potato and to contrast the development of their leaf canopies and the efficiencies with which they used the light intercepted to make growth. The purpose of the irrigation was partly to remove a possible limitation to growth and partly to extend the duration of leaf cover. The three cultivars were Guardian, Maris Piper and Pentland Dell which represent a range of foliage type and maturity class. The irrigation kept the plants growing well until after the second week of August when high winds caused lodging of the canopies. Thereafter the foliage remained alive but there was appreciable plant to plant variation in further growth especially in the early cultivar.

The average rates of dry matter increase to 12 August were 1.75 g/MJ for Guardian, 1.60 g/MJ for Maris Piper and 1.59 g/MJ for Pentland Dell. For the second year running Guardian has been shown to have a higher growth efficiency than the other two cultivars. An effect of irrigation was to raise this value in Maris Piper.

The growth analyses performed on these growing crops is also providing useful information on the phasing of the development of the crop. Final tuber yields were 77.9, 72.7, and 60.9 t/ha for Guardian, Maris Piper and Pentland Dell respectively.

(D. K. L. MacKerron)

A modified form of last year's experiment to examine light interception in relation to tuber yield, has included irrigation to minimise drought stress. Large differences in radiation interception and yield were recorded between the treatments which included cultivar, spacing and planting date. The most extreme values were obtained for the cultivars Maris Bard and Cara. Maris Bard planted in June intercepted 900 MJ/m^2 of light and produced 926 g/m^2 of tuber dry matter (47 t/ha fresh weight) during the growing season, compared with 1,376 MJ/m^2 of light intercepted and 1,430 g/m^2 of tuber dry matter (66 t/ha fresh weight) produced by Cara from an April planting.

Across treatments the relationship between intercepted radiation and tuber dry matter yield was poor, with little evidence of linearity. This highlights the need for measurements to take account of the changes with time in harvest index and in efficiency of light utilisation as canopies senesce.

(R. Thompson, H. Taylor, Janet E. Brinklow)

Potato: Water stress and tuber initiation and development.

A glasshouse experiment with four intensities of water-stress applied by withholding water at three different stages of plant growth examined the relationship between water shortage and tuber initiation and development in the cv. Maris Piper. Daily records of soil moisture tension greater than 10kPa were summed to provide a measure of total water stress in each treatment (in a fashion comparable with the calculation of day degrees).

There was a direct reduction in tuber numbers per stem with increasing water stress among plants deprived of water from 50% emergence, but there was no effect on tuber number when water was withheld from tuber initiation or from the small tuber stage. Plants which had been stressed for 880 kPa days after emergence had a mean of 4.6 tubers/stem compared with 7.9 tubers/stem in the non-stressed control.

The total yield of tubers at the final harvest was not affected by any of the water-stress treatments.

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

Potato: Growth cracking.

An experiment was conducted to investigate the effect of altered water supply on the incidence of growth cracking in tubers of cv. Sheriff. In one treatment plants were irrigated at the full potential evaporation rate (calculated after Penman) and in another at half this rate. Two further treatments involved changing between these basic regimes. In all cases there were only slight indications of susceptibility to growth cracking. It appeared that the plants in the drier treatment were still adequately supplied with water and that significant fluctuations in water stress had not actually been imposed, despite the relatively low rainfall in 1982.

In a second experiment, plants of the cultivars Guardian, Record and Sheriff were grown either with rainfall and partial irrigation or with the soil water supply restricted by polythene sheeting. In Guardian the incidence of cracking was about 10% of tuber numbers with no differences between the treatments. No cracking was observed in Record from either treatment, and very little in Sheriff.

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

Potato: Pre-emergence growth of sprouts.

Experiments were set up to investigate the dependence on temperature of potato sprout development and extension in soil as there is little information available on this subject in the literature.

In the first experiment mini-chitted seed tubers of cv. Maris Piper were planted at three depths and six constant temperatures. Times to emergence were noted together with observations on numbers of sprouts emerging and subsequent stem extension rate in the dark. The purpose of planting at three depths was to identify a lag phase during which the new sprouts develop and an extension phase during which they lengthen. The depths were 7.5, 15 and 22.5 cm while the temperatures were 3, 5, 7.5, 10, 12.5 and 15°C.

At 15°C the time to 50% emergence (E_{50}) was 22, 24 and 26 days after planting at 7.5, 15 and 22.5 cm depth respectively indicating that at high temperatures shoot extension is very rapid once it begins. At 3 and 5°C no sprouts had emerged by 155 days after planting (30 September) and the tubers were lifted and examined. At 3°C the tubers were in almost the same condition as when they had been planted. At 5°C all tubers had formed small sprouts of 10-20 mm length, but no roots had been formed. The base temperature for development of the potato sprout on the tuber would appear to be close to 5°C and that for root formation may be a little higher. Depth of planting became more significant at lower temperatures.

In a second experiment seed tubers of Maris Piper were chitted in the light with 380 day degrees C (base temperature 2°C) and then planted at 15cm depth at 5, 10 and 15°C. Extension rates were proportional to the

time-temperature integral above 2°C. That is, the base temperature for shoot extension was 2°C and extension rates were 0.8 mm per day degree C above 2°C. Fewer shoots emerged from tubers in soil at 5°C. Continued growth of shoots after emergence (but in the dark) indicated that the later emerging sprouts from a tuber had a lower growth rate than had the first emerging.

(D. K. L. MacKerron)

Potato: Development of the crop canopy.

A preliminary investigation of canopy development was made in an irrigated crop of cv. Maris Piper. A new leaf appeared every 40 day degrees C above an assumed base of 0°C. Observations at two leaf positions (⅓ and ⅔ up the main stem) showed that it took 20 days, at a mean temperature of 13°C, for a leaf to extend from 10 to 90% of its final length. Leaf area index of 3 (full canopy) was attained 75 days after planting, when seven leaves had expanded on the main stem and the twelfth leaf was about to expand. There were a total of 17 leaves before the flower on the main stem.

A more detailed study of the influence of temperature on leaf expansion will be carried out over the next 2 years, both in the field and growth rooms. It is envisaged that this will provide a more mechanistic basis for the modelling of canopy expansion.

(B. Marshall)

Potato: Modelling growth and development.

Using UCSD PASCAL mounted on an Apple II microcomputer, procedures for handling climatic data were developed. Two units were written to aid in the visual display of information and assist in storage and retrieval of data referenced by calendar date.

The climatic programs will serve two purposes; first, collation, range checking and storage on floppy disk of meteorological data recorded at Invergowrie. This information can be passed to the mainframe for processing or, with the development of future programs, can be processed locally on the microcomputer. Second, they provide a climatic input for models of potato development and growth. The first of these models is now running on the microcomputer, and estimates the potential yield of a potato crop, using soil and air temperatures and solar radiation as the climatic inputs.

(B. Marshall)

Values for crop and weather variables for seven regions of the UK in 1977 were put into the model and potential yields calculated. The shortfalls in yield were examined and reasons for the discrepancies postulated. Restricted water supply was a factor which even taken alone

would account for most of the reductions in yield. This is not to say that potential yields would be achieved by the single expedient of removing water restrictions.

As a further test of the model, crops of potato were examind on selected farm fields during the growing season. This work, which was intended as a pilot survey, highlighted two shortcomings in the model itself although, fortuitously, their effects cancelled out. Yields obtained from an irrigated field were very close to those calculated as the potential for that field and year. Yields from irrigated crops at Invergowrie were also close to the potential, while yields from two non-irrigated fields were substantially below their potential.

Work was also in hand to improve the operation of the model over the early stages of crop growth and is expected to remove the discrepancies mentioned above.

(D. K. L. MacKerron)

WEED INVESTIGATIONS

01021-4 *Weed ecology and control in soft fruit, flower bulbs and vegetables.*

Herbicide evaluation.

Further evaluation of the selective grasskillers alloxydim sodium, fluazifop butyl and sethoxydim suggested that potato, field and broad bean, black currant and raspberry (managed with or without cane vigour control) should all have adequate tolerance to rates of application required for the control of perennial grasses. Both types of bean were more sensitive to alloxydim sodium than to the other herbicides, while black currant, particularly cv. Ben More, wa relatively less tolerant of fluazifop butyl. This cultivar was also more sensitive to 3,6 dichloropicolinicacid than the cultivars Ben Nevis and Ben Lomond. Both swede and calabrese showed acceptable tolerance to this herbicide applied as a post-emergence treatment for annual weed control. In a screening trial, metazachlor and a benazolin/3,6 dichloropicolinic acid mixture had no harmful effect on growth or yield of swede cv. Marion when applied post-emergence (eight leaf-stage of the crop).

Glufosinate and a bentazone/propanil mixture applied at 20 or 80% emergence of potato cv. Maris Piper both caused relatively more crop injury than was recorded with the standard rate of paraquat applied at the same growth stages. The evidence suggests that both new herbicide treatments would require to be applied strictly pre-emergence of seed potato crops.

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

Weed/crop competition.

Data on dry matter accumulation by weeds in the presence or absence of vining peas at two densities was used to compare six diversity indices as

measures of changes in the structure and behaviour of the weed flora. Analysis of variance was carried out for each index and the residuals were examined for skewness, kurtosis and heteroscedasticity. Indices based on species number (richness) and species evenness were found to be effective and reliable over the wide range of data examined and permitted new information to be derived. They showed that while increasing competition from the pea crops suppressed weed growth and reduced the number of species recorded at successive sampling dates, there was no selection pressure and species evenness was not reduced.

(Pauline B. Topham, H. M. Lawson)

01029 *Weed control in crop rotations.*

Volunteer crops.

Seedling emergence records from a field site and from an outdoor pot experiment at Invergowrie have demonstrated the ability of potato true seed to survive in the soil well beyond the normal rotational interval (3 years) between ware crops. The two sites have produced seedlings in every one of the last 6 and 5 years respectively. True seedlings were also found growing in a number of seed potato fields on farms in Tayside and Fife in 1982. They were particularly prevalent in and around crops grown in stone-separated soils which had received no soil cultivation since planting and ridging. All the sites had last been planted with potatoes 6-7 years previously, usually with cv. Maris Piper, a prolific producer of potato berries.

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

VEGETABLE AND ARABLE CROPS

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

Potato: Shoot development.

Last year, despite marked differences in shoot numbers produced by various types of sprout damage, no differences in yield or size grading were found. This was surprising considering that one treatment resulted in a 25% increase in stem numbers. This year a slightly modified set of treatments included total desprouting, apical shoot only retained, removal of shoot tips and tubers cut into four pieces following desprouting, to be compared with normally sprouted undamaged controls. The cultivars Maris Piper and Pentland Crown were planted at 15 and 45 cm spacings in 72 cm drills on 21 April. Emergence ranged from 23 May to 1 June for the control and desprouted respectively, and Pentland Crown was about 3 days later than Maris Piper.

Following high shoot numbers initially, a rapid reduction occurred around the time of emergence, leading by the end of June to values sustained for the rest of the season. Pentland Crown reached its constant

stem number slightly earlier than Maris Piper, and as would be expected produced fewer stems (by about 25%) than Maris Piper.

There was little effect of spacing on stem numbers per plant and the greatest values were obtained from the tubers with shoot tips removed, with 5 stems/plant for Pentland Crown and 7.8 stems/plant for Maris Piper. Fewest stems were produced by the desprouted cut treatment with 2.8 stems/plant and 3.6 stems/plant for Pentland Crown and Maris Piper respectively, but these values were only slightly less than those for the remaining treatments.

As would be expected, increasing the plant population reduced tuber numbers per plant at the final harvest in October, but on a unit area basis the close spacing produced almost double the number of tubers compared with the wide spacing (Table 1). The greatest tuber numbers resulted from the tip removal treatment for both cultivars and the lowest values were given by the desprouted cut treatment. Somewhat surprisingly the apical shoot only treatment gave a similar value to that of the undamaged control.

There was little effect of treatment on total yield which averaged 49 t/ha. The differences in tuber number were reflected in the yields of seed tubers (35-55 mm) (Table 1).

Table 1

Yield of 30-55 mm sized tubers t/ha and number of tubers/m² (in brackets)

		Treatment					
Cv.	Spacing cm	Control	De-sprouted	De-sprouted /cut	Apical	Tipped	
Pentland Crown	15	30 (71)	23 (60)	17 (59)	19 (53)	33 (75)	SED±3.0
	45	8 (37)	9 (27)	6 (22)	11 (37)	13 (42)	(SED±4.7)
Maris Piper	15	40 (85)	31 (85)	32 (75)	33 (80)	33 (94)	
	45	23 (48)	18 (42	10 (35)	23 (48)	29 (57)	

(R. Thompson, H. Taylor, Janet E. Brinklow)

Potato: Measured maximum (MM) yield.

Last year high yields were obtained from plants grown in MM conditions and also in normal soil conditions but with additional water and nutrients, whereas a conventional crop gave only about one half of these yields. The number of tubers produced from the two field soil plots was similar but only half that from the MM plot. This year a growth analysis was made to establish the pattern of crop development in the three treatments.

Unfortunately the structures supporting the MM plot canopies collapsed causing the haulm to lodge about mid-July, from which date the results for this treatment are therefore of questionable significance.

Total dry weight increased at a similar rate for all three treatments until early July, but within the next month that for the non-irrigated and MM plots levelled off giving final values of about 130 g/plant and 90 g/plant respectively. Final total dry weight for the irrigated soil crop was 260 g/plant. Tuber dry matter production was greatest initially for the non-irrigated plot but this was exceeded by that for the irrigated soil plot at the end of August. Tuber dry weight for the MM plot was lower throughout the season than that of either of the other two treatments.

Increase in tuber fresh weights followed a similar pattern to that of dry weights but was modified by the large differences in % dry matter of the tuber. At the final harvest tuber yields were 107 t/ha, 60 t/ha and 55 t/ha for the irrigated soil, MM and control plots respectively with corresponding values for dry matter content of 19, 14 and 23%.

Stolon numbers did not differ consistently between treatments and, after reaching peak values of about 45/plant at the end of June, declined progressively over the rest of the season.

Although tuber initiation was delayed in the two high fertility plots compared with the control, similar numbers of tuber initials (15/plant) had been produced for each treatment by mid July. Tuber numbers declined from about $170/m^2$ in each treatment in mid July to 138, 115 and $121/m^2$ for the MM, irrigated soil and control respectively in October.

Canopy development was most rapid for the MM plot until about mid-July, leading to a peak leaf area index (LAI) of 11 at this time. Maximum LAI for the irrigated and non-irrigated plots were 10 and 6 obtained in early August and late July respectively.

During the period of full canopy development the MM and irrigated canopies intercepted about 98% of incoming radiation, while the values for the non-irrigated control was about 92%. Light utilisation was highest for the irrigated soil plot at 1.6 g dry matter per MJ intercepted, and was least efficient in the MM plot at 0.6 g dry matter/MJ; the intermediate value for the non-irrigated control was 0.75 g dry matter/MJ of intercepted radiation. These efficiencies were probably strongly
affected by including in the calculations an appreciable amount of light intercepted by senescing leaves and by stems.

(R. Thompson, H. Taylor, Janet E. Brinklow)

Potato: Physiological age.

One measure of the physiological age of tubers is the number of day degrees accumulated above a base temperature of 4°C. The relationship between accumulated temperature and yield varies between cultivars but, generally, levels which result in good sprouts of about 1cm long produce satisfactory yield. Relatively high temperature with light are required to induce sprouts of this size and about 1 month at 16°C is usually

sufficient. The effects of the timing of this sprouting regime within the storage period between November and April were examined for the cultivars Maris Piper and Pentland Javelin. Samples of tubers were transferred from 5 to 16°C for periods of 1 month, on five monthly occasions from November to April and then returned to 5°C. At each transfer, three lots of tubers were used, one receiving the sprouting treatment in light, a second in the dark, and the third was identical to the second but was subsequently desprouted immediately prior to planting.

Average sprout lengths of tubers of Pentland Javelin sprouted in light and dark were 28 and 59 mm, respectively; the corresponding values for Maris Piper were 17 and 22 mm.

Total yields of tubers on 16 August averaged over treatments were similar for the two cultivars, at 35 t/ha, and on 28 September Pentland Javelin produced 40 t/ha and Maris Piper 45 t/ha. At neither harvest did the timing of the high temperature sprouting treatment affect total yield. Also there was no difference in yield between tubers sprouted with light and those sprouted without, with an average of 42 t/ha, but sprout removal reduced yield to 37 t/ha. This reduction in total yield for desprouted tubers resulted in an increase in the proportion in the seed grade (35-55mm) with 74 and 66% at the first and second harvests respectively. Corresponding values for light and dark chitted seed, which performed similarly, were 49 and 43%. A feature of these results was the lack of treatment effect on stem numbers. It would be expected that high temperature early in the storage period would lead to greater apical dominance and hence fewer shoots. It is likely that the main reason for the failure of high temperature to induce apical dominance was an insufficiently early start for the high temperature treatment.

(R. Thompson, H. Taylor, Janet E. Brinklow)

Potato: Planting rates.

Kennebec and Pentland Squire are among several cultivars noted for the paucity of seed size tubers they produce. Higher planting rates are known to improve the proportion of seed tubers, but this remedy frequently is uneconomic. To obtain a better understanding of the mechanisms controlling tuber size a preliminary experiment examined effects on stem and tuber numbers of Kennebec and Pentland Squire planted at 10, 20, 30 and 40 cm (11.0, 5.5, 3.7, 2.8 t/ha) spacing in 72 cm rows.

Total yields tended to be lower at extreme spacings for both cultivars, and maximum yields obtained were 50 t/ha and 58 t/ha for Kennebec and Pentland Squire respectively. Seed yield (35-55 mm) for Pentland Squire was almost double that of Kennebec (26 t/ha and 15 t/ha) when averaged over spacing treatments. The highest yield of seed tubers however was obtained at the closest spacing for both cultivars, with 22,

15, 14 and 10 t/ha for Kennebec and 31, 28, 25 and 20 t/ha for Pentland Squire respectively for each increased spacing.

The number of tubers per stem declined as spacing was reduced, for both cultivars but, on average fewer tubers per stem were produced for Kennebec (1.7 tubers/stem) than for Pentland Squire (2.4 tubers/stem).

(R.Thompson, H. Taylor, Janet E. Brinklow)

Potato: cv. Record – geographical origin of seed tubers.

Performance of stocks of the cv. Record (FS2) from several sites between Kelso and Orkney was compared. Seed from the eight farms originated from a common VTSC source.

Stem numbers ranged from 15-21 stems/m^2, but there was no obvious relationship with the latitude of the site of origin of the samples. The crops were harvested on 17 August and 27 September, and at the first harvest there were no differences between stocks in either total yield or seed yield (35-55 mm). At the second harvest total yield ranged from 38.4 to 43.1 t/ha and seed yield from 26.2 to 32.5 t/ha, Again no link was apparent between yields and site of origin. As all the material was stored under similar conditions at Invergowrie from soon after harvest, the recorded differences in performance must have been due to the properties of the seed as received.

(R. Thompson, H. Taylor, Janet E. Brinklow)

Potato: Within- and between-plant competition.

Studies in 1981 and 1982 showed that leaf growth on individual stems of the potato was closely related to temperature, in the absence of between-stem competition. Three aspects of competition were examined this year, to provide a basis for a competition function to be used in the model of growth and development.

Competition between sprouts on the same mother tuber was investigated in the field using cv. Maris Piper. Eyes were excised from multi-sprouted tubers to leave one, two or four sprouted eyes per tuber. Following planting, samples for growth analysis were taken at weekly intervals until emergence.

Some of the main sprouts failed to emerge but there were no differences between treatments in number of main sprouts per eye. However, from 14 days after planting there were significant differences in the number of branch sprouts per eye, and the one, two and four-eye tubers gave final above-ground stem numbers of 5.6, 5.9 and 7.5 respectively. At emergence, the total dry weights of sprout and root per eye were 0.65, 0.51 and 0.39, in the three treatments, indicating the extent of within-tuber competition.

There were no differences in tuber yield between treatments at harvest in early October, but the proportion in the 35-55 mm size grade increased from 33 to 41 to 53% in the one, two and four-eye tubers respectively.

In a second experiment, the phasing of competition between plants and between stems within plants was examined, again using Maris Piper.

Single-eye cores, each weighing 10 g, were taken from chitted tubers and held for 48 h at high humidity to promote periderm formation. They were then planted singly or in groups of two, four and eight cores, at a conventional spacing of 30×70 cm and at 90×140 cm, at which spacing it was anticipated that there would be no competition between plants at least in the first half of the season. Plants were sampled for growth analysis at weekly intervals until early July and at 2 week intervals thereafter. The onset of stem-to-stem competition was indicated by the divergence between the growth rates of single stems and stems from the grouped cores. Plant-to-plant competition at the conventional spacing was identified when growth rate per plant fell below that of the wide-spaced plants.

Stem numbers were 1.4, 2.6, 5.2 and 9.9 from the one, two, four and eight core treatments respectively. Leaf area per stem in the four and eight core treatments was already lower than in the single core at the time of the first sampling just after emergence.

The onset of plant-to-plant competition in the convential spacing treatment occurred at a Leaf Area Index of between 1 and 2.

The experiment was irrigated, so water supply should not have been the factor determining the phasing of competition. Leaf samples from mid-June onwards were analysed for N, P, K, Ca and Mg by the MISR. There was no indication of deficiency levels for any nutrient except K, in any of the treatments. Tissue K content was low in all treatments, despite apparently adequate soil levels, but differences between treatments were small.

(H. A. Ross, P. A. Gill, P. D. Waister, W. M. Crooke[1])

Potato: Reserve mobilisation and intersprout competition in the field.

Tubers and, where possible, sprouts from the first experiment above were sampled at weekly intervals and analysed for changes in starch, protein, soluble sugars, free amino acids, total N, P, K, Mg and Ca. An insignificant amount of the total starch and protein was mobilised in the mother tuber during pre-emergence growth. However, from samples taken 1 week before emergence it was calculated that a two to threefold 'excess' of soluble sugars still existed in the mother tuber, compared with the amount of sugar already utilised by sprouts and roots for growth up to that point. Similarly, a fivefold excess of tuber amino acid existed compared with the combined protein and amino acid content of sprouts and roots. These excesses occurred irrespective of the number of sprouting eyes per tuber.

[1]MISR.

The levels of reducing sugars (glucose + fructose), while variable even between replicates, exceeded those of sucrose by five to tenfold in both tubers and sprouts. Compared with tubers, sprouts contained much higher amounts of sugars and free amino acids (up to three-fold) on a dry weight basis. There was no evidence of a reduction in either sprout sugar or amino acid concentrations with an increase in sprouting eye number.

The concentrations of tuber N, P, K and Mg changed very little during pre-emergence growth and there was little indication that concentrations varied in the sprouts with an increase in sprouting eye number. Tuber calcium concentrations increased almost threefold in the 3 weeks prior to emergence and in the latter stages higher concentrations occurred in tubers with greater numbers of sprouting eyes. These increases were reflected in similar changes in calcium concentrations in the sprouts.

(H. V. Davies, W. M. Crooke[1])

Potato: Reserve mobilisation and intersprout competition under controlled environment conditions.

Tubers with either one, two or four sprouting eyes were transferred to 16°C either:

(a) In chitting trays in the dark;
(b) In chitting trays under continuous white light, or
(c) In 15cm diameter pots in UC compost (in the dark).

UC treatment resulted in the most rapid rate of sprout growth, both in terms of length and dry weight increase. Light treatment produced the slowest rates. Dry weight accumulation per sprouting eye was reduced with an increase in the number of sprouting eyes per tuber (i.e. intersprout competition) but UC treatment reduced the severity of this effect. The mean sprout length per tuber in all three treatments ((a)-(c)) was affected much less by an increase in sprouting eye number than was dry weight accumulation per eye.

At a time when intersprout competition was evident, substantial quantities of soluble sugars still remained in the tubers (1.5 to 2.0 fold that already incorporated into sprouts and, where present, roots). Sprouts from treatment (a) contained up to 10% of their dry weight as starch, light treated samples in the region of 6% and UC samples only 2%. The diversion of what appears to be an excess of soluble sugars into starch synthesis in slow growing sprouts suggests that the availablity of sugars is not a major factor limiting sprout growth. While suboptimal concentrations of some individual components may have imposed certain limitations, there was little evidence from total amino acid levels that low concentrations in either tuber or sprout were primarily responsible for limiting growth. Similarly, mineral analysis failed to implicate N, P, K, or Mg but the eightfold higher concentration of Ca in sprouts of treatment (c) compared with that of in the slower growing sprouts of treatment (a) suggests an important role for this divalent cation in the control of sprout growth rate.

(H. V. Davies, W. M. Crooke[1])

[1]MISR.

Potato: Sprout growth from tuber cores.

An alternative approach to the investigation of factors limiting sprout growth involved the use of tuber cores. Cores of 1.5 cm diameter, each with a single growing sprout, were taken from the apical region and cut transversely to give core fresh weights of 2, 4, 8 and 16 g. After periderm formation the cores were placed either in darkness or continuous white light on filter paper moistened either with distilled water or 10 mM $CaSO_4$ solution. Growth was monitored over a 30-day period at 16°C.

The rate of increase in sprout dry weight was higher in darkness than in light and higher for larger than smaller cores. Nevertheless, the data indicated a considerable reduction in dry weight increase only when the core fresh weight fell below 4 g. Ca had no effect in the light but enhanced dry matter accumulation in darkness, also preventing the onset of subapical necrosis. Ca also promoted extension growth in the dark but, in contrast to dry weight accumulation, extension growth was faster for sprouts from smaller tuber cores. Root growth from the smaller cores directly onto the Ca medium (thus enhancing uptake) would appear to account for this effect. Roots from the larger 8 and 16 g cores failed to reach the medium during the experiment. Sprout dry matter would only appear to be utilised in extension growth in the presence of adequate amounts of Ca.

Ca had no effect on the level of total amino acids in 8 g cores from the dark treatment, yet enhanced both dry weight accumulation and extension growth. This appears to provide additional evidence that the availability of amino acids is not limiting.

(H. V. Davies)

Potato: haulm desiccant evaluation.

Glufosinate applied on 16 August at 0.6 and 1.2 kg a.i./ha achieved final levels of desiccation equivalent to those obtained with diquat. Although slower acting, glufosinate treatments produced comparable yields of tubers and showed no greater incidence of physiological or pathological disorders than were recorded on plots treated with diquat. Seed tubers have been stored for assessment of any residual effects on sprout development.

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

01050 *Control of growth, yield and quality of protein and other seed crops used for feed manufacture.*

Field bean: EEC joint cultivar trial.

This year's trial included 16 cultivars, eight of which were common to all trial sites in the EEC. All cultivars matured earlier than in previous years. The highest yielding cultivar was the early maturing Diana with 5.2 t/ha, which compares with an average of 4.3 t/ha for the trial.

Strubes and Wierboon gave about 5 t/ha and were only slightly later maturing than Diana. In previous years the large seeded Minica has given the highest yield but this year its yield was only 4.2 t/ha. Overall, yields were lower than in previous years, presumably because of the very dry conditions.

(R. Thompson, H. Taylor, Janet E. Brinklow)

Fodder pea; EEC joint cultivar trial.

Of the nine pea cultivars included, four unnamed (159-5, 159-6, 347-1 and 347-5) semi-leafless types were earliest, reaching maturity in the first week of August, with yields of about 4 t/ha. Amino gave the highest yield among the conventional types with 5.0 t/ha, but did not reach maturity until about mid-August.

(R. Thompson, H. Taylor, Janet E. Brinklow)

Field bean: Cultivar observation plots.

Breeding lines from a number of sources have again been examined with the main objective of identifying early maturing material. The earliest were determinate types derived from the Sjödin mutant, about 10 days earlier than cv. Maris Bead, but yield from these was low at about 3 t/ha compared with 4.8 t/ha for Maris Bead. A population (64/16) derived from the PBI/SCRI breeding programme was 7 days earlier than Maris Bead and gave a yield of 4.4 t/ha. A number of other populations from this programme also looked promising and will be re-assessed in 1983.

(R. Thompson, H. Taylor, Janet E. Brinklow)

Field bean: Measured maximum MM yield.

Four cultivars – Aquadulce, Minica, Giza and Herz Freya – have again been grown in normal field soil with and without irrigation, and in MM conditions.

In three of the cultivars the yields of the MM and irrigated soil plots were similar. Mean values were 3, 4.7 and 7.3 t/ha for Aquadulce, Giza and Herz Freya respectively. Minica yielded at the rate of 10 t/ha in the MM plot and 6.8 t/ha in the irrigated soil plots. Yields from the control plots for all cultivars differed little and averaged 3.8 t/ha. Harvest index was lowest in the MM plot for all cultivars, with an average of 37%, but somewhat surprisingly those in the irrigated soil and non-irrigated control were similar with averages of 50 and 54% respectively.

Of the cultivars grown in MM conditions Minica gave the highest efficiency of light utilisation, with a final value of about 0.9 g total dry matter/MJ of intercepted radiation, the least efficient being Giza with 0.5 g/MJ.

(R. Thompson, H. Taylor, Janet E. Brinklow)

Field bean: Competition and pod set.

Previously (SHRI Ann. Rep. 1979, p.37 and 1980 p.64) it has been reported that by increasing the spacing of close spaced pot grown field beans for a short period during flowering, marked increases in pod set may occur. An obvious implication is that competition for light in some way controls pod set. To examine this possibility in more detail plants of the cultivars Minica and Herz Freya were grown at close and wide spacings with periodic transfer between the two as before. Other plants were grown with overhead shade allowing the passage of 23% of total incident radiation or with close fitting vertical cylinders (socks) which allowed through 5% of light. Plants were grown in each of these treatments throughout the season. Sets of plants were transferred between close spacing, wide spacing and overhead shading for about 14 day periods during early and late flowering.

Responses of both cultivars to a period at wide spacing in an otherwise close spaced regime were similar to those found previously. This treatment given at early flowering produced yields of 13 g seed/plant for Minica and 7.6 for Herz Freya. The corresponding values for plants grown continuously at close spacing were 4.3 and 5.6 g seed/plant. Continuous wide spacing gave 27 and 26 g seed/plant for Minica and Herz Freya respectively compared with 20 and 14 g seed/plant for the overhead shading and 26 and 20 g seed/plant for the sock treatment. Harvest indices were similar for the wide spaced and both of the shaded treatments, at 62 and 50% for Minica and Herz Freya respectively. Corresponding values for continuously close spaced plants were 44 and 34%.

Perhaps the most surprising response was that for the sock treatment which was intended to simulate close spacing. Here only the upper leaves were exposed to full light, lower ones being restricted to about 5% of total incoming radiation, but growth and yield were similar to those of the continuously wide-spaced treatment. It seems that a factor other than light intensity was instrumental in determining pod set.

(R. Thompson, H. Taylor, Janet E. Brinklow)

Field bean: Independent floral vascular supply.

Plants with independent vascular supply (IVS) to each flower have been identified by workers at Durham University. The responses of these types to environmental stress have been examined in two experiments.

In one experiment grown at 60 plants/m^2, there was little difference in growth and performance of cv. Maris Bead and IVS line G with or without irrigation.

When grown at a range of plant densities without irrigation, IVS line G produced a maximum of 800 pods/m^2 at 75 plants/m^2, whereas Maris

Bead produced its maximum of 400 pods/m^2 at a density of 40 plants/m^2. However, yields for these two treatments were similar because for IVS line G only about half of the pods produced seed.

(Gretel White[1], R. Thompson, H. Taylor)

FRUIT CROPS

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

Raspberry harvesting.

A plantation of four cultivars was picked by hand and by machine in 1981, and the residual effects of machine harvesting were assessed in 1982 when all plots were hand harvested. In contrast to previous experiments, there were no differences in yield between treatments, possibly because conditions in the dry summer of 1981 did not favour infection by the wound fungus *Leptosphaeria coniothyrium*. The selection 14/106 (10.5 t/ha) outyielded Malling Jewel, Glen Prosen and 33R40 (7 t/ha).

The relationship between machine forward speed and picking efficiency is critical in any economic assessment of machine harvesting. Three forward speeds and three picking head settings of the Littau machine were applied in four replicates in a plantation of Glen Isla. Increasing the vigour of shake (but not forward speed) from 160 to 240 rpm slightly increased the amount of ripe fruit removed from the plants, and increased the proportion of under-ripe and smaller ripe fruit in the sample, Increasing the forward speed from 0.5 to 2 mph also increased the total quantity of fruit removed, but the proportion of under-ripe fruit decreased. More fruit was dropped to the ground at the higher forward speeds so that the quantity of ripe fruit collected by the machine was similar at all speeds.

At present, the benefits of any system of growing or harvesting raspberries must be measured against either Glen Clova or Malling Jewel grown normally and hand picked. Plots of a number of cultivars in a mature plantation were converted to biennial cropping, picked by machine and compared with hand picked annual Malling Jewel. Glen Prosen and 13118/27 outyielded Malling Jewel (6 t/ha) by about 25%, Meeker and Orion by over 50% and 14/106 by 90%. Samples of 14/106 contained very low proportions of under-ripe fruit(<1%).

In a more direct comparison with commercial hand picking, the Littau machine was used to pick a small part of a 6.5 ha field of mature Malling Jewel. It was driven at 1 mph with the picking head frequency set at optimum at each pick as judged by a preliminary pass over an adjacent setting row. Fruit from machine and hand harvested rows was put

[1]Durham University.

through the same mechanical screen to produce screened pulp with debris removed. Six passes of the machine (two passes per week) removed as much screened fruit per row as did hand pickers in five passes (over a longer period). Though fruit recovery by the machine was slightly better than usual, the result mainly reflected the relative inefficiency of the hand picking on the farm.

In response to grower queries and in order to confirm the findings of previous work with the Agricultural Sciences machine, an experiment was conducted to measure the effects on yield and quality of Malling Jewel when picked by the Littau machine only, alternately by machine and hand, and by hand only. There was little difference between the yields of hand only and alternate treatments which each outyielded the machine only treatment by about 40%.

The occurrence of lateral and pedical breakage was observed in machine picked samples of seven cultivars. Glen Moy, Malling Jewel and Glen Isla appeared more susceptible to breakage than 20/64, 9/9, Glen Prosen and Joy.

Samples of machine picked fruit of Glen Isla were passed onto a simple sloping sorting belt built by SIAE, with the object of separating whole and broken fruit. It appeared that in dry conditions and providing the correct slope was maintained, the system could sort out a sample containing very little broken and stalked fruit although some whole fruit was carried over with the broken.

The unusually dry picking season of 1982 undoubtedly contributed to the high quality of machine picked fruit.

(M. R. Cormack)

Fruit retention strength in relation to fruit composition.

As berries ripen they become progressively easier to remove from their receptacles so that any assessment of mechanical harvester efficiency must take into account the distribution of ripeness grades of the fruit presented to the harvester. Previous work has shown a good correlation between titratable acidity (TA) and fruit retention strength (FRS) as measured with a Correx Tension gauge. However, there is significant residual variation and it is not certain that TA is the most relevant indicator of ripeness for harvest.

Examination was made of the relationships between FRS, TA, soluble solids (SS) and berry colour at two harvest dates, and for berries removed separately from the upper, middle and lower portions of the fruiting areas. The relationship between FRS and TA again accounted for much of the variation and it was not significantly improved by taking account of SS, colour and fruit position on the cane. However, the data revealed some interesting relationships between SS, colour, position of fruit on the canes and date of harvest. For equal ripeness grades, based

on colour, there were differences in SS at different positions. Fruit at the top of the cane contained 3% more soluble solids than that from the lower third. This difference was maintained at different harvest dates though the absolute SS levels varied between dates.

It is concluded that titratable acidity remains the best indicator of fruit maturity in relation to ease of harvest but further work is needed to determine whether there is a causal relationship between a decrease in acidity and the weakening of the attachment between the fruit and its receptacle.

(D. T. Mason)

01018 *Control of growth, yield and quality of raspberries by cultural methods and choice of genotype.*

Cane vigour control.

In a cane management experiment in cv. Malling Jewel commencing in 1981, removal of the first flush of young canes in that spring increased mean berry weight but not the numbers of berries produced by the current year's fruiting canes. Growth of replacement canes was much less than that of first-flush canes on untreated plots, leading to *ca.* 30% less cane length being available for fruiting in the following year. However, replacement canes produced more and bigger berries per unit length in 1982, resulting in fruit yields no less than on untreated plots. This occurred whether or not cane removal had been repeated in the second year. Replacement canes showed a lower incidence of cane blight (*Leptosphaeria coniothyrium*) than was recorded in first-flush canes. Raspberry cane midge was of negligible importance in 1981 in this plantation.

(H. M. Lawson, B. Williamson)

Glufosinate applied at 0.6 kg a.i./ha when young canes were 5-10 cm or 25-30 cm tall showed promise as a cane desiccant. Although much slower acting than dinoseb-in-oil, it eventually produced a high degree of desiccation of treated canes. There was no evidence of translocation to fruiting canes or into replacement canes. End-of-season records showed that replacement canes on plots treated with glufosinate had produced as much total growth as those on plots treated with dinoseb-in-oil.

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

National Fruit Trial 1980.

Although cane development in 1981 was less than satisfactory and the 1981/82 winter weather was severe, appreciable cane death occurred in only one selection, 2662/32, and fruit yields in 1982 were generally good. Selections 2447/78, 3662/32, 3650/3 and 3650/6 produced yields similar to that of Malling Jewel (ca. 9 t/ha) and the rest cropped at a level

similar to Glen Clova (ca. 16 t/ha). Heaviest yields were produced by Glen Moy (20 t/ha) and the largest fruited selection, 3655/56 (18 t/ha).

Glen Moy and 3887/113 ripened slightly earlier than Glen Clova and 3650/3 and 3650/6 distinctly later than Joy.

(M. R. Cormack)

01019 *Control of growth, yield and quality of strawberries by cultural methods and choice of genotypes.*

Cultivars from the Pacific Northwest.

This trial was completed in 1982 when the third full crop was harvested.

The plants in two of the four replicates were defoliated early in August 1980 and 1981 after the first and second full harvests. In contrast to past experiments where massive increases in yields had been recorded in some cultivars, there was limited response to defoliation except in 1982 when yields from defoliated Olympus were more than double those from intact plants. Data from post-harvest dissections indicated that this difference was due mainly to a higher proportion of crowns producing primary trusses in defoliated plants than in intact.

Level and pattern of cropping in 1982 was similar to that of the previous year. The majority of cultivars outyielded Cambridge Favourite (14 t/ha). The lightest crop was recorded from Totem (9 t/ha), a yield which could be much improved by growing matted rows instead of the spaced plants of this trial. Jurica (26 t/ha), 69GU94 (23 t/ha), Troubadour (18 t/ha) and Olympus (17 t/ha) produced the heaviest yields.

(M. R. Cormack)

The balance between the fruiting and vegetative phases in the strawberry.

Factors affecting the balance between the fruiting and vegetative phases of strawberry have been studied in the field and in controlled environments over a 3-year period.

Growth and development of the vigorous cv. Saladin, which responds to defoliation, were compared with those of cv. Cambridge Favourite which does not. Saladin produced a greater amount of dry matter in all of its plant parts, and there was some evidence of greater proportional allocation to fruit than in Cambridge Favourite. Its yield was therefore appreciably higher. Cambridge Favourite diverted a greater proportion of its dry matter to runners. When Saladin was defoliated in the year after planting there was a small yield response in the following year. Defoliation in both the planting year and in the first cropping year led to production of more inflorescences per crown in Saladin, but total growth was less and yield was reduced relative to intact Saladin. These effects were demonstrated by taking regular samples for growth analysis.

In a pot experiment it was shown that the defoliation effect on inflorescence initiation in Saladin could be equalled or exceeded in intact plants by artificially shortening the daylength for 54 days from 7 August.

Non-induced and induced plants of Cambridge Favourite were produced in controlled environment rooms by adjusting daylength and temperature. When planted in the field in May both treatments gave higher crown numbers and initiated more inflorescences per crown than conventional runner plants, and produced higher yields in the following year.

Batches of non-induced plants of Cambridge Favourite and an unnamed seedling were placed in pots outdoors at successive fortnightly intervals during spring and early summer. In the first year they produced responses ranging from heavy cropping with no runnering, to vigorous runnering and no cropping, depending upon the temperature and daylength conditions to which they were first exposed. It was shown that, prior to planting, these non-induced plants could be held for several weeks at 2°C without harmful effects and without initiating flowers.

Experiments on micropropagation of Cambridge Favourite demonstrated that the rooting phase could be shortened by culturing on agar containing only mineral nutrients instead of the full rooting medium used by other workers. The plants produced in this way grew and fruited normally.

(H. M. A. Wahdan[1], P. D. Waister)

Matted row plots of cv. Cambridge Favourite (3-year old) had all leaves and leaf stems removed once in spring/early summer 1982. Treatments were carried out at weekly intervals from 23 April until 28 May. All defoliated plots rapidly produced a further flush of leaves. but those treated on 23 April and (to a lesser extent) on 30 April showed a higher incidence of frosted flowers following a severe frost in early May than plots which still had their foliage at that date.

Fruit yields showed 20-25% reductions in comparison with untreated plots for those defoliated 30 April to 21 May inclusive, but *ca.* 30% for those defoliated on 23 April and 28 May. Yield loss was attributable to reductions in both numbers and mean size of berry. Despite these effects on fruit production, destructive crown counts taken in autumn 1982 showed no differences in numbers or weights of crowns sampled from treated or untreated plots.

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

Desiccant evaluation.

Glufosinate was compared against dinoseb-in-oil and paraquat for runner control. Although relatively slow-acting, rates of 0.6, 0.9 and 1.2 kg

[1]Institute of Horticulture, Cairo.

a.i./ha produced final levels of desiccation equivalent to those obtained with dinoseb-in-oil, but not quite as high as with paraquat. There was relatively little response to increased dose.

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

01012 *Ecology of new fruit crops for Scotland.*

Rubus species.

In a year when yields were considerably lower than usual, the blackberries cv. Bedford Giant and cv. Ashton Cross produced about 10t/ha. Extensive cane death noted in spring may have resulted from severe winter weather, the fungus *Clathridium corticola* (see Mycology and Bacteriology report p.121) or a combination of both.

(M. R. Cormack)

Vaccinium species.

Irrigation significantly increased the crop from mature plants of highbush blueberries in the very dry summer of 1982. Yield of cv. Berkeley was increased by 160% and fruit size by 40%. Cv. Bluecrop was less responsive (40% more yield and 30% larger fruit), which might indicate a greater drought tolerance.

In the final year of a cranberry cultivar trial planted in 1971, CN and Franklin produced the heaviest yields (4.9 and 3.6 t/ha). These yields are not high in comparison with other soft fruit crops, but it should be noted that these moisture-demanding plants were grown without irrigation.

(M. R. Cormack)

CHEMISTRY

M. J. ALLISON

As in previous years, the main work of the department was concerned with the routine estimation of quality factors important in plant breeding. Routine chemical analyses included estimations of SMCO in brassica (1,850 samples), estimations of thiocyanates in brassica (900 samples), estimations of alpha and beta amylase in barley (650 samples and 1,000 samples repectively), estimations of nitrogen (1,950 barley and brassica samples), estimates of malting quality (550 samples), estimates of reducing sugars (500 samples), estimates of protein content (400 samples), estimates of the digestibility of kale (900 samples) and estimates of glycoalkaloids in potato (30 samples). During the year a malt analyser developed by the Carlsberg laboratories was acquired as part of our malting quality assessment procedures. In this assessment method, grain modification is estimated by fluorescent staining of unmodified cell walls, using the stain calcafluor white M2R. Research work on routine methods included the development of an auto-analyser method for the estimations of sugar and protein in both potato tubers and swede bulbs with the aim also of attempting to estimate these factors by near infra-red analysis (NIR).

There was an increase in electrophoretic work this year, mainly SDS PAGE separations of barley hordein proteins as a means of monitoring the transfer of male genes in crosses using irradiated pollen. Results from electrophoresis were in agreement with evidence from scores made of agronomic characters, which showed that the irradiated pollen method can be used to achieve limited male gene transfer in barley. Furthermore, it was observed that variants with novel hordein patterns are generated by the irradiated pollen method. A number of variants had new hordein bands in the low molecular weight range (<40,000). Because the low molecular weight A hordeins (<30,000) are nutritionally superior to the B and C hordeins (40,000 to 70,000), these new variants may have an improved nutritional quality.

Regression equations derived from NIR for the rapid estimation of spore counts for the barley diseases, powdery mildew, brown and yellow rusts, were used successfully this year for routine spore counting. Haemocytometer and NIR estimated spore counts were highly correlated ($r<0.95$) and the spore concentration was extended from 60,000 per ml (original calibration) up to 90,000 per ml. In addition, preliminary

experiments indicated that this rapid method of spore counting could be extended to include the spores of powdery mildew of brassicas.

During the course of some collaborative work on digestibility with J. White[1], high correlations (r = 0.98) were observed between *in vitro* (using cellulases) and NIR estimations of Italian ryegrass digestibility. A regression equation derived from a population of kale cultivars was also successful in predicting the digestibility of the Italian ryegrass samples (r = 0.95 for NIR predicted versus cellulase estimates). Both grass and kale populations used for calibration ranged widely in digestibility (DOMD range of 20%). When the equation was used to estimate the digestibility of some current kale cultivars with a narrow range of digestibility (DOMD = 7 units), the results were less successful. Some collaborative research on relative digestibility of cell walls in different tissues in kales is progressing well.

Other collaborative work included promising results on the NIR estimation of fibre content of hay (samples from Northern Ireland College of Agriculture) and preliminary work on developing a NIR method for mite damage in cereal flour (collaboration with MAFF Laboratories, Slough). Further attempts to estimate the hot water extract values of barley malt from NIR scans of grain flour were unsuccessful, but good progress was made in developing an NIR equation for the rapid estimation of sugars in swede bulbs. This equation plus one for the rapid estimation of SMCO in kale will be rigorously tested on the coming year's breeding material.

All of the data processing for both malting quality and digestibility assessment is now dealt with electronically starting with the transfer of balance weights into our Apple microcomputer to the completion of the calculated results. New software for data produced by the Neotec 6350 is being developed and is nearing completion. The software includes principal components analysis and normalisation of spectral data for efficient wavelength selection, both to be used via the EMAS link.

07002 *Brassicas: develop and apply screening tests for useful and harmful biochemical components in brassicas and related species.*

S-Methylcysteinesulphoxide (SMCO).

This toxic factor which can cause haemolytic anaemia in kale-fed ruminants was estimated again this year by both haemocytometer and NIR methods. One NIR equation calibrated for the estimation of the SMCO content of cv. Maris Kestrel leaves was unsuccessful when applied to other kale cultivars currently in use (r = <0.4), and the correlation did not improve significantly when these cultivars were used as the calibration population.

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[1]NIAB.

Thiocyanates.

In earlier analyses over the past 2 years, rape samples (whole plant) have been uniformly low in their indoleglucosinolate content (measured as the release of thiocyanate ions). Thus it seemed likely that some other glucosinolate is the main goitrogen or goitrogen precursor in rape. This possibility received support from experiments at FRI which showed that the main glucosinolate in rape is a progoitrin. Methods are currently being developed for the measurement of progoitrin in SCRI breeding material.

Reducing sugars.

The reducing sugar contents of cores from swede bulbs of different cultivars were estimated by a sensitive autoanalyser method and the samples ranged widely in sugar content. Preliminary results indicate that the reducing sugar content of swede bulbs could be estimated by NIR.

(R. Borzucki)

07011 *Brassicas: breed kale and fodder cabbage cultivars.*

An NIR prediction equation which was successful in estimating the digestibility of kale from polycross populations (originating from a wide genetic base including kale, brussels sprout and cabbage) was also successful when applied to Italian ryegrass ($r = 0.95$ for cellulase versus NIR predicted digestibility). These results indicate that common factors may limit digestibility in both grasses and brassicas. When this equation was applied to a new breeding population of current kale cultivars with a narrow range of digestibility ($= 7$ units of DOMD) estimates correlated poorly ($r = <0.4$) with the *in vitro* values obtained using cellulases.

An investigation of digestibility in kale was initiated in collaboration with Dr M. C. Jarvis[1]. In this investigation, cell walls were obtained from leaf and stem fractions of kale cultivars known to differ in digestibility. Initial results show that yields of cell walls and dry matter percentage vary significantly between cultivars.

(I. A. Cowe)

08009 *Barley: study biochemical components of barley and oat grains related to malting, feeding and processing quality.*

SDS PAGE separations of barley hordein proteins were used to monitor male gene transfer in irradiated pollen crosses. These added further confirmation to results for agronomic characters, which show that limited genetic transfer of male genes can be achieved in barley by the irradiated pollen method. Secondly, it was shown that novel hordein patterns can be generated by this technique. As the hordeins are extracted from a single endosperm slice, and the embryo can be grown

[1]Glasgow University, Agricultural Chemistry Department.

on, the variants can be grown and used to study any hordein protein changes which may affect malting and feeding quality. Some variants had extra hordein bands in the low molecular weight range, 17 to 35 kilodaltons and these are of particular interest as the A proteins (low molecular weight hordein) are nutritionally superior to the B and C hordeins (40,000 to 70,000) in barley.

(M. J. Allison)

08010 *Develop and automate small scale tests for malting, distilling, brewing and milling quality.*

The malt analyser system developed at Carlsberg was added to our battery of malting quality tests. In this analysis malted grains are embedded in clay, sanded down and the endosperm cells are stained with calcaflour white M2R, a fluoroscent dye which binds to certain beta glucan linkages. When viewed under a uv. lamp, the amount of fluorescence indicates the extent of cell wall breakdown, and so modification can be monitored after malting, and related to extract.

(I. A. Cowe, F. Bruce)

DATA PROCESSING

PAULINE B. TOPHAM

Data Processing and Statistics (Pentlandfield).

There has been a large increase in the use of computing facilities during 1982, both ERCC mainframes and Apple microcomputers.

Use of the ERCC mainframes has increased, partly because the Potato Breeding Department has computerised much of its breeding programme using the data base package CHIP written within that department, and partly because of increasing awareness of the benefits of using computers. The number of jobs using ERCC facilities was 10,737, more than double that of the previous year.

During the year a terminal control processor (TCP) was leased from ERCC. This allows eight terminals to be linked simultaneously to EMAS; four have been sited in the data processing room and the other four at strategic points throughout the Institute. The card-punch contract was terminated as its work was taken over completely by key-to-disk data entry on the Apples. A hard-disk for the Apples was purchased at the end of the year to allow faster program development and use of larger data bases.

The seven Apple microcomputers are now accepted as an integral part of the overall computer configuration and are widely used not only for automatic data capture from electronic balances and hand-held data terminals, but also for label printing, key-to-disk data entry, text processing, data manipulation and data analysis.

Existing Apple programs written for general use were updated and several were added: DRUM facilitates key-to-disk data entry, DATAFILER allows the manipulation of data in text files, RANDOM produces uniformly distributed random numbers and random permutations, and REGRESSION allows the user to examine the fit of a regression line on a screen display. All these were documented.

Work is being carried out jointly with ARCUS to examine the calibration equations used by the Neotec 6350 scanning infra-red analyser in the Chemistry Department; software has been written to enable the Neotec to communicate with an Apple. Programs are being written for the Apples to perform routine digestibility estimations in the Chemistry Department.

Introductory courses for both EMAS and the Apples are now provided on demand, and notes to accompany these courses are available.

Statistical consultancy continued as before, but now that the development work for the Apples has been completed there will be scope for a more sustained effort in this direction.

(J. W. McNicol, R. Kidger)

Statistics (Mylnefield).

Programs for chi-squared analysis of contingency tables, regression and 1-sample statistics were added to the statistics programs available on the Apple.

(J. Cowan)

Miss Bryan-Jones of ARCUS developed a procedure to compute ED50 values for scored infectivity titrations, part of a procedure to determine potato tuber susceptibility to infection by soft rot *Erwinias*.

Shoot strength of black currant bushes seems likely to be an important yield component in high yielding cultivars. A screening technique is being developed to separate the contributions of shoot diameter and springiness and to estimate the modulus of elasticity.

(Barbara M. Tulloch[1], P. Smith)

Multivariate techniques are being applied in several fields: principal co-ordinate analysis of RNA hybridisation in 13 strains of tobra-virus has produced a useful visual display of their relationships; cluster analysis of the nematode genus *Helicotylenchus* and of species of *Xiphenema* is being used to study relationships and morphometrics; methods used to study genotype x environment interactions are being applied to study the interaction between pathogenic organisms and the genotype of the host in several applications.

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

Data Processing (Mylnefield).

A Superbrain QD microcomputer was bought in March to replace one of the control card punches, and has intensified the trend to use micro-computers for data entry.

A Hewlett Packard 7220T graph plotter was attached as a peripheral to the TCP in May. It produces high quality graphs in a variety of colours on paper or transparent paper suitable for overhead projection. Various graphic programs were examined and EASYGRAPH, available on EMAS, was selected for annotated line and scatter plots. Training and help in running EASYGRAPH jobs are given by DP staff and usage is building up, but there is still a need for simple graphics, e.g. for histograms.

Problems were encountered in December when a temporary fault on the paper-tape reader caused reconsideration of the loading of the TCP

[1]Soft Fruit Breeding Department

software. This can now be down-loaded from the node at Edinburgh, a much faster procedure.

An Apple program was written to acquire from a balance graded potato tuber weights, to accept counts from the keyboard, to check mean tuber weight in a grade against a stored profile for the particular cultivar involved and to store the data for transmission to the mainframe. The program was written for a particular experiment, but will be generalised for wider use.

Among various Tektronix developments, the nematode measurement and identification program has been adapted to new applications including measurement of areal cover of *Phragmidium rubi-ideae* on raspberry leaves; areas of syncitia and cell nuclei on photomicrographs; areas of fungal colonies on agar plates, whilst its graphic display facilities were used to show projections of dodecahedral virus particles in different orientations, to assist in the interpretation of negatively stained EM plates.

A series of six seminars on different DP facilities was held at Mylnefield; all DP staff at both sites took part. In addition R. Clark gave introductory courses on EMAS in April and November, each attended by about 10 people, and J. Cowan on graph plotting in October. All facilities except the System One showed increased use since 1981 (Table 1) and the DP rooms are now very overcrowded.

(Pauline B. Topham, R. Clark, J. Cowan, P. Smith).

Table 1 – *Use of Data Processing Facilities at Mylnefield.*

	ERCC 2980 %	Tektronix 4051 %	System One %	Graph Plotter %	Apple II %	Superbrain QD %
Physiology and Crop Production	25.4	17.5	12.7	30.1	70.8	93.1
Mycology and Bacteriology	19.5	7.1	9.5	40.3	11.5	3.8
Plant Breeding	20.0	15.1	54.9	–	4.8	1.5
Virology	1.7	34.5	0.1	–	–	–
Zoology	10.4	18.2	11.1	2.1	11.5	1.5
DP Group	21.1	13.5	–	27.4	–	–
Other	1.9	0.8	11.6	–	1.5	–
Usage[1] 1982	12203	650.4	875.8	226	430.7	390.3
Usage 1981	8947	626.4	1051.2	–	–	–
%Change	+36.4	+3.8	−16.7	–	–	–

[1]Units: hours of use, except for 2980 (log ons) and graph plotter (graphs).

Data Management (Mylnefield).

Support continued for bibliographies, catalogues and address lists; specialist catalogues connected with raspberries and black currants were maintained and were used by overseas and local scientists.

Work was started in June with the Field Experiments Officer, G. Wood, on an analysis of the way information on field experiments was generated, stored and analysed. Two main areas emerged where computing techniques could help. The first was the storage and retrieval of field experiments records; data base management systems were considered and discarded in favour of an Apple II based system from the Farm Plan Company which can be adapted to maintain records on the annual turnover of about 200 experiments and provide summaries and management information. The second was the time-consuming task of allocating land to experiments in an optimal way subject to constraints of irrigation, etc. A program is being developed on the Tektronix 4051 to draw plans using a heuristic approach.

The EMAS system is being used to compile information on herbicides for soft fruit and rhubarb for use by horticultural advisers. The file contains data on 140 weed species and 40 herbicides. Advisers in offices around the country will be able to access the latest information on weed control in these crops. The file has been made available to a few potential users for evaluation and comment before general release.

Data contributed to the European Plant Parasitic Nematode Survey was used to produce a Distribution Atlas of the Netherlands; a Belgian Atlas is also under preparation. Scientists from Spain and Belgium spent periods at the Institute analysing their data, and collaborative studies of biogeographic variation were initiated. A trial of the RAPPORT data base management systems was carried out with the help of the ERCC, and this system will be used to co-ordinate the various national data bases into a single European collection.

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

VIROLOGY

B. D. HARRISON

An important event during the year was the commissioning of the new Virology glasshouse block. This provides a greatly improved standard of accommodation for culturing viruses and for doing infection experiments with plants. All cubicles are provided with thermostatically controlled steam heating, with supplementary lighting, and with screens to exclude insect vectors and pests; some cubicles are also equipped with forced air ventilation for cooling in summer. A special facility provides for the safe containment of any exotic viruses being studied. The headerhouse includes specialised laboratory areas and controlled temperature rooms for culturing plants or vector insects, and connects directly with a glasshouse in which healthy test plants are grown. By December, the move into the new building was almost completed, with only slight disruption of the research programme.

Several of the lines of research pursued during the past year concern the extent of natural variation occurring among strains of individual viruses. Work on tomato black ring virus, a nepovirus, indicated that the sequence of nucleotides at one end of genome RNA molecules is remarkably constant. Tests on a tobravirus isolate from Italy provided evidence of the first possible example of a naturally occurring pseudo-recombinant isolate (a virus obtained by mixing parts of the genomes of other virus isolates). Work on tobacco rattle virus showed that the antigenic variation between isolates from *Narcissus* is so great that conventional serological tests failed to detect many of them, although all could be identified by a test that uses complementary DNA. Studies on raspberry bushy dwarf virus confirmed the existence in southern England of a resistance-breaking strain that seems to pose a potential threat to Scottish raspberry crops.

Among other noteworthy findings described below are the transfer between serologically unrelated viruses of a small circular RNA species that has properties of a satellite RNA and alters the severity of symptoms produced by the recipient virus; detection of small circular DNA molecules in particles of cassava latent virus; application to virus diagnosis of a 'dot-blotting' technique based on the use of radioactive probes obtained by cloning virus DNA; data on the morphology of particles of a nepovirus; and progress in analysing the mechanism of hypersensitive resistance of potato plants to potato virus Y.

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

Comparison of genomes of tobravirus strains

Previous detailed studies on the two genome parts of three strains of tobacco rattle virus (TRV) showed that, in strains ORE-Y and SYM, the RNA-1 species are very similar in nucleotide sequence but the RNA-2 species have no detectable sequence homology with one another. Also, no homology was detected between either RNA species of these serotype I/II strains and the corresponding species of strain CAM (serotype III). To obtain a more complete picture of the sequence relationships between tobravirus genomes, unfractionated genome RNA was prepared from 15 strains and complementary DNA (cDNA) copies of nine of these preparations were made and used in hybridization experiments.

Nucleic acid preparations from ten TRV strains of serotype I/II, comprising three from Scotland, two from England, three from the USA and one each from Japan and New Zealand, cross-hybridized in all combinations tested. All the RNA preparations hybridized with the cDNA to strain ORE-Y about as well or better than did RNA of strain SYM, and they hybridized with cDNA to strain SYM at least as well as did RNA of strain ORE-Y. The only simple explanation of this observation is that all 10 strains have substantial nucleotide sequence homology in their RNA-1 species. Some combinations of RNA and cDNA hybridized to a greater extent than happened when strains SYM and ORE-Y were compared, probably because of sequence homology in the RNA-2 species in such instances. Strain CAM, the only well-characterized member of TRV serotype III, showed no significant cross-hybridization with any of the other 14 tobravirus isolates.

Two strains of the English serotype of pea early-browning virus (PEBV) proved to be similar to one another in nucleotide sequence, but showed little or no cross-hybridization with any of the TRV strains. However, strain Italy 6, previously classified as an atypical strain of PEBV, cross-hybridized with both PEBV and TRV serotype I/II strains, including strain SYM. It produced symptoms typical of TRV in *Phaseolus vulgaris,* but its particles all reacted with PEBV antiserum and not with TRV (strain PRN) antiserum. Thus strain Italy 6 seems to share properties both with TRV and with PEBV, but is not a mixed culture of the two viruses. cDNA copies of RNA-2 of strain Italy 6 hybridized strongly with RNA of PEBV, but not with RNA of TRV strain SYM. It seems therefore that strain Italy 6 contains an RNA-2 species similar in sequence to that of PEBV and an RNA-1 species consisting largely or completely of sequences typical of RNA-1 of TRV serotype I/II. Strain Italy 6 therefore seems to have arisen as a pseudo-recombinant between TRV and PEBV.

cDNA copies of RNA from broad bean yellow band virus (BBYBV), another tobravirus from Italy (supplied by Professor G. P. Martelli[1]), hybridized with RNA of an English strain of PEBV, although less extensively than with its homologous RNA, but did not hybridize with RNA of strain Italy 6 or of any of the TRV strains. This result suggests that BBYBV has sequences in common with RNA-1 of PEBV, but not with RNA-2 of the English strain; it may represent a new serotype of PEBV.

(D. J. Robinson)

Effects of actinomycin D on infection of protoplasts

Earlier work showed that infection of tobacco protoplasts by inoculation with particles of TRV can be diminished by adding actinomycin D or cordycepin (inhibitors of DNA-dependent RNA synthesis) to cultures immediately after inoculation, but not by adding them after a delay of about 3 h. In further work, similar effects were found on infection by tobacco mosaic, tobacco ringspot and potato leafroll viruses. In contrast, actinomycin D did not prevent infection of protoplasts when it was added to cultures immediately after inoculation with RNA from either TRV or tobacco mosaic virus. These results suggest that infecting particles of these viruses take up to 3 h to uncoat and release infective RNA, and that actinomycin D prevents uncoating itself or a step in replication that occurs soon after uncoating.

(M. A. Mayo, H. Barker)

NEPOVIRUSES

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

Comparison of nucleotide sequences of RNA species of tomato black ring virus (TBRV)

Hybridization experiments with complementary DNA (cDNA) have previously shown that each of the two species of genome RNA of the Scottish serotype of TBRV has only limited homology with the corresponding species of the German serotype, about 30% in RNA-1 and about 10% in RNA-2; also that no sequence homology could be detected between RNA-1 and RNA-2 of the same serotype.

In further work, the nucleotide sequence adjacent to the 3′ polyadenylate tract of each RNA species was determined by the dideoxynucleotide chain-termination method. Extensive sequence similarities between these regions of RNA-1 and RNA-2 were found with both serotypes. A strain of the Scottish serotype has only one difference in 121 nucleotides, and one of the German serotype has only two differences in 142 nucleotides. In addition there is much sequence similarity between the serotypes: in RNA-1, 108 residues out of 130 (83%) were homologous, and in RNA-2, 109 residues out of 129 (84%).

[1]Istituto di Patologia Vegetale, Bari, Italy.

The 3′-terminal sequences of these molecules were found to be rich in uridine residues; for example, the composition of the RNA-1 (German serotype) sequence is 49% uridine, 20% adenosine, 14% cytidine and 17% guanosine. Translation termination codons occur in all three reading frames of all the sequences. The sequence AUAAA is common to both RNA species of both serotypes and may represent a polyadenylylation signal. A sequence of 17 nucleotides in all four RNA molecules also occurs in RNA-2 of cowpea mosaic virus, a member of the comovirus group. Possible secondary structures were explored using a computer programme that searches for the conformation with minimum free energy. The most stable structures for the sequenced regions of all four RNA molecules were similar, despite individual base changes.

(Sarah M. Dodd, D. J. Robinson)

Homologies between RNA species of different nepoviruses

The nucleotide sequences of the genome RNA of several nepoviruses were compared with those of the genome RNA species of TBRV by hybridization experiments with complementary DNA. cDNA copies of TBRV RNA-1 and RNA-2 (both Scottish and German serotypes) were hybridized with unfractionated genome RNA of each virus in amounts sufficient to ensure complete reaction. No sequence homology was detected between TBRV RNA and RNA from mulberry ringspot, myrobalan latent ringspot, arabis mosaic, raspberry ringspot or strawberry latent ringspot viruses. Grapevine chrome mosaic virus was found to have about 20% of its RNA-2 sequences and about 5% of its RNA-1 sequences in common with TBRV (German serotype), but little if any in common with the Scottish serotype.

(Sarah M. Dodd, D. J. Robinson)

Satellite RNA of tomato black ring virus (TBRV)

Satellite RNA molecules of mol.wt. about 0.5×10^6 were previously found in cultures of two isolates of the Scottish serotype of TBRV and three of the German serotype, and evidence was obtained of a substantial difference in nucleotide sequence between satellite RNA species associated with the two virus serotypes. In further work, satellite RNA of mol.wt. 0.4×10^6, estimated by electrophoresis of glyoxylated RNA in agarose gels, was found in two other TBRV isolates of the Scottish serotype. These smaller satellite RNA species seem to occur in greater concentration in TBRV preparations than do the species of mol.wt. 0.5×10^6.

(A. F. Murant, J. H. Raschké)

TBRV cultures containing satellite RNA of mol.wt. 0.5×10^6 produce particles with a variety of buoyant densities, in addition to those found in satellite-free cultures. The buoyant densities in CsCl were determined previously: the RNA contents can be calculated from mol.wt. values

obtained by electrophoresing glyoxyl-denatured RNA in agarose gels, and by assuming that each particle contains 60 protein subunits of mol.wt. 57,000. The observed buoyant densities (ρ.) do not fit well with those predicted by the widely used empirical relationship:

$$\rho = 1.31740 - 0.00101\ (\text{RNA}\%) + 0.00013\ (\text{RNA}\%)^2$$

(Sehgal *et. al., Phytopathology 60,* 1778,1970).

Instead the data fall on a straight line when $1/\rho$ is plotted against RNA%. This is in agreement with the relationship expected on theoretical grounds:

$$1/\rho = \text{RNA}\% \left(\frac{\bar{V}_N - \bar{V}_P}{100}\right) + \bar{V}_P$$

where $\bar{V}_N$ and $\bar{V}_P$ are the partial specific volumes of the nucleic acid and protein moieties respectively.

(A. F. Murant)

Properties of the satellite RNA of strawberry latent ringspot virus (SLRV)

Previous work showed that particles of the type isolate (T39) of SLRV contain three RNA species. It was suggested that the smallest (RNA-3), which is not essential for the multiplication of SLRV, is a satellite RNA. When DNA complementary to RNA-3 was hybridized with RNA from an isolate derived from T39 but lacking RNA-3, no more than about 30% of the DNA reacted. Thus at least 70% of the sequence of RNA-3 does not occur in the SLRV genome. cDNA was also used to test for RNA-3 in extracts of *Nicotiana clevelandii* plants which had been inoculated with purified RNA-3, but none was detected. As a more sensitive test, similar extracts were mixed with RNA from an isolate lacking RNA-3 and inoculated to *N. clevelandii.* RNA-3 was detected in the inoculated leaves in extracts made 2 h after inoculation (presumably because some inoculum was retained in an infective state) but not in extracts made 7 days after inoculation. These results confirm that RNA-3 cannot replicate independently and show that it is a satellite RNA, not a subgenomic fragment.

The satellite RNA did not alter the symptoms induced by SLRV in a range of plant species, but in messenger-dependent reticulocyte lysates it was translated into a single methionine-containing polypeptide with a mol. wt. of about 38,000, corresponding to almost the whole length of the RNA molecules (mol.wt. *ca.* 4×10^5). In these properties, SLRV satellite RNA resembles the satellite RNA of tomato black ring virus. Both satellites also contain a polyadenylate sequence, are linked to a genome protein and in purified preparations of virus particles they do not exceed in abundance the RNA of their helper virus.

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

Structural features on nepovirus particles

Particles of tobacco ringspot virus were trapped on carbon/plastic filmed grids by immunosorbent electron microscopy to give controlled, even distributions of particles on the grids, then freeze-dried using a special module (SHRI Ann. Rep. 1978, p.110), and shadowed at 45° with uranium. When treated in this way, many particles showed knobs arranged with regular symmetry. Examination of enlargements of defocussed micrographs in an adapted microfiche reader showed the knobs to be capsomeres arranged as in a T – 1 structure. Micrographs of individual particles could be matched with pictures of models of a T = 1 structure comprising 60 subunits, which is therefore thought to be the structure of the protein coat of particles of this virus and probably of other nepoviruses.

(I. M. Roberts)

Polypeptides in particles of cherry rasp leaf virus (CRLV), a possible nepovirus

Previous work showed that the raspberry isolate of CRLV resembles nepoviruses in some properties but unlike them possesses two coat protein polypeptides of mol.wt. about 20,000 and 22,000 instead of one of mol.wt. about 55,000. In further work with this isolate, and a cherry isolate from Canada, some protein preparations were found to consist mainly of three polypeptides (mol.wt. 24,000, 16,000, 15,000), whereas others contained predominantly one polypeptide of mol.wt. 55,000, even after denaturation with 8 M urea. The 55,000 mol.wt. protein was found in virus purified from cucumber, or from *C. quinoa* plants harvested at different intervals after inoculation, and in virus that was further purified by centrifugation to equilibrium in Cs_2SO_4 gradients. No evidence was obtained that it is an aggregate of the smaller polypeptides or that they are its degradation products. Nonetheless the data suggest that particles of CRLV can be modified *in vivo* or *in vitro* to alter their polypeptide composition. Although the mol.wt. of the largest polypeptide is characteristic of nepoviruses, the results obtained indicate that caution is needed when inferring relationships between viruses from the apparent molecular weights of their coat proteins.

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

VIRUSES OF FLOWER BULBS

04010 *Viruses infecting bulbous ornamentals*

Tulip chlorotic blotch virus (TCBV)*

Although both TCBV, a virus found in Australia, and tulip breaking virus can cause the same types of flower-breaking symptoms in tulip, no serological relationship between the two viruses was detected in reciprocal

*Held under DAFS licence.

microprecipitin tests; however, both viruses showed a very distant relationship (serological differentiation index = 13) to bean yellow mosaic virus, another potyvirus. A preparation of protein from particles of TCBV contained two polypeptides of mol.wt. 36,000 and 28,000, the smaller polypeptide probably resulting from proteolysis of the larger. When *Chenopodium amaranticolor* was used as an indicator plant, TCBV was not detected in tulips with flower break symptoms from 19 locations in Great Britain. Thus there is as yet no evidence that TCBV occurs in Great Britain or continental Europe.

(W. P. Mowat)

Diagnosis of tobacco rattle virus (TRV) in Narcissus

A range of tests were compared for detecting and diagnosing TRV infection of *Narcissus*. Field-grown plants of six cultivars with leaf symptoms suggestive of TRV infection all contained readily sap-transmissible virus isolates which produced the typical rod-shaped nucleoprotein particles (M isolates). However, because of their antigenic diversity, less than half of the isolates were identified by immunosorbent electron microscopy and still fewer by enzyme-linked immunosorbent assay using antibody to TRV strain PRN. In contrast, all the isolates were identified by a nucleic acid hybridization test in which DNA complementary to RNA-1 of strain PRN was allowed to react with nucleic acid extracted from leaf tissue. Serological tests therefore seem unsuitable for surveying TRV incidence in *Narcissus* whereas the cDNA procedure seems promising if it can be adapted for handling large numbers of samples.

(W. P. Mowat, B. D. Harrison, D. J. Robinson, G. H. Duncan)

Chocolate spot in Narcissus

Although chocolate spot has long been recorded in plants of commercial stocks of *Narcissus* its cause is not known. This year it was observed for the first time in virus-tested clones. The elongate chocolate-coloured markings developed in plants of single virus-tested clones of the cultivars Golden Harvest and King Alfred in the second year of growth following twin-scale propagation. Plants grown in soil-less compost were affected whereas other plants of the same clones grown in the same gauze house in soil fumigated with methyl bromide were not. None of the viruses known to infect *Narcissus* could be detected in affected plants, and work elsewhere has failed to detect fungal or bacterial pathogens in affected leaves. Thus chocolate spot may be a physiological disorder induced by the environmental conditions.

(W. P. Mowat)

04011 *Production of virus-tested bulb stocks*

Propagation of virus-free Narcissus

In 1982 the seventh annual batch of virus-free clones was released by SCRI at the request of SNSA (Flower Bulbs) Ltd for further rapid multiplication by ESCA and NSCA. The issue consisted of 30 kg of bulbs of the cultivars Carlton, Sempre Avanti, Barrett Browning and Verger. Forty-one clones of five cultivars have now been released by SCRI since the scheme began.

(W. P. Mowat)

Selection of sites for Narcissus *propagation*

With G. M. Mackintosh[1] and W. M. R. Laidlaw[2], 33 field sites have been examined since 1978 for their suitability for propagation of Foundation Stock *Narcissus*. Nematode-borne viruses were detected at only two sites by bait-plant test but none was free from potential nematode vectors. At one site, nematicide treatment (one of the requirements of the DAFS Certification Scheme) proved remarkably effective. Application of dichloropropene (200 litres/ha) decreased the longidorid and trichodorid populations from 35 and 201 nematodes/litre of soil to 3 and < 1 nematode/litre, respectively, within 6 weeks. Three years later, the populations were still < 4 nematodes/litre. The practice of fumigating sites in the year before planting and growing stocks for 2 years before lifting therefore seems to be satisfactory.

(W. P. Mowat, T. J. W. Alphey[3])

Virus-indexing of virus-tested clones

One thousand leaf samples from virus-tested *Narcissus* clones in second stage propagation at ESCA and NSCA were checked by enzyme-linked immunosorbent assay for freedom from narcissus mosaic and narcissus tip necrosis viruses in the year of their release to SNSA (Flower Bulbs) Ltd for field propagation. As in tests on the material in the three previous releases by the Colleges, no infection was found. Likewise, no infection was found in similar tests on 500 plants of the virus-tested clones in the third year of field propagation by SNSA (Flower Bulbs) Ltd. Furthermore, no infection with soil-borne viruses was detected by infectivity tests on 200 plants from the same planting, and visual inspection of the clones did not reveal any virus-like symptoms. Thus the prospects for maintaining the health of virus-tested stocks during long-term field propagation continue to be good.

(W. P. Mowat)

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[1]Dept. of Agricultural Zoology, NSCA.

[2]DAFS, Agricultural Scientific Services, East Craigs.

[3]Zoology Department.

04003 *Viruses infecting raspberry*

Raspberry bushy dwarf virus (RBDV)

Studies at SCRI during the past 14 years have shown that the two main commercial raspberry cultivars, Malling Jewel and Glen Clova, are immune to RBDV isolates common in Scotland. This immunity is determined by a single dominant gene, *Bu*. Recently, however, tests at EMRS showed that these, and some other cultivars considered immune to Scottish isolates of RBDV, can be infected by graft inoculation with an isolate of RBDV (RBDV-RB) found in plants grown from seed imported from the USSR. Furthermore, RBDV was found at EMRS in field-infected plants of Burnetholm Seedling and Malling Delight, cultivars considered immune to Scottish isolates of RBDV. To determine whether these differences in host range are caused by differences in virus strain, environmental conditions or inoculation technique, raspberry plants were graft-inoculated at SCRI and at EMRS with the Scottish type isolate (RBDV-S) and RBDV-RB.* Tests at both locations showed that RBDV-S readily infected Lloyd George but failed to infect Malling Jewel and Glen Clova, whereas RBDV-RB infected all three cultivars. Further tests at SCRI showed that RBDV-RB, but not RBDV-S, can be transmitted by grafting to the raspberry cultivars Glen Moy, Joy and Malling Delight, and to Tayberry. RBDV-RB therefore appears to be a resistance-breaking strain.

Another RBDV isolate, originally obtained from a raspberry plant at EMRS and associated with a severe leaf curling symptom in cv. Norfolk Giant was also found to be a resistance-breaking strain. It is not known whether this RBDV isolate is the same as RBDV-RB nor whether it is the cause of the leaf curling. However, it seems clear that resistance-breaking isolates of RBDV occur in Kent and present a potential threat to the Scottish raspberry crop.

(A. T. Jones, Susan J. Henderson)

Tests were conducted to find a reliable method of distinguishing between normal and resistance-breaking isolates that is more rapid than grafting to indicator raspberry cultivars. A range of RBDV isolates from different red raspberry sources was examined, including the two resistance-breaking isolates described above, but no serological differences were detected, nor were any reliable differences found in extensive host range comparisons.

(A. F. Murant)

*Held under DAFS licence.

Enzyme-linked immunosorbent assay was extensively and successfully used to detect RBDV in *Rubus* species and selections. However after late September, RBDV was not detected reliably in field-grown or glasshouse-grown infected raspberry plants either by this method or by inoculation of sap to *Chenopodium quinoa* test plants.

(Susan J. Henderson, A. T. Jones)

Virus-like symptoms in Tayberry associated with mites

In continuing studies on the severe virus-like symptom observed in Tayberry, various combinations of black raspberry necrosis, raspberry leaf mottle and raspberry leaf spot viruses were found to cause mild chlorotic mottling, but not severe symptoms. Moreover, Tayberry plants derived from root cuttings of severely affected field-grown plants were either symptomless or showed only a mild mottle when grown outdoors, suggesting that virus infection is an unlikely cause of the symptoms. Moreover, several severely affected plants were found to have large infestations of the leaf and bud mite (*Phyllocoptes gracilis*). When severely affected plants in a crop at Forfar were sprayed in early May 1982 with the acaricide vamidothion, leaves on their fruiting canes showed severe symptoms in the summer, but whereas such symptoms also occurred on new canes of unsprayed plants, they did not occur or were uncommon on new canes of sprayed plants. The mean numbers of mites per terminal leaflet on new canes of sprayed and unsprayed plants were 0.9 and 37.8 respectively. These results strongly suggest that the severe virus-like symptoms in Tayberry are induced by *P. gracilis* and not by virus infection.

(A. T. Jones, S. C. Gordon[1])

04004 *Production of virus-tested raspberry stocks*

During the year, six imported *Rubus* species and selections, 16 selections from the *Rubus* breeding programme at SCRI and one from the programme at EMRS were indexed for virus infection. No previously undescribed virus was found. Imported clones found to be infected were either destroyed or, if needed for further study, kept in quarantine conditions. In addition, 54 imported *Ribes* species and selections were tested and found to be free from viruses that are mechanically transmitted to *Chenopodium quinoa, Cucumis sativus* or *Nicotiana clevelandii.*

(Susan J. Henderson, A. T. Jones)

VIRUSES OF UMBELLIFEROUS PLANTS

04007 *Viruses infecting umbelliferous crop plants*

Carrot red leaf and carrot mottle viruses

Nucleic acid preparations from purified particles of carrot red leaf virus contained single-stranded RNA of estimated mol.wt. 1.8×10^6, as indicated

[1]Zoology Department.

by electrophoresis in 2.4% polyacrylamide gels of samples treated with deoxyribonuclease or ribonuclease in conditions of high or low ionic strength. Some preparations obtained from the superficially similar particles purified from plants infected with both carrot viruses contained an additional component that migrated faster than carrot red leaf virus RNA. This component was extracted from agarose/acrylamide gels and shown to possess carrot mottle virus infectivity. These results are consistent with earlier evidence that leaf extracts from *Nicotiana clevelandii* plants infected with carrot mottle virus contain an infective RNA of mol.wt. *ca.* 1.5×10^6.

(A. F. Murant, J. H. Raschké)

Helper-dependent transmission of heracleum latent virus (HLV) by aphids

Further studies confirmed that HLV, a closterovirus with filamentous particles *ca.* 730 nm long, depends on a second closterovirus, heracleum virus 6 (HV6), with filamentous particles *ca.* 1400 nm long, for transmission by the aphid *Cavariella theobaldi*. Aphids did not transmit HLV from any of 20 hogweed plants infected by manual inoculation, or from any of 7 plants that became infected with HLV alone following exposure to aphids from plants infected with both viruses. Also, in 14 experiments, HV6 but not HLV was transmitted by aphids that fed first on a pure source of HV6 and then on a source of HLV. In contrast, both viruses were transmitted from all of 5 hogweed source plants infected first with HLV (by manual inoculation) and then with HV6 (by aphid inoculation). HLV was also transmitted by aphids from coriander plants containing both viruses, although less readily than from hogweed source plants.

(A. F. Murant)

POTATO VIRUSES

04001 *Potato viruses, especially soil-borne viruses*

Detection and diagnosis of tobacco rattle virus (TRV) in potato tubers

Previous work showed that stem-mottle symptoms in potato foliage are usually caused by NM isolates of TRV, which do not produce nucleoprotein particles and cannot be detected serologically but which can be identified by a test that uses DNA complementary to TRV RNA-1. A similar range of tests were applied to potato tubers affected by spraing disease, one type of which is caused by TRV. Affected tubers in some potato stocks yielded only NM isolates of TRV: nucleic acid extracts were infective for test plants whereas previously frozen sap extracts were not. Nucleic acid extracts from recently harvested tubers were much more infective than those prepared from affected tubers after 8 months' storage. In other potato stocks, some spraing-affected tubers contained NM isolates and the rest contained particle-producing isolates (M isolates) of TRV. Infectivity was readily detectable in sap and nucleic acid extracts from

stored tubers infected with M isolates. TRV was detected and identified by nucleic acid hybridization in extracts of almost all tubers infected with M or NM isolates, even when the tubers were stored for up to 8 months before testing.

The apparent rarity of M isolates in potato tubers, the infrequency with which they invade the shoots of daughter plants, and the assumed inability of vector nematodes to transmit NM isolates, suggest that TRV will rarely become established in fields as a result of planting infected potato tubers. Indeed the virus is essentially dependent on weeds and wild plants for its survival.

(B. D. Harrison, D. J. Robinson, G. H. Duncan)

Infection of potato leaf protoplasts with potato virus Y (PVY)

The behaviour of potato virus Y (PVY) was studied in plants and protoplasts from 10 virus-resistant potato clones provided by G. R. Mackay[1]. The clones were derived from crosses between wild *Solanum* spp. (*S. simplicifolium, S. stoloniferum, S. rybinii, S. demissum* and *S. chacoense*) and *S. tuberosum,* and were known to possess comprehensive major gene resistance to PVY. When glasshouse-grown plants of these clones were manually inoculated with PVY, they developed necrotic local lesions and either sporadic or more extensive systemic necrotic symptoms. Graft inoculation resulted in a similar range of systemic necrotic symptoms. However the growth of these clones was less affected than that of susceptible cultivars such as Kerr's Pink.

When protoplasts were inoculated with PVY particles, considerable amounts of virus from the inoculum became attached to the protoplast surface, and infection could not be assessed accurately by staining protoplasts with fluorescent antibody to virus particles. PVY RNA was therefore used as the inoculum in further work, and up to 11% protoplasts were infected, as judged by fluorescent antibody staining. However, no consistent difference was found, in the percentages of protoplasts infected, between Kerr's Pink and any of the 10 resistant clones. Thus the resistance to PVY expressed by the intact plant was not evident in the behaviour of the virus in isolated protoplasts. These results parallel those obtained in work elsewhere on tobacco and tomato cultivars with hypersensitive resistance to infection with tobacco mosaic virus.

(H. Barker, B. D. Harrison)

Behaviour of strains of potato leafroll virus (PLRV) in protoplasts

Of the PLRV strains found in previous work, several were readily aphid-transmitted but differed in the severity of symptoms induced in test plants, and one strain was poorly aphid-transmitted although serologically indistinguishable from the others. This difference in aphid transmissibility

[1]Potato Breeding Department.

was maintained when aphids acquired PLRV by feeding through membranes on purified preparations of virus particles. When mesophyll protoplasts from cv. Kerr's Pink potato were inoculated with purified particles of four selected virus strains, no consistent differences between strains were found in their ability to infect, or in the intensity of fluorescent antibody staining of infected protoplasts. Thus the differences in aphid transmisssibility and effects on plants seem not to reflect large differences in specific infectivity or in the virus content of protoplasts.

(H. Barker, B. D. Harrison)

OTHER VIRUSES

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

Cassava latent virus (CLV)

Preparations of the single-stranded genome DNA of CLV were supplied to collaborators at the JII to prepare clones of bacteriophage M13 containing CLV DNA inserts. They have used these clones to establish that CLV preparations contain two species of circular DNA of almost equal size, and to obtain the complete nucleotide sequences of both species.

In work at SCRI, replicative form DNA from some of these clones was used to prepare ^{32}P-labelled probes by nick-translation. Hybridization of these probes with 'dot-blots' prepared by baking denatured plant sap on nitrocellulose filters was used to detect CLV DNA in infected plants. In particular, two clones of cassava plants with African cassava mosaic disease, but containing no CLV as judged by immunosorbent electron microscopy or infectivity tests, were shown to contain both CLV DNA species in amounts not greatly less than those in cassava plants which contain infective CLV particles. Moreover in graft-transmission tests, scions from plants containing CLV particles induced symptoms in cassava in 3-4wk but only in a proportion of the leaves produced, whereas scions from plants apparently free from CLV particles took longer to produce symptoms but these developed in all leaves. The difference in disease syndrome in the plants apparently lacking CLV particles suggests an analogy with other viruses, defective isolates of which either do not produce coat protein or produce it in a non-functional form.

These results remove a barrier to accepting the idea that CLV is the cause of African cassava mosaic disease. Furthermore, results of enzyme-linked immunosorbent assay showed that CLV occurs in greater concentration in symptom-bearing than in symptom-free parts of the same leaves of particle-containing cassava plants, again emphasising the link between CLV and cassava mosaic.

(D. J. Robinson, J. C. Sequeira, B. D. Harrison)

Particles of CLV were readily disrupted by 0.03% sodium dodecyl sulphate and by alkali. The main component of preparations of virus coat protein

was a polypeptide of mol.wt. 32,000, estimated by polyacrylamide gel electrophoresis, and in which no carbohydrate could be detected. Preparations of CLV single-stranded DNA contained four main types of molecule in addition to some polydisperse linear material: circular and linear molecules of mol.wt. *ca.* 0.8×10^6, and circular and linear molecules of about half this size. The small circular molecules are packaged in 'half-geminate' particles, which mostly accumulate in the later stages of infection. Only the large circular molecules are infective, as judged by symptom production in the test plants. However, polyacrylamide gel electrophoresis of DNA samples and careful measurement of molecules in electron micrographs suggested that the large circular molecules are of two slightly different sizes.

(J. C. Sequeira, B. D. Harrison, G. H. Duncan)

Satellite activity of small circular RNA molecules

In further work on the small RNA molecules (RNA-2) detected in particles of lucerne transient streak virus (LTSV)*, both circular and linear forms were found. Cultures of LTSV containing RNA-2 (LTSV-N) and lacking RNA-2 (LTSV-C) were indistinguishable serologically, in host range and in symptomatology except that, in *Chenopodium amaranticolor* and *C. quinoa,* LTSV-N induced necrotic local lesions whereas LTSV-C induced chlorotic ones. RNA-2 alone did not multiply detectably in *C. amaranticolor* or five other plant species but when it was added to inocula containing RNA of LTSV-C (RNA-1), a proportion of the lesions induced were necrotic, and this proportion increased with increasing concentration of RNA-2. The infectivity of LTSV RNA-1 was destroyed by treatment with snake venom phosphodiesterase (SVPDE) or proteinase K but the ability of RNA-2 to alter the lesion type induced by LTSV-C was not. These results suggest that circular molecules of RNA-2 are biologically functional and do not need a genome-linked protein for this activity. LTSV RNA-2 is therefore not a viroid or a necessary part of the LTSV genome and seems to be a satellite RNA that can affect symptom expression.

(A. T. Jones, M. A. Mayo, G. H. Duncan)

Work in Australia with small circular RNA-2 molecules of two other viruses, related serologically to one another but not to LTSV, indicates that they are, unlike LTSV RNA-2, necessary for virus infectivity. Moreover, the specificity of these apparent genome pieces was such that they could not be exchanged between the two related viruses. The RNA-2 of one of these viruses, *Solanum nodiflorum* mottle* (SNMV), has 377 nucleotides compared with *ca.* 300 nucleotides for LTSV RNA-2, and the two RNA-2 species can be distinguished by their different mobilities during electrophoresis in slab gels. When inoculated alone to *C. amaranticolor, SNMV RNA-2 induced no symptoms but, when added to RNA of LTSV-C,*

*Held under DAFS licence.

most of the lesions formed were necrotic, not chlorotic, and this activity of SNMV RNA-2 was not affected by treatment with SVPDE. Furthermore, particles of a single lesion isolate of LTSV-C + SNMV RNA-2 were serologically indistinguishable from LTSV-C, did not react with antiserum to SNMV and contained SNMV RNA-2 but not LTSV RNA-2. SNMV RNA-2 thus has satellite-like properties in association with LTSV, and its activity is not as specific as previously supposed.

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

*Elderberry latent virus (ELV)**

This virus was shown to be serologically related to the recently described pelargonium ringspot virus (PRSV). In double-diffusion serological tests in agarose gels, the titre of PRSV antiserum to the homologous virus (each kindly supplied by Dr Olwen Stone[1]) was 1/256 and to ELV was 1/128; the homologous titre of ELV antiserum was 1/512 and its titre to PRSV was 1/64.

(A. T. Jones)

Broad bean stain virus

Observations on tick bean plants grown from seed produced in England indicated an unusually high incidence of seed-borne virus infection. Serological tests detected up to 10% seed-borne infection with broad bean stain virus but no infection with Echtes Ackerbohnenmosaik Virus.

(A. T. Jones)

TECHNIQUES

04021 *Techniques for electron microscopy*

Immunosorbent electron microscopy (ISEM) of human and animal viruses

In collaborative work with D. Gregory[2], and E. Gray[3], the ISEM technique as used to detect plant viruses was applied to particles of human and animal viruses in faeces and tissue cultures. Viruses tested included members of the astrovirus, flavivirus, rotavirus, adenovirus and herpesvirus groups.

Limited success was obtained. Increases in particle counts per grid of five to fiftyfold were obtained with rotaviruses from human, calf and lamb sources, and with louping-ill virus (a flavivirus from sheep), but no increase in detectability was achieved with the other viruses tested. With rotaviruses, it was important to test several different antisera to find one that gave satisfactory results. Indeed the lack of success achieved with

*Held under DAFS licence.

[1]GCRI.

[2]Department of Bacteriology, University of Aberdeen.

[3]Moredun Institute (ADRA), Edinburgh.

some of the other viruses may be because only one antiserum to each was available.

An important feature for success was the adoption of the micro-mortar extraction technique (SHRI Ann. Rep. 1979, p.108), which released more virus from faecal debris and broke up clusters of virus particles, thus distributing them more evenly on the electron microscope grids.

A useful observation was the increase in particle numbers that occurred when untreated grids were left on virus-containing samples for up to 2 hours, instead of the usual 1-2 min. The increases ranged from twofold for adenoviruses and rotaviruses to more than tenfold for a herpesvirus.

(I. M. Roberts)

Examination and printing of micrographs using a microfiche reader

Electron micrographs are usually examined only after printing, or by using a hand lens to inspect illuminated negatives. A microfiche reader (Bell & Howell, type ABR 900) proved to be very suitable for examining electron microscope negatives at enlargements of 15-40 times; incorporation of a reference grid enabled areas to be coded and re-located. Also, the instrument, with the following modification, was used as a photographic enlarger to produce good quality prints from selected areas of the negatives. A metal sheet, with a hole coinciding with the projector lens, was inserted at the base of the viewing screen and fitted with a simple pivot shutter; when filters were needed (e.g. for reversal papers) they could be taped to the underside of the metal plate. Prints were obtained by focussing the image of the selected area of the negative, exposing a sheet of photographic paper (clipped to cardboard for rigidity) for a suitable period, and then processing the paper. The biggest advantage of this system is the opportunity it provides for selecting and printing immediately one particle from a micrograph containing several hundred, and for observing features which might remain unobserved in prints at smaller magnifications.

(I. M. Roberts, G. H. Duncan)

Clarification of extracts for electron microscopy

The detectability of virus particles in electron micrographs of sap extracts is decreased by various plant components, especially those in the glutinous extracts of bulbous plants. Moreover, clarification of such extracts by centrifugation can remove most or all filamentous virus particles from the supernatant fluid. However, when extracts made with a micro-mortar were shaken with 20% chloroform, the aqueous phase contained readily visible virus particles and could be examined without further dilution. Particles of tulip chlorotic blotch, tulip breaking, tulip X and potato X viruses seemed to be chloroform-tolerant; when extracted by this method from tulip leaves or petals, they were readily detected and amenable to subsequent coating with antibody.

(G. H. Duncan)

ESTATE

F.J.W.ENGLAND
W. I. A. JACK

Mylnefield

The pursuit of objectives for integrating the efficient use of land at Mylnefield, Gourdie and Ninewells farms, initiated in 1981, has continued. Much thought and progress has been made in planning a crop rotation designed to meet the Institute's needs as work is transferred from Pentlandfield; to date 34 ha of land of uniform status are in a state of readiness where there are neither residual effects from previous cropping, chemical treatments and pathways, nor weed or pathogen problems.

The choice of a rotational cropping system is restricted by the need to conserve such PCN-free land as we have, to avoid the consequences of growing too much barley relative to the needs of the barley breeding programme, and to be consistent with good farming practice; the rotation being introduced incorporates, in the main, winter and spring sown cereals, grass, and all land required for field experiments.

The ever-rising crop production costs of recent years tended to ease as the year progressed and, together with higher produce prices obtained, helped to redress the below average yields of most crops. Crops which had looked as though they were going to yield well, in many cases failed to do so. As the meteorological records show, following a fairly early spring which allowed land work to forge ahead, dry conditions prevailed from mid-March to the first week of September, while June was dull and cool. Although suiting harvesting operations, the conditions experienced were not conducive to obtaining good yields on the soil type at Mylnefield. From mid September we suffered one of the wettest autumns on record, with resulting difficulties in the lifting of the potato crop and in the land work.

Farm crops and field experiments

Farm crops included 43.4 ha barley, 10.9 ha hay, 2.1 ha grass, 4.0 ha flax, 1.6 ha field beans, 0.8 ha potatoes and 1.6 ha fallow. This shows an increase of 11.9 ha from the previous year as less land was required for experimental crops.

Barley cv. Golden Promise sowing started on 18 March, 19 days later than the previous year, and was completed in 6 days. Germination and

the established plant population were satisfactory, but subsequent growth was uneven resulting from the drought conditions that prevailed though to harvest; mildew (*Erysiphe graminis*) was evident on all fields in late May, requiring the application of a fungicide. Harvesting started on 29 July and was completed under favourable conditions on 10 August. The yield of 4.8 t/ha was down 1.2 t/ha on the previous year, with grain samples containing quite a proportion of 'greens' which spoilt the appearance of the harvested grain. However, being of good quality, having a moisture content averaging 16.8% and with a suitable nitrogen content, all the grain was sold for malting.

Grass grew rapidly in the early spring but was then affected by the drought conditions of April and May. Hay was cut on 3 June, the cool weather conditions being far from ideal for hay making, and baling was completed on 15 June. The yield at 6.0 t/ha was up 1.0 t/ha on the previous year and was of good quality.

Flax cv. Hara was grown at Ninewells as part of an exercise involving growers, the Flax and Linen Association of Great Britain, the East of Scotland College of Agriculture and the Scottish Development Agency with a view to fibre production in the east of Scotland. The crop was sown on 13 April and established successfully, plant number and growth being satisfactory and even. A desiccant was applied on 18 July and the crop was pulled, baled and carted on 26-29 September. Samples taken for retting tests indicated the fibre to be of good quality, and the crop is due to be exported for retting sometime in the New Year.

Field bean cv. Maris Bead sowing started on 24 February into good land conditions but by mid March the ground had set so hard that emergence was erratic and, although plant numbers were satisfactory, the drought conditions caused the straw to be short and pod numbers low. The crop ripened rapidly and was combined on 31 August, 32 days earlier than the previous year; the yield of 1.9 t/ha was down 2.5 t/ha on the previous year.

Potatoes grew well where irrigation was available but on non-irrigated plots a high proportion of the tubers were cracked; harvesting was protracted as the result of difficult ground conditions from late September until the crop was finally lifted on 22 November. The yield of 32.6 t/ha was up 7.0 t/ha on the previous year; however due to the weather conditions over one quarter of the harvested yield had to be dressed out.

Field experiments included 10.1 ha raspberries, 6.2 ha black currants, 1.9 ha strawberries, 1.9 ha blackberries and hybridberries, 4.8 ha potatoes, 2.9 ha brassicas, 0.6 ha field beans and peas, 0.4 ha cereals and 3.0 ha other crops; this represents a decrease of 4.2 ha on the previous year.

Fruit picking began with strawberries on June 21, followed by black currants and raspberries on 1 July, Tayberries on 10 July, blackberries on 14 July, Loganberries on 8 August and finally blueberries on 9 August. The weather, apart from June which was dull and cold, was settled throughout the season with little time lost through wet weather. Apart from the fruit being smaller in size, the quality remained high; losses through pest and diseases were negligible.

The fruit crop sold included 28.9 t raspberries, 11.9 t strawberries, 4.5 t black currants and 0.3 t other fruits, showing an increase of 3.1 t over the previous year. Marketable produce from a greatly reduced area of vegetable trials totalled 6.9 t, an increase of 0.7 t over 1981.

Following harvest, the routine programme of stubble clearing and subsoiling had to be abandoned due to the hard ground conditions and instead sprays of glyphosate (Round-up) were applied. Then persistent wet weather from mid September to the end of the year caused a hindrance to outside work and ploughing, started in October, continued as conditions allowed until almost completed by 24 December. 10.1 ha of winter wheat, cv. Avalon, was sown on 21-22 September. Germination was good and produced a good plant stand, and despite the wet conditions it went into the winter in fine fettle.

Estate work was confined to Gourdie farm where 1,000 m of security and vermin-proof fencing were erected on the south and part of the east boundary of the farm.

New farm equipment acquired during the year included a vineyard tractor, a combine harvester and a portable sprayer; a 1,000 l capacity tractor mounted sprayer with 12 m working width boom was designed and built by the farm workshop staff.

Glasshouse

The completion of the new Virology Department and Plant Breeding Department ranges increased glasshouse accommodation by 1,375 sq.m of heated glass. The plant holding house came into use in December and the complete block is gradually being brought into use.

A site in South Bullionfield was identified to accommodate polythene and gauze tunnels and a start was made on construction. To date, two Filclair gauze tunnels have been erected and one filled with 4,800 *Narcissus* bulbs. Areas have been soil sterilised with dazomet in preparation for future use.

Plant production at 114,349 units was up 2,531 on 1981; included were 52,476 for Virology, 27,998 for Plant Breeding, 12,212 for Mycology and Bacteriology, 12,106 for Estate, 7,331 for Zoology and 2,226 for Physiology and Crop Production Department. Black currant plants raised totalled 13,000 from hardwood cuttings and from seed; 1,000 *Chamaecyparis leylandii* plants were raised for future hedge planting at Gourdie

farm, and several sowings of seed produced plants for field trial of raspberries and brassicas. 4,500 raspberry plants were raised from root cuttings, both for glasshouse and field trials, and batches of potato plants from stem cuttings were raised with great success.

Pest and disease control gave few problems following prompt and regular control measures; however, some unusual items should be noted. Raspberry moth, *Lampronia rubiella,* posed a problem, being recorded for the first time as a glasshouse pest at Mylnefield; the infestation resulted from the forcing of field lifted whole plants. Vine weevil, *Otiorrhynchus sulcatus,* spread from the nematode micro plots (1981 Report) to other houses and posed problems of control. Diflubenzuron used for the first time has given promising results in the control of sciarid flies.

Investigations started in 1981 into soil-less compost mixtures and the slow release fertiliser Vitax Q-4, were extended to identify the conditions required under which maximum root production can be obtained from virus-free parent material of raspberry cultivars. An observation trial set up in the gauzehouse using different soil-less compost mixtures and container sizes resulted in useful information being collected and prompted further trials being scheduled for 1983.

Pentlandfield

Murrays Farm

The weather in 1982 was marked by a dry spring and a wet autumn, but by June drought conditions prevailed. Heavy rain in June helped winter wheat, potatoes and brassicas to recover from stress conditions but was too late for spring barley. Temperatures were similar to the average of the previous 10 years but total rainfall was the highest since records started in 1972.

Spring barley sowing began on 18 March and finished on 23 March. Thirty-five hectares of spring barley cv. Golden Promise treated with triadimenol (Baytan) seed dressing were drilled into a good seed bed which had received fertiliser (22:11:11) at the rate of 370 kg/ha. A further 17 ha were sown to spring cereal plots between 22 March and 22 April. Spring barley brairded well but growth was checked by dry weather in May. As a result, heads were poorly filled and grain samples were thin and light. There was little sign of disease on the barley apart from an attack of mildew on a crop sown late in April round the potato plots. Harvesting started on 11 August and was completed on 27 August. Despite the poorly filled grain the crop was sold for malting. Yields averaged 4.20 t/ha.

The small area of winter barley cultivars Maris Otter and Igri surrounding the trial fields overwintered well in spite of the severe winter. Yields were not measured as the areas were too fragmented.

The winter wheat, which had been sown in Longriggs and Sunnyside fields, grew well. It was top dressed at the beginning of March with 375 kg/ha of fertiliser (22:11:11) and was sprayed with triadimefon (Bayleton) fungicide at the beginning of May. The crop withstood the dry spring well. Towards harvest some patches of take-all showed up. Harvesting started on 31 August and finished on 12 September. Yields were 6.93 t/ha for 29.8 ha.

Harvesting of both wheat and barley was straightforward and the grain required little drying.

Potatoes occupied 10 ha in Wall field, the remainder of the field was sown in with spring barley. For the potatoes, 1050 kg/ha of fertiliser (15:15:19) were broadcast before ridging. Two hectares were planted with early potato trials on 31 March. The remainder was planted with maincrop trials between 19 and 24 April. Thiofanox (Dacamox) aphicide granules were applied in the drills before covering. The maincrop potatoes were sprayed with metribuzin (Sencorex) at the recommended rate 3 weeks after planting and again at half rate 6 weeks after planting. Despite the double spraying, weed control was disappointing. During the summer the crop was sprayed at intervals with aphicides, alternately pirimicarb and demeton S-methyl. A fungicide was incorporated with the spray when blight risk justified it. The early trials were harvested at the beginning of July and maincrop harvesting started on 23 September and finished on 19 October. The crop was pulverised and sprayed with metoxuron (Deftor) 3 weeks before harvest. Yields were satisfactory. The field has been grubbed at intervals during frosty periods since harvest in an effort to reduce groundkeeping tubers.

Brassicas occupied 7.0 ha in Loan field. The area received 375 kg/ha fertiliser (0:21:21) at the end of March and at the end of April 850 kg/ha fertiliser were broadcast, 15:15:19 for swedes and 20:10:10 for leafy brassicas. Trifluralin plus napropamide (Neepex) for swedes and trifluralin (Treflon) for leafy brassicas were incorporated in the soil before sowing. Sowing started on 10 May and continued at intervals unto 10 August. Chlorpyrifos (Dursban 48E) was sprayed on the crop immediately after sowing and again 3 weeks later. Growth was good throughout the season. Harvesting started at the end of September and is still in progress (February 1983).

Grass in Folly, Loan and Reserve B fields was top dressed with 350 kg/ha fertiliser (22:11:11) at the end of February and the hay which was cut in June yielded 6.39 t/ha. The aftermath in Reserve B was grazed by lambs from ESCA. Potato Shed West and Hollow fields, which were direct-seeded with grass in the spring, were also grazed. After harvesting, the grass in Folly and Loan was sprayed with glyphosate (Round-up) and ploughed.

Following the broadcast application of 250 kg/ha fertiliser (8:20:16) winter cereal trials were soon in Loan field in mid-September.

In Wee Murrays field 375 kg/ha fertiliser (7:24:24) were broadcast before winter wheat cv. Mardler which was drilled on 25 October. Potato Shed east field received 280 kg/ha fertiliser (7:24:24) before winter wheat cultivars Mardler and Norman were drilled on 27 October. By Christmas all winter cereals were growing well, though Norman winter wheat was very slow to braird and establish.

In spite of the wet autumn, ploughing was completed before the end of the year and other winter work was well advanced.

(G. R. White)

Field Trials Unit

The Field Trials Unit carries out trials of breeders' advanced material of cereals and brassicas for SCRI, for sister institutes and for other bodies. Much of the work is at 'off-station' sites. Accounts based on data acquired by the Unit appear in the reports of the appropriate client department.

Winter cereal trials were drilled in early October and despite the severity of the weather overwintered satisfactorily. Spring cereal trials were drilled at the usual time in the latter half of March. Yellow rust and mildew reached moderately high levels on the winter barley but were present at much lower levels in the winter wheats. Winter barley trials were combined in early August and the winter wheat and spring cereal trials in early August and September.

The very dry weather that persisted throughout May made the production of good quality seed beds on the heavy land at The Murrays very difficult, and this largely accounted for the poor establishment in the kale and swede trials. At many of the regional sites, especially in the west, establishment and early growth were excellent. However, attacks by mildew occurred in the swede trials and the later drilled rape trials. Caterpillar damage was a problem at one site, emphasising the need for vigilance and for the timely use of insecticides against pests which are not usually a problem.

Winter cereal trials for harvesting in 1983 were drilled at the end of September, which is the earliest date we have so far managed to sow winter cereals. Emergence was good and by the end of the year there was a very even stand.

The number of plots grown by the Unit in each of the three main categories was as follows: winter cereals 1060, spring cereals (mainly barley) 2720, brassicas 560.

(I. M. Chapman)

INFORMATION SERVICES

R. J. A. EXLEY

Within any ARS institute the organisation of the service departments and the scale and type of services which they provide are decided by senior management and the allocation of finance. However, the requirements of the particular work concerned largely govern the choice of equipment and techniques which are used. Nevertheless the service workers themselves are essential catalysts in this interactive situation.

The range of commercially available display, graphics, information retrieval, photographic and word processing systems grows at an increasing rate; usually these are sophisticated, specialised in their application, and expensive. Accordingly, for a future of uncertain budgets, it will be rational and necessary for increasingly more searching cost benefit evaluations to be applied by the particular specialists concerned before finance is committed. This process requires professional competence and current awareness conditioned by the recognition that most requirements for service will continue not to be esoteric, and by a pragmatic judgment of priorities.

LIBRARY

The libraries at Mylnefield and Pentlandfield provide a general service to the staff of the Institute and to occasional external enquirers. In-house services include book loans, periodical circulation, current awareness and online literature searches.

Collectively over 400 periodicals are currently received, with a proportion inevitably duplicated due to the remoteness of the two sites. In addition to the book stock there are collections of reports, technical information and reprints.

Mylnefield

During 1982, 816 volumes were borrowed from the library stock and 1322 items were obtained by inter-library loan. This represents an increase in in-house lending and an insignificant decrease in external borrowing from 1981. Eleven literature searches and 17 translations were carried out for various members of staff.

Revision of the periodicals circulation lists revealed that 65 members of staff receive periodicals and photocopied contents pages on circulation. On average, each user of the system receives 28 titles.

Access to the DIALOG information system was changed over from direct access via the GPO International Packet Switched Service (IPSS) to the PSS via the ERCC Gateway. This reduces costs and gives flexibility in the use of terminals.

The periodicals holdings list was computerised as a step towards rationalising the periodicals lists at Mylnefield and Pentlandfield.

A Bell & Howell ABR-900 microfiche reader was acquired.

The librarian attended two meetings of the Scottish Agricultural Librarians' Group and the biennial ARS Librarians' Meeting. Both members of library staff attended the NLS inter-library loans meeting in Edinburgh.

(Ursula M. McKean)

Pentlandfield

During 1982, the current awareness bulletin continued to be issued at fortnightly intervals. The bulletin covers recently published literature in areas relevant to research carried out by members of staff. Copies are also circulated outside SCRI and anyone else interested in receiving a copy should contact the librarian. Individual current awareness lists were also issued regularly to five members of staff. Literature searches were conducted on 40 different topics and 45 detailed enquiries were handled. Library loan figures remained fairly static with 720 items being borrowed from the library and 432 from external sources. Ten translations were undertaken by the librarian. One hundred and thirty-three acquisitions were added to the book stock and two new journal subscriptions were taken out. A collection of reprints, the majority dealing with work on potatoes, was donated to the library by Professor N. W. Simmonds, a former Director of the Scottish Plant Breeding Station.

During the year the librarian attended meetings held by the Scottish Agricultural Librarians' Group, ASLIB and the Library Association as well as the ARS Librarians' meeting at Norwich.

(Barbara Asher)

VISUAL AIDS

Demand for specialised photography including cine micrography, time-lapse, ultra-violet, aerial and macro-photography, has increased over the last 5 years and now forms a large proportion of the work. Regarding the overall trend in the work being undertaken, it is interesting that although the number of jobs for 1982 has marginally decreased from the previous year the analysis shows that there is an increase, in some instances substantial, in the use of the various types of photography.

	PHOTOGRAPHY					GRAPHICS
	Jobs	Colour	Monochrome	Diazo	E.M./Prints	Jobs
1981	1613	4191	6544	486	2056	76*
1982	1574	5133	7158	519	2553	96

*Over an 8 month period.

Two international conferences were organised by the Institute for the Annals of Applied Biology and the European Society of Nematologists in August and September; these involved not only a large amount of photography and graphics work but organisational, administrative and advisory services associated with the visual aids side of the conferences.

A new scanning enlarger was purchased in February and has proved invaluable in the production of monochrome prints especially from photo and electron micrographs; used in association with the automated processor a better print can be made in a very much less time than with convential methods.

Measurements using photography was technique examined during the year, with film images being measured on a digitiser. The method proved to be successful and a great advantage for accurate measurement of non-uniform specimens.

On 21-22 September the Visual Aids group attended the 5th ARC Photographers and Graphics Officers' Conference in Cambridge.

(T. G. Geoghegan)

SCOTTISH SOCIETY FOR CROP RESEARCH

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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.

The Society was formerly known as the Scottish Society for Research in Plant Breeding which acted as managing agent for the Scottish Plant Breeding Station. After the amalgamation of the latter with the former Scottish Horticultural Research Institute to form the Scottish Crop Research Institute during 1981, the Society adopted its new name and its membership was expanded by the welcome inclusion of the members of the former Scottish Horticultural Research Institute Association.

Since its formation and up to the end of 1982, the Society had held a number of meetings on topics of interest to the agricultural community and industry, the most important of which were:

(i) a seed potato seminar at the Scottish Crop Research Institute, Invergowrie, on 26/11/81

(ii) a soft fruit seminar at the Scottish Crop Research Institute, Invergowrie, on 23/11/82.

The proceedings of these meetings have been published in SSCR Bulletins, the contents of which are listed below. Copies are available from the Secretary of the Society.

The 1981 Society Lecture was given by Dr R. Riley, F.R.S., Secretary of the Agricultural Research Council on 23rd April 1981, the topic being 'Research – An Agricultural Resource.' The 1982 Lecture was delivered on 15th April by Prof. W. F. Raymond, Chief Scientist (Agriculture & Horticulture), Ministry of Agriculture, Fisheries and Food, who chose as his theme 'Some Limits to Intensity in Agricultural Production.' The texts of both Lectures have been circulated to members.

The Society gratefully acknowledges the assistance and help given by the Director and staff at Scottish Crop Research Institute in arranging and presenting these meetings.

During 1982, the Society sustained a loss through the death of Mr James Gray, O.B.E., T.D. a former Trustee and Chairman of the Scottish Society for Research in Plant Breeding Board of Directors. Mr A. Pattullo, M.C., J.P. was appointed a Trustee in place of Mr Gray.

The death also occurred during 1982 of Mr W. Robb, N.D.A., F.R.S.E. who was the second Director of the Scottish Plant Breeding Station and served in that capacity from 1925 to 1950. Mr Robb's death removed one of the last remaining links with the early days and operations of the Scottish Society for Research in Plant Breeding.

SSCR Bulletin No. 1 (N.S.) (March 1982)

Producing Quality Seed Potatoes in Scotland

[1]Horberry & Baker Ltd
[2]ADAS

(£1·50)

SSCR Bulletin No. 2 (March 1983)

Soft Fruit

[1]DAFS

(£1·50)

01046 *Agrometeorological Recording*

Mylnefield

The weather of 1982 comprised a sequence of extremes from coldest winter through driest summer to wettest autumn. It was a year in which the value of irrigation was appreciated.

Wind

Windspeeds from August to November were the highest for the period since our records began in 1959, the August average windspeed being 135% of the 15 year mean.

Rainfall

Distribution of rainfall during the year was very unusual. There was a 3-week period in April to May without any rain which was the longest such spell since 1955. And the period April to July was the driest since our records began, with only 56% of the average rainfall. The dry spell lasted through August to be followed by the wettest September to November with 177% of the average rainfall.

As a consequence of low rainfall, soil moisture deficit was 133mm at the end of August. This was the greatest deficit that we have calculated.

Temperature

January 1982 had the lowest temperatures on our record with a minimum air temperature of $-17.1°C$ and a minimum grass temperature of $-22.9°C$. Thereafter conditions were generally warmer than average and the maximum temperature of 27.8°C recorded on 5 June was the highest temperature recorded since 1955.

Sunshine

Total hours of bright sunshine were 99% of the long term average but this disguises some considerable variation. June was an unusually dull month but it was followed by one of the brightest Julys on record.

MYLNEFIELD 1982

Month	Temperature: Daily Air Maxima Mean °C	Daily Air Maxima DFA *	Daily Air Minima Mean °C	Daily Air Minima DFA *	0.1m Soil Mean °C	0.1m Soil DFA *	0.3m Earth Mean °C	0.3m Earth DFA *	Accumulated Day Degrees Above 6°C	Accumulated Day Degrees Below 6°C	Days Ground Frost	Potential Evap-oration mm	Rainfall Total mm	Rainfall DFA *	Bright Sunshine hours Total	Bright Sunshine hours DFA *	Mean Daily Solar Radiation mWh/cm²	Windspeed Mean km/h	Windspeed DFA †
January	3·9	−1·7	−2·6	−2·6	0·7	−0·8	0·8	−1·7	11·6	176·4	24	2·5	86·5	+23·3	40·6	−12·6	52	10·2	−0·9
February	7·4	+1·7	2·0	+1·9	3·0	+1·5	3·9	+1·3	17·6	48·6	16	12·7	38·5	−10·0	51·6	−22·4	96	13·9	+1·8
March	8·9	+0·9	2·0	+0·3	3·7	+0·4	5·2	+1·0	30·6	47·1	22	34·1	44·6	+ 0·4	131·9	+26·1	237	15·4	+0·7
April	12·4	+1·3	4·6	+1·4	8·0	+1·8	7·6	+0·7	91·3	16.9	17	63·4	24·2	−17·1	154·8	− 4·2	344	12·5	−2·1
May	14·1	+0·4	5·1	−0·7	11·1	+1·0	10·0	−0·1	129·3	16·6	16	89·9	25·9	−30·2	218·6	+34·8	475	11·3	−1·3
June	16·3	−0·7	9·5	+0·9	14·3	+0·4	13·1	−0·4	208·3	0·5	1	83·1	30·8	−18·1	124·7	−58·7	431	11·4	−0·5
July	19·6	+1·2	11·1	+1·0	16·8	+1·6	15·2	+0·1	289·3	0·0	0	105·1	37·7	−27·0	240·3	+64·5	541	9·3	−1·4
August	18·7	+0·6	10·6	+0·6	14·6	+0·3	14·6	−0·2	270·7	1·1	3	84·5	47·0	−22·6	176·2	+21·5	355	13·5	+3·7
September	16·0	+0·1	8·5	0·0	11·2	−0·3	12·3	−0·3	190·7	2·6	5	51·8	86·3	+27·6	112·3	− 7·0	230	14·6	+3·8
October	12·1	−0·6	6·7	+0·4	8·0	−0·3	9·8	0·0	113·9	7·0	6	21·8	125·4	+67·9	57·2	−33·8	106	13·8	+2·5
November	8·5	+0·2	3·5	+1·4	4·7	+0·7	6·9	+1·2	41·4	40·5	17	8·3	93·0	+36·8	64·5	− 2·8	57	14·0	+1·9
December	5·9	−0·4	−0·1	−1·0	1·4	−0·9	3·2	−0·3	9·4	104·9	29	3·5	72·0	+ 3·7	32·6	−12·4	33	10·9	−1·1

*DFA Deviation from 1954-1978 average

†DFA Deviation from 1959-1978 average

THE MURRAYS 1982

Month	Mean Air temperature °C		Mean Soil temperature °C		Number of Days air temperature ⩽0°C		Total rainfall	Number of wet days
	Max.	Min.	5 cm	10 cm	Air	Grass	mm	>1·0mm
January	4·7	−2·0	0·9	1·1	14	19	78·3	9
February	7·3	1·6	2·4	2·9	7	13	22·8	5
March	8·7	1·6	3·4	3·5	6	18	37·3	10
April	12·1	4·0	7·7	7·4	0	8	14·4	3
May	14·8	4·4	10·8	10·2	1	10	41·4	8
June	16·1	8·5	14·9	13·8	0	0	75·1	7
July	19·2	10·0	17·0	15·9	0	0	46·9	5
August	17·8	10·3	14·3	14·2	0	0	46·9	13
September	16·1	8·4	11·4	11·4	0	0	60·7	12
October	11·8	6·1	7·8	8·1	0	4	84·5	15
November	8·6	3·3	4·5	5·1	3	13	94·4	16
December	6·0	0·2	1·5	2·1	14	21	74·0	12
Annual total	—	—	—	—	45	107	676·7	115
Annual mean (365 Days)	11·9	4·7	7·8	8·0	—	—	—	—

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INSTITUTES FOR AGRICULTURAL RESEARCH IN GREAT BRITAIN

The research programmes of all the institutes supported from public funds are co-ordinated by the Agricultural Research Council. Most publish a report annually and details are obtainable from the Secretary of the Institute concerned.

ARC Institutes

Animal Breeding Research Organisation	King's Buildings, West Mains Road, Edinburgh, EH9 3JQ
Food Research Institute	Colney Lane, Norwich, NR4 7UA
Institute of Animal Physiology	Babraham, Cambridge, CB2 4AT
Institute for Research on Animal Diseases	Compton, Newbury, Berks., RG16 0NN
Letcombe Laboratory	Wantage, Berks., OX12 9JT
Meat Research Institute	Langford, Bristol, BS18 7DY
Poultry Research Centre	Roslin, Midlothian, EH25 9PS
Weed Research Organisation	Begbroke Hill, Yarnton, Oxford, OX5 1PF

State-aided Institutes in England and Wales

Animal Virus Research Institute	Pirbright, Woking, Surrey, GU24 0NF
East Malling Research Station	East Malling, Maidstone, Kent, ME19 6BJ
Glasshouse Crops Research Institute	Rustington, Littlehampton, Sussex, BN16 3PU
Grassland Research Institute	Hurley, Maidenhead, Berks., SL6 5LR
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
National Institute for Research in Dairying	Shinfield, Reading, RG2 9AT
National Vegetable Research Station	Wellesbourne, Warwick, CV35 9EF
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
Wye College, Department of Hop Research	Ashford, Kent, TN25 5AH

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 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

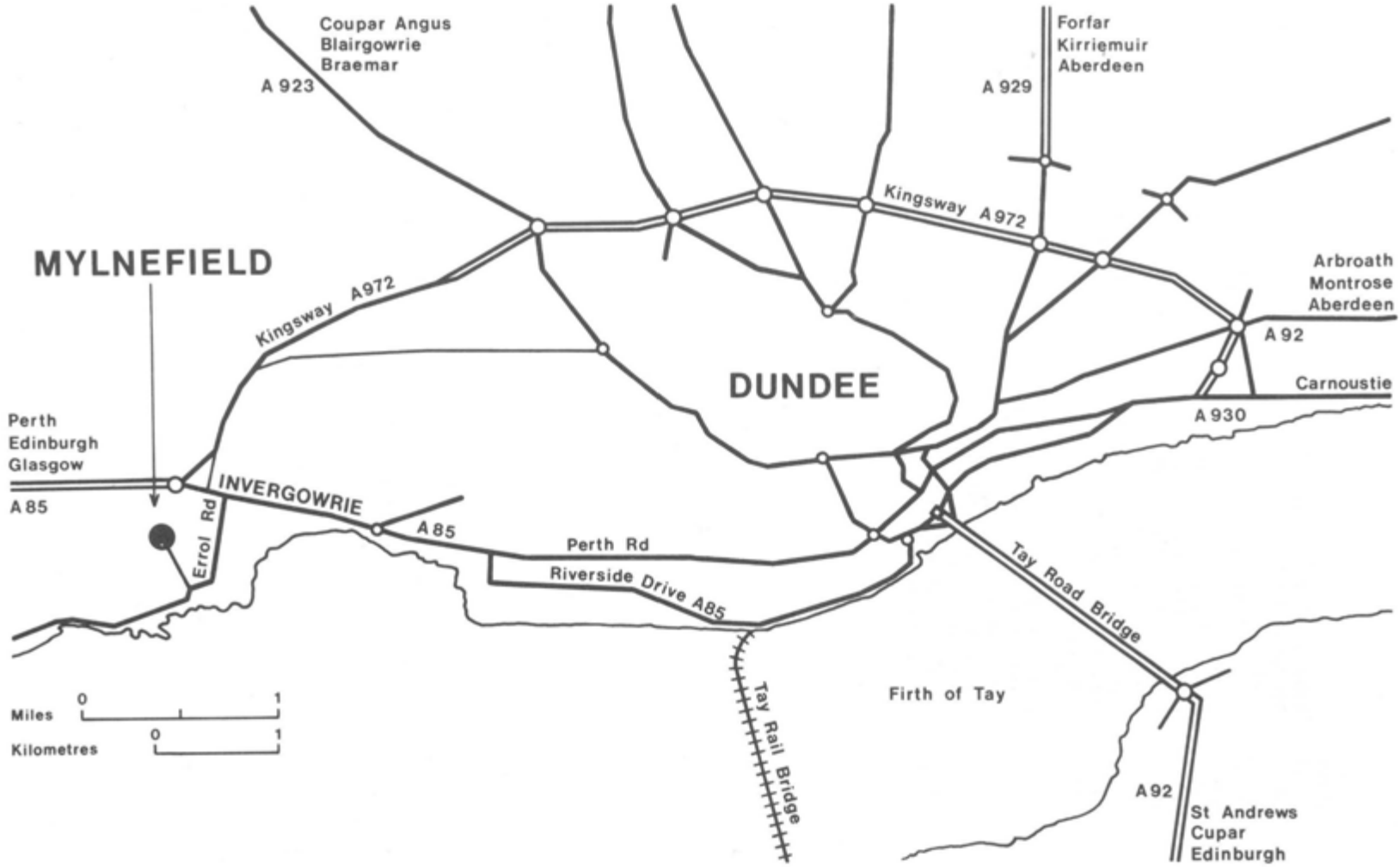
LIST OF ABBREVIATIONS

Countries and Organisations

AAB	Association of Applied Biologists
ADAS	Agricultural Development and Advisory Service
ARC	Agricultural Research Council
ATB	Agricultural Training Board
BA	British Association
BAPB	British Association of Plant Breeders
BC	British Columbia
BSPP	British Society of Plant Pathology
COSAC	Council for Scottish Agricultural Colleges
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
EMRS	East Malling Research Station
ERCC	Edinburgh Regional Computing Centre
ESCA	East of Scotland College of Agriculture
ESN	European Society of Nematologists
FRI	Food Research Institute
HEA	Horticultural Education Association
IRAD	Institute for Research on Animal Diseases
ISHS	International Society of Horticultural Science
ISPP	International Society of Plant Pathology
ISTA	International Seed Testing Association
JII	John Innes Institute
MAFF	Ministry of Agriculture, Fisheries and Food
MISR	Macaulay Institute for Soil Research
NATO	North Atlantic Treaty Organisation
NIAB	National Institute of Agricultural Botany
NLS	National Library of Scotland
NSCA	North of Scotland College of Agriculture
NSDO	National Seed Development Organisation
NVRS	National Vegetable Research Station
PBI	Plant Breeding Institute
PMB	Potato Marketing Board
SEB	Society for Experimental Biology
SERC	Science and Engineering Research Council
SHRI	Scottish Horticultural Research Institute
SIAE	Scottish Institute of Agricultural Engineering
SNSA	Scottish Nuclear Stock Association
SPBS	Scottish Plant Breeding Station
SRC	Science Research Council
STV	Scottish Television
UC	University of California
UK	United Kingdom
USA	United States of America
USSR	Union of Soviet Socialist Republics
WPBS	Welsh Plant Breeding Station
WRO	Weed Research Organisation
WSAC	West of Scotland Agricultural College

Others

ACAS	Agricultural Chemicals Approval Scheme
ARS	Agricultural Research Service
Cv.	cultivar
DOMD	Digestible organic matter in dry weight
DM	dry matter
EEC	European Economic Community
EHF	Experimental Husbandry Farm
EHS	Experimental Horticultural Station
ELISA	enzyme-linked immunosorbent assay
EMAS	Edinburgh Multiple Access (Computer) System
NFT	National Fruit Trials
NIR	near infra-red
NLT	National List Trial
PCN	potato cyst nematode
RCCA	Research Council Co-operative Award
r.h.	relative humidity
SAC	Scottish Agriculture Colleges
SMCO	S-methyl cysteine sulphoxide
TLC	thin layer chromatography
VTSC	virus tested stem cutting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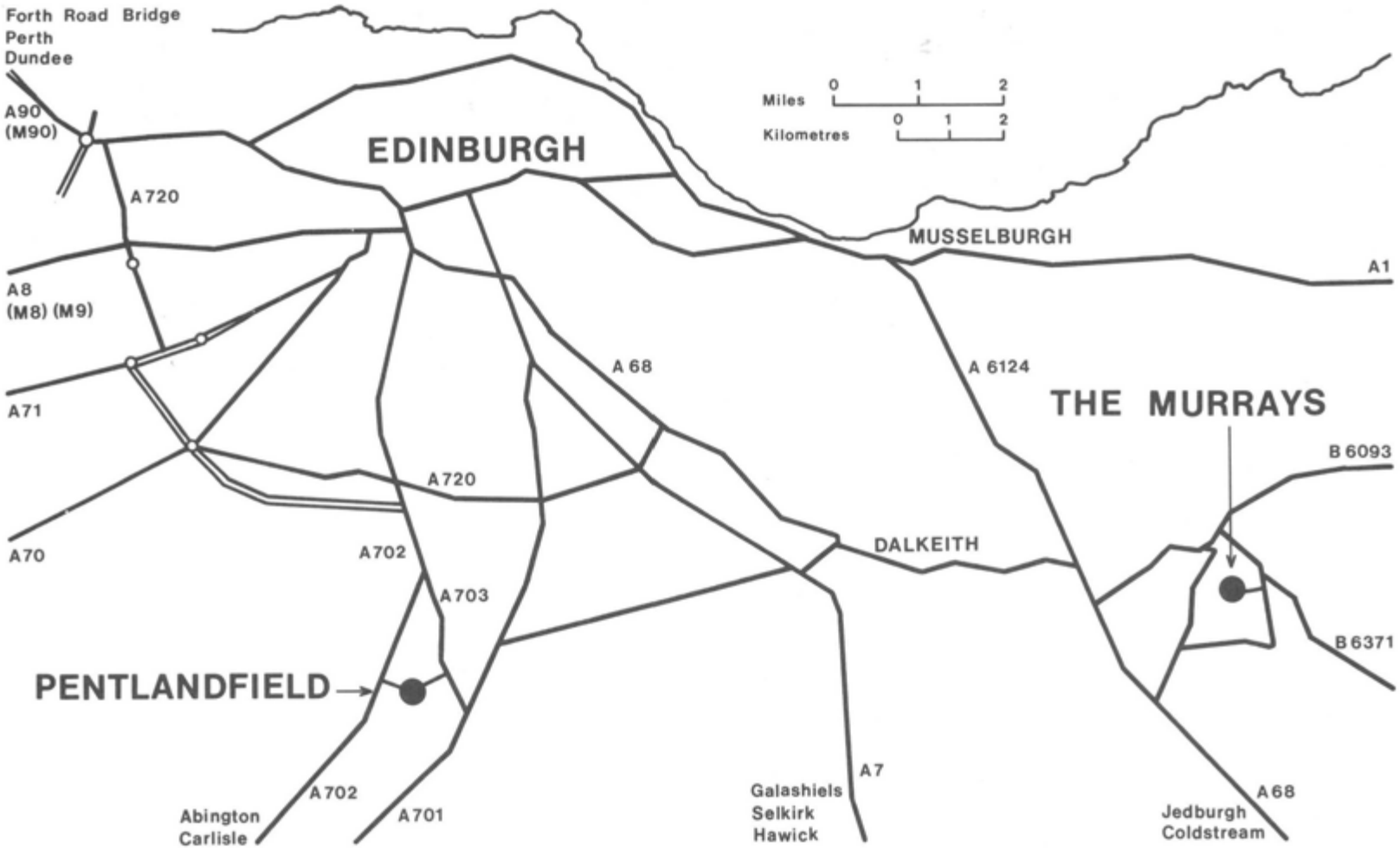
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