

# Annual Report 1980

Scottish  
Horticultural  
Research  
Institute



27th Annual Report for the year 1980

---

The Scottish Horticultural Research Institute  
Invergowrie, Dundee DD2 5DA *Telephone* INVERGOWRIE (082 67) 731

West of Scotland Unit  
Auchincruive, Ayr *Telephone* ANNBANK (0292) 520 293

---

Published 1981

ISSN 0559-1961

## CONTENTS

Members of Governing Body	4
Staff	5
General Report	9
Index to Projects	34
Crops Research	37
Plant Breeding	54
Mycology	69
Virology	92
Zoology	109
Estate	122
Information Services	125
Scottish Horticultural Research Institute Association	127
Meteorological Records	128
Publications	131
ARC Institutes	136
Abbreviations	137
Map of approach routes	138

GOVERNING BODY  
(AS AT 1 JANUARY, 1980)

*Chairman* A. Gordon Porter, Esq.

John Arbuckle, Esq., O.B.E.

George Bruce, Esq.

David W. H. Cargill, Esq.

T. Martin Clucas, Esq.

Professor W. W. Fletcher, B.Sc., Ph.D., F.R.S.E., F.L.S.,  
F.I.Biol.

M. Douglas Henderson, Esq.

Professor P. G. Jarvis, M.A., Ph.D., Fil.Dr.

Professor D. L. Lee, B.Sc., Ph.D.

Ian D. Lowe, Esq., M.A., Dip. Agric.(Cantab), M.B.A.

John R. Robertson, Esq.

Professor N. F. Robertson, C.B.E., B.Sc., M.A., Ph.D.,  
Dip.Agric.Sc., F.R.S.E.

Ronald Smith, Esq.

Professor D. H. N. Spence, B.Sc., Ph.D., F.R.S.E.

Professor W. D. P. Stewart, Ph.D., D.Sc., F.R.S., F.R.S.E.

Professor M. B. Wilkins, B.Sc., Ph.D., D.Sc., A.K.C.



## STAFF

*Director* C. E. Taylor\*†, B.Sc., Ph.D., F.R.S.E., F.I.Biol.

*Deputy Director* B. D. Harrison\*, B.Sc., Ph.D., F.R.S.E.

### Crops Research

*Head of Section* P. D. Waister\*, B.Sc., Ph.D.  
Mrs Janet E. Brinklow.  
R. J. Clark, B.A.  
M. R. Cormack, N.D.H.  
J. B. Cowan, B.Sc., M.I.S.  
P. A. Gill.  
H. M. Lawson, B.Sc., M.Agr.Sc., Dip. Agric.  
D. K. L. MacKerron, B.Sc., Ph.D.  
D. T. Mason, B.Sc., Ph.D.  
Heather A. Ross, M.I.Biol.  
H. Taylor, N.D.H.  
R. Thompson, B.Sc., M.Sc., M.I.Biol.  
Pauline B. Topham, M.A., B.Sc., Ph.D.  
K. N. Weaver, B.Sc.  
J. S. Wiseman, S.D.H.

*Assistants* D. Crabb.  
Mrs Margaret Garland.  
Sandra L. Mudie.  
G. C. Nicol.  
R. N. Wilson.  
Mrs Gladys Wright.

### Plant Breeding

*Acting  
Head of Section* D. L. Jennings†, B.Sc., Ph.D., S.H.M.  
M. M. Anderson, N.D.H., S.D.H., D.H.E.  
Eleanor Carmichael.  
A. Dale, B.Sc., Ph.D.  
J. R. T. Hodgkin, B.Sc., Ph.D.  
A. J. Redfern, B.Tech.  
P. Smith, B.Sc.  
Judith Thomson.  
Barbara M. M. Tulloch, S.D.H.  
A. B. Wills, B.Sc., M.S., Ph.D.  
Mrs Eveline M. Wiseman.

*Assistants* J. N. Dick.  
Mrs Norma Dow.  
T. P. Reid.

## West of Scotland Unit (Auchincruive)

- Acting  
Officer in Charge* R. J. McNicol, B.Sc.
- Assistant* Mrs Janet H. Campbell.
- Attendant* Wilma Farrell.
- Clerical Officer* Mrs Elizabeth A. Hunter Johnston.
- Estate* R. Dorman,  
J. C. Goddard.  
C. A. Reid.

## Mycology

- Head of Section* R. A. Fox<sup>o</sup>, B.Sc., B.Agr., M.I.Biol.  
E. Patricia Dashwood, B.Sc., M.Sc.  
J. M. Duncan, B.Sc., Ph.D.  
J. G. Harrison, B.Sc., Ph.D., M.I.Biol.  
Diana M. Kennedy, B.Sc.  
R. Lowe.  
G. D. Lyon, B.Sc., M.Sc., Ph.D., D.I.C.  
Isabel G. Montgomerie, B.Sc., Ph.D.  
M. C. M. Pérombelon, B.Sc., M.Sc., Ph.D.  
D. A. Perry, B.Sc., Ph.D.  
B. Williamson, B.Sc., M.Sc., Ph.D.  
H. M. Wilson.
- Assistants* Mrs Alison M. Campbell,  
Mrs Norma M. Colliar,  
Mrs Lisbeth J. Hyman,  
Teresa McNally,  
Naomi A. Nyananyo,  
Alison Savege.
- Attendant* Mrs Joan Jenkins.

## Virology

- Head of Section* B. D. Harrison<sup>o</sup>, B.Sc., Ph.D., F.R.S.E.  
H. Barker, B.Sc.  
Susan J. Badenoch, B.Sc.  
G. H. Duncan,  
A. T. Jones, B.Sc., Ph.D.  
M. A. Mayo, B.Sc., Ph.D., M.I.Biol.  
W. P. Mowat, B.Sc., Dip.Agr.Sci.  
A. F. Murant, B.Sc., Ph.D.  
J. H. Raschké.  
I. M. Roberts, Dip.R.M.S.  
D. J. Robinson, M.A., Ph.D.
- Assistants* Wendy F. Adams,  
Erica M. Bell,  
Margaret J. Cannon,  
Susan Mahoney,  
Dawn Williams.
- Attendant* Mrs Rena Reid.

## Zoology

*Head of Section* D. L. Trudgill\*, B.Sc., Ph.D.  
T. J. W. Alphey, B.Sc., Ph.D.  
B. Boag, B.Sc., Ph.D.  
D. J. F. Brown, B.A.  
S. C. Gordon.  
W. M. Robertson.  
J. A. T. Woodford\*, M.A., Ph.D.

*Assistants* Mrs Carol Henry.  
D. Hobbs.  
Mrs Sheena S. Lamond.  
Mrs Irene E. Raschké.

## Estate

*Manager* W. I. A. Jack.  
*Experiments Officer* G. Wood, B.Sc., Ph.D.  
*Supervisors* R. W. Reid.  
R. D. Taylor.  
A. Bruce.  
C. C. Carrie.  
W. C. W. Jolly.  
A. D. Lindsay.  
A. W. Mills.  
R. Ogg.  
D. S. Petrie.  
A. Pirie.  
D. G. Pugh.  
J. Small.  
E. L. Allsworth.  
I. D. Burge.  
E. A. Davidson.  
E. A. M. Gardiner.  
A. E. Grant.  
J. P. T. Grant.  
W. D. J. Jack, B.Sc.  
R. Keith.  
W. W. Killoh.  
P. T. Logie.  
N. McInroy.  
L. A. McNicholl.  
J. Mason.  
Mandy Morris.  
A. Nicoll.  
B. D. Robertson.  
D. R. Simpson.

## Farm Workshop

W. R. S. Batchelor.  
G. W. Pollock.

## Maintenance

*Head of Section* J. H. Couttie,  
J. R. Caithness,  
A. Davidson,  
A. Low,  
R. MacDonald,  
G. Merchant,  
D. J. G. Redford,  
J. Rowe,  
L. A. Swan.

## Information Services

*Information Officer* R. J. A. Exley, C.D.H.  
*Photography* T. G. Geoghegan, A.I.I.P.  
S. F. Malecki.  
*Graphics* Maureen I. McMaster, D.A.  
*Librarian* Ursula M. McKean, M.A., Dip. Lib.  
Mrs Margaret Mitchell.

## Administration

*Secretary* N. D. Anderson.  
*Assistant Secretary* A. P. Thomson,  
D. L. McIntosh,  
I. A. McLeish,  
Mrs Feida Soutar.  
*Director's Secretary* Ruby B. L. McGill,  
Margaret Campbell,  
Mrs Joyce Davidson,  
Mrs Jean Findlay,  
Mrs Maureen Murray,  
Pamela J. Reid.  
*Stores* Mrs Anne L. Bertie,  
J. Heeney.

\* Honorary Lecturer in the University of Dundee.

† Honorary Senior Lecturer in the University of St Andrews.

## GENERAL REPORT

C. E. TAYLOR

---

This is the 27th and final Annual Report from the Scottish Horticultural Research Institute and covers the period up 1 February, 1981.

In October, 1980, the Institute was renamed the Scottish Crop Research Institute in anticipation of the amalgamation with the Scottish Plant Breeding Station, Pentlandsfield. The amalgamation became effective from 1 February, 1981, when the Scottish Society for Research in Plant Breeding relinquished the management of the Scottish Plant Breeding Station to the new Institute. Dr C. E. Taylor was appointed as Director. An extensive building programme has been initiated at Invergowrie to provide the laboratories, crop handling buildings, glasshouses and other facilities for the Institute.

Talks about such integrations of interests between the Scottish Plant Breeding Station and the Scottish Horticultural Research Institute were initiated in April, 1977, and in June, 1977, the Directors of the two institutes presented a report to the Department in which they concluded that the interests of crop research in Scotland would best be served by a unification of resources and the research programmes of the two institutes.

As previously reported (Ann. Rept 1979) a Working Party was set up by the Secretary of State for Scotland in July, 1978, to review the future requirements for state-funded plant breeding and crop research in Scotland. The report of the Working Party became available in the December and its recommendations were accepted by the Secretary of State in December, 1979, after a lengthy period of presentation of views from interested parties and particularly from the staff side unions. In 1980 an ARC Programme Review Group was established, at the request of the Department, and was convened in Edinburgh in March, 1980, to review the ongoing research programmes at SPBS and SHRI and to receive the views of staff at those institutes. The report of the Programme Review Group was made available in May, 1980, and in October, 1980, the Secretary of State for Scotland responded to the report and indicated the research strategy and outline of the research programmes for the Scottish Crop Research Institute (SCRI). In view of the importance of these documents in relation to the future development of SCRI they are published in full below.

The main objective of the amalgamation is to develop a strong and vigorous research organisation at Invergowrie with a programme directed towards exploiting the advantages and solving the problems of crop production in northern Britain. Amalgamation of the two institutes is seen as a more efficient use of the crop research resources which are administered in

Scotland by the Department of Agriculture and Fisheries. It appears to be a logical move when the financial constraints imposed by Government prevent the further development of research institutes. However, for some time it has been recognised that increasing scientific specialisation would inevitably lead to a consideration of ways in which research programmes could be integrated to provide a broader and more intensive scientific input for a particular crop interest.

It is sad to note the end of the Scottish Horticultural Research Institute as a name, but the vigorous, innovative research which characterised it in the past will continue to make its mark in the reorganised programme of the new institute. In order to strengthen the scientific backing for the breeding of potatoes, forage brassicas and cereals derived from the Scottish Plant Breeding Station programme, it has been necessary to curtail some of the research activities of the Scottish Horticultural Research Institute. In particular, the strawberry breeding programme at Auchincruive will be terminated in 1981 and the germplasm will be transferred elsewhere within the ARS. There will remain, however, a further two years of selection from crosses made in 1980 and it is anticipated that several cultivars will be named. Also, the breeding of horticultural brassica crops will be phased out over the next few years, but in that time improved parent lines will have been selected for Celtic type hybrid cabbages and further work done on in-breeding of calabrese for the selection of useful parent lines. However, the breeding of raspberries and other *Rubus* crops and black currants will continue, together with research on the agronomy and plant pathology of these crops, as well as on horticultural vegetables.

*REPORT OF THE SCOTTISH HORTICULTURAL RESEARCH  
INSTITUTE/SCOTTISH PLANT BREEDING STATION  
PROGRAMME REVIEW GROUP:*

*23rd-26th MARCH, 1980*

**BACKGROUND**

1. In July, 1978, the Secretary of State for Scotland set up a Working Party to examine the present arrangements for the commissioning and organising of research on horticulture, plant breeding and arable crop production at the Scottish Horticultural Research Institute (SHRI) and the Scottish Plant Breeding Station (SPBS), and to consider whether any changes were necessary to optimise the benefits for the horticultural and agricultural industries.

2. The Secretary of State, in accepting the recommendation of the Working Party, announced in December, 1979, that the total research effort at the SHRI and SPBS on plant breeding, plant pathology and zoology, and crop physiology would be integrated at Mylnfield, Dundee, under the control of one Governing Body and one Director.

**TERMS OF REFERENCE AND MEMBERSHIP**

3. Following this decision the Department of Agriculture and Fisheries for Scotland (DAFS) asked the Council urgently for advice on the research programmes of both Institutes. In consultation with DAFS the following terms of reference were drawn up for a Review Group:

“To review the present programmes of SPBS and SHRI and their proposals for

future work against the background of related work within the Agricultural Research Service and to make recommendations both as to (a) future plant breeding and crop research strategy for the development of the Institute to be formed by the amalgamation of SHRI and SPBS and (b) the content of the packages of research to be commissioned by DAFS with that Institute."

4. The Group had the following membership:

*Members*—Professor J. L. Jinks, F.R.S. (Chairman), Mr W. A. Biggar, C.B.E., Dr G. W. Cooke, C.B.E., F.R.S., Professor J. D. Hayes, Professor D. L. Lee, Professor N. F. Robertson, Professor W. J. Whittington.

*ARC Secretariat*—Dr B. G. Jamieson, Mr D. C. M. Corbett, Dr J. Ingle, Mr G. Jenkins, Dr J. Moorby, Mr S. M. Lawrie.

*DAFS Secretariat*—Mr G. S. Murray, Mr J. G. Brotherston, Dr T. W. Hegarty.

5. The Group took account of the special needs of Scottish agriculture and horticulture and of related effort elsewhere in the Agricultural Research Service (ARS). They recognised that the initial programme must depend largely on existing staff resources, and other facilities at SHRI and SPBS, but considered that their primary objective was to establish longer-term strategy to guide the new Institute's Governing Body and Director.

#### CURRENT WORK

6. Work at the eight Scottish State-aided Research Institutes (SARI) is commissioned by DAFS in sets of Research Packages at each institute. The existing Packages relating to crop research are:

#### SHRI

1. Effect of climate on horticultural and arable crop production in Scotland.
2. Research on cultural methods and choice of cultivars of horticultural and arable crops for Scottish conditions.
3. Breeding of soft fruit and bulbous ornamentals (perennials).
4. Breeding of vegetable crops (perennials and biennials).
5. Pre- and post-harvest fungal and bacterial diseases and physiological disorders of horticultural and other crop plants with special reference to the Scottish environment.
6. Viruses infecting horticultural and other arable crops, with special reference to soil borne viruses and to viruses occurring in Scotland.
7. Research on invertebrate pests causing loss of yield or quality of horticultural and arable crops, especially those of economic importance in Scotland.

#### SPBS

1. Cereals.
2. Brassicas.
3. Potato breeding and related pathological and genetic studies.
4. Commonwealth Potato Collection and related genetical and pathological studies.
5. New crops (Forage Exploration Unit).

#### Macaulay Institute for Soil Research (MISR)

7. Investigations on the fertility of soils and the yield of agricultural crops (limited to sub-package 7b—Soil-plant relationships).
8. The study of factors affecting crop composition.

7. The total recurrent cost of these Packages is currently £2.6m per annum. They cover the entire programmes of SHRI and SPBS and about one-fifth of the MISR programme.

*Future research strategy*

8. The Group are aware of the background which led to the Secretary of State's decision to merge SHRI and SPBS on one site at Mylnefield and fully believe that the interests of Scottish agriculture and horticulture will be better served by the new combined Institute. Its general task will be to do the research needed to sustain and increase crop production in Scotland and northern England. The programme must be fitted to the particular problems and needs of farmers and growers in northern Britain; there should be strong emphasis on plant breeding, crop physiology, agronomy, and crop protection.

9. In crop-orientated research there is always a danger of working on too many crops. The Group recommend that the new Institute should concentrate on potatoes, spring barley, the main forage brassicas (swedes, rape and kale), raspberries (and related fruit) and black currants. Concentrating the existing SHRI and SPBS breeding programmes in this way will be a further step in rationalising UK public sector plant breeding. It will be important for the main state breeding centres in Scotland, England and Wales to continue to develop complementary and collaborative programmes, and to expand existing arrangements for joint trials and for exchanging breeding material under selection.

*Research Programme*

10. The programme of a well-rounded crop research institute must contain three broad components—commercial or variety plant breeding, sciences such as genetics, plant pathology and agronomy to support the breeding programme, and basic science to increase knowledge and provide options for further more applied research. The existing SHRI and SPBS programmes are broadly complementary and, together, they provide a sound basis for the programme which should be developed at the new Institute as opportunities arise over the next few years. The Group carefully examined these existing programmes and had constructive discussions with the two Directors and their senior staff on proposals for the future. Paragraphs 11-24 give the Group's recommendations on the main features of the new programme with comments on the need to increase or reduce staff effort.

*Potato breeding*

11. The 1978 Working Party stressed the importance of potato breeding and related research. The Group concur. The main aim should be to provide varieties for the UK. Breeding for overseas markets, which would require extensive overseas trialling and probably specialised varieties, should not be a primary objective, but the possibility of overseas exploitation of varieties developed for the UK market should not be overlooked. As there is virtually no private-sector breeding in the UK, potato programmes at two centres, the new Institute and the Plant Breeding Institute (PBI) are justified; but the position should be reviewed again in a few years.

12. The programme needs adequate support from genetic and cytological studies. There is also a continuing need for extensive pathological screening and an additional scientist should be appointed, possibly to lead the breeding work for resistance to fungal pathogens. Furthermore, there is an urgent need to fill existing staff vacancies in the potato breeding team.

*Cereal breeding*

13. Barley is the main tillage crop in northern Britain and is particularly important in Scotland. The new Institute should have a strong spring barley breeding programme based on existing SPBS work, with a sustained emphasis on malting quality. The existing programme is just coming on stream and its potential for successful variety production should be assessed after five years. Although the proportion of



winter-sown barley in Scotland is increasing, a separate winter barley programme is not justified at present. Instead, the existing level of evaluation in Scotland of PBI material should be increased.

14. Oats present a problem. The Welsh Plant Breeding Station (WPBS) spring oats breeding programme is supported by a wide range of genetic, biochemical and other work which the SPBS programme lacks. On balance, the Group believe that WPBS should take the lead in UK oat breeding. A collaborative programme should be developed between the two Institutes with the aim of generating spring oat material at WPBS suitable for Scotland. But if the Ministry of Agriculture, Fisheries and Food are unable to continue supporting WPBS spring oat breeding, the new Institute should have its own programme.

#### *Brassica breeding*

15. The new Institute should assume responsibility within the UK for state-supported work on forage brassicas. It should concentrate the breeding effort on, in order of priority, swedes, rape and kale, with some work on novel brassicas and adequate cytogenetical, pathological, biochemical and statistical support. Up to six research scientists would be needed to lead this work. Work on horticultural brassicas now done at SHRI should be phased out.

#### *Soft Fruit breeding*

16. The breeding of raspberries, other *Rubus* crops, and black currants at SHRI has been successful and should be maintained by the new Institute. But there is much less justification for breeding strawberries in Scotland. The existing SHRI programme at Auchincruive should be transferred elsewhere in the ARS to achieve a single breeding centre for the entire UK. One Auchincruive post might be used in the new Institute's soft fruit breeding programme.

#### *Field beans*

17. Several SHRI and SPBS staff proposed a seed legume breeding programme at the new Institute. But few field beans are grown in northern Britain commercially and livestock feed processors show little interest in the grain. The Group recommend that the new Institute should be limited in the meantime to continuing the present collaboration between SPBS and PBI.

18. Plant breeding must have close links with, and adequate support from genetics, statistics, chemistry, biochemistry, plant pathology, crop physiology and agronomy. Decisions on crops to be bred to finished varieties will provide a framework for other parts of the programme. When the resources of the two institutes are combined, scientific support in some of these subjects, especially in support of potato breeding, will have to be reorientated or augmented.

#### *Chemistry and biochemistry*

19. The SPBS Chemistry Department has a good record of providing an analytical service using the latest infra-red instruments and demand from breeders and others will increase. One graduate and two support scientists are likely to be needed, with the possibility of more as the new programme builds up and the analytical demands of other departments increase.

#### *Crop protection*

20. The combined expertise in mycology should be sufficient to support the breeding programme, but redeployment will be needed to strengthen work on cereal fungal diseases, brassica leaf diseases, potato blight and black leg. Work on diseases of strawberries and vegetables should be reduced accordingly. There are not enough entomologists to provide the information required by the breeding programme on aphids on potatoes and other crops. At least one more research leader is needed.

The existing SHRI virology programme is of high quality and is an important part of overall ARS effort. It should continue unimpeded. Work on potato viruses relevant to the breeding programme, which is largely done by SPBS virologists at present, should be strengthened by appointing another research leader.

#### *Agronomy*

21. The combined resources of the SPBS Agronomy Division and the SHRI Crop Research Section are more than adequate to support the breeding programme. The current SHRI programme will need to be reduced, with effort concentrated on supporting the breeding programme particularly on potatoes and also on forage brassicas and fruit.

22. Combining resources for field experiments and trials and locating them all at one centre, Mylnfield, should also produce staff and other savings.

#### *Physiology*

23. The Group considered crop physiology to be the most serious deficiency in the institutes' combined resources. A programme is needed to tackle both fundamental problems and those allied to the production of seed tubers, and the strategic breeding of potatoes, forage brassicas and barley. The latter will need to be co-ordinated with the large programmes on cereal physiology elsewhere in the ARS. It is envisaged that there could be five research leaders in the physiology team of whom one or possibly two might be transferred from the existing Crops Research Section at SHRI. Four of these five should be concerned with the potato crop; one should be of sufficient seniority and standing to lead the physiology programme. The use of simulation techniques would seem to be appropriate to some of this work. Some work at MISR on plant physiology and on soil factors affecting crop composition is very relevant to this proposed new programme and it should be associated closely with work at the new Institute.

#### *Basic science*

24. Part of the work of the SHRI Virology, Mycology and Zoology Sections is basic research not directed to particular crops or agricultural problems. It is important that these areas of scientific excellence should be maintained to broaden the programme, to provide ideas for more applied research, and to establish the scientific reputation of the new Institute. However, there is a potential danger in locating a major breeding programme alongside work on exotic viruses and further research on non-indigenous viruses of crops that form part of the programme should be strongly discouraged.

#### *Research packages*

25. It is necessary for accountability and management purposes for the programme to be defined in terms of research packages. The Group considered that both the crop orientation of the Institute, and the need for a multi-disciplinary approach to research, would be best served by dividing the programme into the following five packages:

- (i) Potato breeding and related research.
- (ii) Cereal breeding and related research.
- (iii) Forage brassica breeding and related research.
- (iv) Soft fruit breeding and related research.

All these four packages could have sub-packages based on disciplines (genetics, chemistry, plant pathology, physiology and agronomy), or on crops, or a combination of the two.

- (v) Basic science.

Sub-packages could be mycology, virology, zoology and physiology.

### *Organisational structure*

26. With around 170 Science Group staff alone the new Institute will need a formal line management structure. In addition, much of the programme will centre on individual crops. It seems therefore that a matrix structure will be needed. Scientists could be grouped into the following Divisions and Departments:

*Crop Protection Division*—Mycology Department, Virology Department, Zoology Department.

*Crop Science Division*—Agronomy Department, Physiology Department.

*Crop Breeding Division*—Chemistry Department, Plant Breeding Department.

27. The Group make these proposals as illustrations, recognising that alternative or further sub-divisions may be necessary. In particular, the large Plant Breeding Department may need to be sub-divided, possibly on a functional basis. There should also be a separate Statistics Department, outside the divisional structure, formed from existing computing and statistics expertise. Other service groups could be accommodated similarly, with separate line management.

28. Specific Crop Groups, possibly with some executive powers, would provide the horizontal component of the matrix. They should be an essential feature of the Institute's management, established by the new Director, and each should include the entire range of scientists working on the same crop, breeders, geneticists, chemists, plant pathologists, physiologists and agronomists.

29. Although scientists would normally fit into the vertical organisational structure according to their discipline, the Crop Breeding Division should include those who provide support to breeders by screening, and in other ways, and whose work is fully integrated with the breeding programme.

### *Phasing the amalgamation*

30. The Group recommend that staff should be transferred to Mylnefield, as soon as facilities can be provided and as opportunities arise. Care should be taken not to damage staff morale at Pentlandfield or Mylnefield.

31. The main building requirements seem to be glasshouses, especially for the breeders, and controlled environment facilities for pathological and physiological work. A potato seed store is needed urgently. The Group noted that a glasshouse investment plan for 1980-81 should help to meet the need for glass.

32. To hasten the amalgamation it may be necessary to use temporary laboratory and office accommodation. In the interest of integration, temporary inconvenience should be shared equally by former SHRI and former SPBS staff.

33. Because of the proposed phasing out of horticultural brassica breeding, the SPBS brassica programme could be a candidate for early transfer. There is also much in favour of an early move of the SPBS potato programme.

### *The Commonwealth Potato Collection*

34. The Collection has been useful to breeders in the past and offers a range of valuable germplasm for future work. But it should not be increased randomly; in general future accessions should only be to meet requests from UK potato breeders.

35. Future location of the Collection depends on how it is to be maintained. If it is to be evaluated and screened, it should be located within easy reach of a potato breeding programme and, for quarantine reasons, Scotland would be the obvious choice. If the seed is simply to be stored on a minimum maintenance basis the location is of less significance, but a site in Edinburgh might be appropriate.

### *Scientific direction and management*

36. The amalgamation plan has had a hostile reception from some staff at Pentlandfield and the new Institute's Governing Body will inherit a rather delicate situa-

tion. Top priority must be given to creating a new and fully integrated first-class crop research institute in the most appropriate manner and without too much or too little haste. This will call for skilled and sympathetic management by the Director of the new Institute and his senior staff. It is vitally important that the people appointed to these posts have, in addition to scientific standing, the personal qualities and management ability required to steer the new Institute through its formative period.

37. When the process of amalgamation has been successfully completed, Scotland will have a greater capacity for research to benefit agriculture in northern Britain than is provided by the two Institutes that now exist. It is hoped too that the basic work done in the new Institute will enhance the already high reputation of agricultural science in Scotland.

*SCOTTISH CROP RESEARCH INSTITUTE (SCRI)—  
PROGRAMME REVIEW GROUP REPORT  
RESPONSE FROM THE SECRETARY OF STATE FOR SCOTLAND*

RESPONSE TO RECOMMENDATIONS

The Secretary of State for Scotland sought the advice of the Agricultural Research Council (ARC) as to the future research programme to be commissioned with the Scottish Crop Research Institute (SCRI) to be formed by the amalgamation of the Scottish Plant Breeding Station (SPBS) and the Scottish Horticultural Research Institute (SHRI). The ARC set up a Programme Review Group to consider the matter against the background of related work in the Agricultural Research Service (ARS). The Report of the Group as homologated by the ARC has been considered carefully together with comments on the Report received from the Ministry of Agriculture, Fisheries and Food, from the Board of SSRPB, from the Governing Body of SHRI, and from representatives of the staff concerned. A list of the main recommendations relating to the programme content of SCRI, with the views of the Secretary of State in each case, is presented at the Annex.

MAIN OBJECTIVE

The main objective of the amalgamation of SPBS and SHRI is the development of a strong and vigorous crop research institute with a programme of work directed towards exploiting the advantage of, and solving the problems of, crop production in northern Britain. The Secretary of State will commission a balanced programme of basic and applied research. The latter will be strongly orientated towards potatoes, spring barley, the main forage brassicas (swedes, rape and kale), raspberries (and related fruit) and black currants.

REDEPLOYMENT

Particular note has been taken of the Programme Review Group comment that there is a danger of working on too many crops. If the benefits of amalgamation are to be achieved there will have to be changes in the current research programmes of both of the existing institutes. This will involve a redeployment of effort and staff both across crops and, in the longer term, across disciplines.

RESEARCH PACKAGES

These changes will be reflected in the new packages to be commissioned with the SCRI. The work at SCRI will be divided into one basic science package and four crop-linked packages dealing with potatoes, grain crops, forage brassicas and horticultural crops. These will be sub-divided to cover the different aspects of the subject in question. The basic science package will contain essentially the strategic work of the institute not directed to particular crops or agricultural problems and the crop-linked

packages will contain essentially the applied work of the institute including the plant breeding.

A capacity must be maintained within SCRI to work on specific problems arising in agriculture and horticulture which merit special attention. There will therefore be flexibility within the package structure to enable such work to be carried out if sufficiently pressing needs can be identified. There will, however, be no major allocation of resources to such topics on a scale which would lead to diversion of effort away from the main objectives of the institute.

#### ORGANISATIONAL STRUCTURE

The Programme Review Group included recommendations touching on a possible organisational structure for the SCRI. The Secretary of State regards the organisation of the staff and other resources as a matter primarily for the Director and Governing Body of the SCRI and commends to their study the views expressed by the Review Group.

#### PHASING OF TRANSFER WORK

Similarly the Secretary of State looks to the local management of the SCRI in consultation with their staff to formulate proposals for the transfer of crops and staff.

### *SCRI RESEARCH PROGRAMME PROGRAMME REVIEW GROUP RECOMMENDATIONS AND VIEWS OF THE SECRETARY OF STATE*

#### STRATEGY

1. *The general task will be to do the research needed to sustain and increase crop production in Scotland and Northern England. The programme must be fitted to the particular problems and needs of farmers and growers in northern Britain; there should be a strong emphasis on plant breeding, crop physiology, agronomy and crop protection (Paragraph 8 of the Report).*

The Secretary of State accepts this recommendation. The success of the new Institute is likely to derive from a programme of research containing an appropriate balance between basic and applied work and between the various disciplines. The applied work to be commissioned at SCRI will be closely linked to specific crops which are of importance in northern Britain (see below). It will include three components: plant breeding including, as may be necessary, the production of finished varieties; work designed to support and further the breeding programme; and work on the problems of crop production and crop protection in their own right. There is already at SHRI a substantial element of work in the last category which is directed towards the crops that will form the focus of effort at SCRI. This work can be expected to continue. However, in order to attain the appropriate balance between the various disciplines some re-orientation of effort within the current institute programmes will be inevitable.

2. *The new Institute should concentrate on potatoes, spring barley, the main forage brassicas (swedes, rape and kale), raspberries (and related fruits) and black currants (Paragraph 9).*

It is important for the success of the work of the Institute that there should be a degree of concentration on crops which have special relevance to northern Britain, taking due account of work on these or other crops at research institutes elsewhere in Britain. In addition, it is necessary in practical terms to be selective to avoid a dissipation of resources on a programme which is too diffuse and which seeks to cover too many crops. The Secretary of State is satisfied that the Working Group has struck a satisfactory balance and accepts this recommendation.

### 3. Potatoes

*The main aim should be to provide varieties for the UK. Breeding for overseas markets, which would require extensive overseas trialling and probably specialised varieties, should not be a primary objective, but the possibility of overseas exploitation of varieties developed for the UK market should not be overlooked (Paragraph 11).*

*The programme needs adequate support from genetic and cytological studies. There is a continuing need for extensive pathological screening and an additional scientist should be appointed, possibly to lead the breeding work for resistance to fungal pathogens (Paragraph 12).*

*Work of relevance to the potato breeding programme should be expanded, in potato blight and blackleg by re-deployment of existing effort within mycology (Paragraph 20), in agronomy by re-deployment of existing effort (Paragraph 21), in physiology by both re-deployment and additional personnel (Paragraph 23), and in entomology and virology by additional personnel (Paragraph 20).*

*Work in physiology is needed to tackle problems allied to the production of seed tubers (Paragraph 23).*

It is intended that SCRI should become the focal point in the UK for research on potatoes, and it is accepted that the research effort on potatoes should be strengthened and expanded largely through additional support for work relating to the breeding programme. Representations have been made to the Secretary of State about the restrictive nature of the recommendation that the breeding programme should have as its main objective the provision of varieties primarily for the UK market. There is an important distinction between conducting a breeding programme specifically to meet requirements abroad and trialling abroad material generated within a programme of breeding for the UK. Further consideration is being given to this matter. In coming to a final decision, the Secretary of State will require to take into account the potential of the various overseas markets and the level of resources required for the various options.

*The Commonwealth Potato Collection should not be increased randomly; in general future accessions should only be to meet requests from UK potato breeders (Paragraph 34).*

Representations have been made to the Secretary of State as to the future role of the Collection. The matter will be considered further in consultation with the Director of SCRI once appointed and in relation to the breeding objectives ultimately agreed for SCRI.

### 4. Cereals

*The new Institute should have a strong barley breeding programme based on existing SPBS work, with a sustained emphasis in malting quality. The existing programme is just coming on stream and its potential for successful variety production should be assessed after five years. A separate winter barley programme is not justified at present. Instead, the existing level of evaluation in Scotland of PBI material should be increased (Paragraph 13).*

*A collaborative programme on spring oats should be developed between SCRI and WPBS with the aim of generating spring oat material at WPBS suitable for Scotland (Paragraph 14).*

*Work of relevance to the spring barley breeding programme should be expanded, in cereal fungal diseases by re-deployment of existing effort within mycology (Paragraph 20) and in physiology in a programme of work co-ordinated with the large programmes on cereal physiology elsewhere in the ARS (Paragraph 23).*

It is accepted that the cereal breeding work at SCRI should be confined to spring barley and that there should be a limited expansion of the research effort on this

crop. Progress in the programmed work on spring barley will be appraised in 1985, as in 1981, in the normal course of the review of research and development packages commissioned by DAFS.

Trialling of other cereal crops will continue and may be expanded. The Secretary of State is aware of the strong interest in Scotland in winter barley and spring oats, and of the concern expressed at the proposed cessation of the breeding of these crops at SCRI. Nevertheless, he considers that progress in the breeding of winter barley and oats is more likely to be achieved through the development by the SCRI of closer links with the breeding programmes at the Plant Breeding Institute (PBI) and at the Welsh Plant Breeding Station (WPBS) respectively so that Scottish requirements are specifically taken into account. MAFF have agreed not to go ahead with the proposed closure of the spring oat breeding programme at WPBS but to continue it on the basis that it will include provision for Scottish needs.

#### 5. Brassicas

*The new Institute should concentrate the breeding effort on swedes, rape and kale, with some work on novel brassicas and adequate cytogenetical, pathological, biochemical and statistical support. Up to six research scientists would be needed to lead this work (Paragraph 15).*

*Work of relevance to the forage brassica breeding programme should be expanded in brassical leaf diseases by re-deployment of existing effort within mycology (Paragraph 20), in agronomy by re-deployment of existing effort (Paragraph 21) and in physiology by re-deployment or the addition of personnel (Paragraph 23).*

*Work on horticultural brassicas now done at SHRI should be phased out (Paragraph 15).*

The SCRI will have the sole UK responsibility for forage brassicas and the Secretary of State accepts that there should be a limited expansion of research effort on these crops with a maximum of six research scientists leading the work on breeding/genetics. However, in view of the major programme of work on vegetables, including horticultural brassicas, being carried out at the National Vegetable Research Station (NVRS) the suggested phasing out of the breeding of horticultural brassicas is also accepted.

#### 6. Soft Fruit

*The breeding of raspberries, other Rubus crops and black currants should be maintained by the new Institute. The existing SHRI strawberry breeding programme at Auchincruive should be transferred elsewhere in the ARS. One Auchincruive post might be used in the new Institute's soft fruit breeding programme (Paragraph 16).*

This recommendation is accepted. Strawberry breeding will continue in the South; a separate programme in Scotland is no longer justified. Any screening necessary for the assessment of strawberry seedlings in Scotland would be undertaken by SCRI in co-operation with the Colleges of Agriculture.

#### 7. Field Beans

*The new Institute should be limited in the meantime to continuing the present collaboration between SPBS and PBI (Paragraph 17).*

This recommendation is accepted. The Secretary of State is, however, aware of the potential importance of vegetable protein crops in both the United Kingdom and Scottish contexts and will keep this matter under review.

#### OTHER RECOMMENDATIONS

##### 8. Basic Science

*Part of the work of the SHRI Virology, Mycology and Zoology Sections is basic research not directed to particular crops or agricultural problems. It is important that these areas of scientific excellence should be maintained to broaden the programme, to provide ideas for more applied research, and to establish the scientific reputation of the new Institute (Paragraph 24).*

*A programme is needed to tackle fundamental problems in crop physiology (Paragraph 23).*

The Secretary of State is aware of the reputation for scientific excellence that is attached to certain aspects of the research programme at SHRI. It is his intention that such work should continue to be supported. The recommendation relating to crop physiology will be borne in mind when framing the packages of research to be commissioned with the SCRI.

#### 9. Chemistry and Biochemistry

*One graduate and two support scientists are likely to be needed, with the possibility of more as the new programme builds up and the analytical demands of other departments increase (Paragraph 19).*

The Secretary of State accepts that the management of SCRI will require to keep the staffing of this Department under review to ensure that its capacity matches the growing needs of the Institute for its services.

#### 10. Crop Protection

*Work on disease of strawberries and vegetables should be reduced (Paragraph 20).*

It is accepted that these are areas of work where staff redeployment will be required if the proposals to strengthen the work on potatoes, spring barley and the forage brassicas are to be achieved.

#### 11. Agronomy

*The combined resources of the SPBS Agronomy Division and the SHRI Crop Research Section are more than adequate to support the breeding programme. The current SHRI programme will need to be reduced (Paragraph 21).*

The SPBS Agronomy Division is already of a size adequate to cope with the relevant SPBS trialling needs.

The Secretary of State accepts that the current work on agronomy at SHRI should be reduced, possibly through an alteration in emphasis towards crop physiology, and that the remaining agronomic work should be concentrated on supporting the new Institute's breeding programme.

#### 12. Physiology — Macaulay Institute

*Some work at the Macaulay Institute for Soil Research (MISR) on plant physiology and on soil factors affecting crop composition is very relevant to the proposed new programme and it should be associated closely with work at the new Institute (Paragraph 23).*

This is accepted and DAFS will arrange for consultation between the Directors of both institutes to bring about the proposed association.

#### 13. Virology

*The existing SHRI virology programme is of high quality and is an important part of overall ARS effort. It should continue unimpeded (Paragraph 20).*

*There is a potential danger in locating a major breeding programme alongside work on exotic viruses and further research on non-indigenous viruses of crops that form part of the breeding programme should be strongly discouraged (Paragraph 24).*

The Secretary of State takes note of these recommendations and will bear them in mind in relation to the exercise of his powers to issue licences authorising any work which it is agreed may be desirable in relation to non-indigenous viruses.

#### 14. Zoology

*There are not enough entomologists to provide the information required by the breeding programme on aphids of potatoes and other crops. At least one more research leader is needed (Paragraph 20).*

The Secretary of State accepts that the entomology programme requires to be strengthened by the addition of at least one more research leader.



### *Governing Body*

Mr George Bruce, Mr David Cargill and Mr Ian Lowe retired from the Governing Body at the end of March. All are well known growers of distinction and have served on the Governing Body of the Institute for many years. They are warmly thanked for their services, and it is hoped that they will maintain an active interest in the Institute for a long time to come.

Thanks also go to the Chairman of the Governing Body, Mr Gordon Porter, who has been appointed Vice-Chairman of the Governing Body of the new Institute, with Mr John Arbuckle as Chairman.

### *Appointments*

The following Assistant Scientific Officers were appointed during 1980:

Mrs Margaret Garland	Crops Research Section
Sandra L. Mudie	Crops Research Section
Dawn M. Williams	Virology Section
D. Hobbs	Zoology Section

Other new members of staff were Susan J. Badenoch, SO, Virology Section; Wilma Farrell, L.A., and Mrs Elizabeth A. Hunter Johnston, CO, West of Scotland Unit (Auchincruive); Mrs Joyce Davidson, Typist, and Mrs Maureen Murray, Audio Typist, Administration; A. E. Grant, EW III, Estate Section.

### *Resignations*

Mrs Jeanette McD. Brown	ASO, Crops Research Section
D. G. Cathro	ASO, Crops Research Section
Jane Kettles	ASO, Crops Research Section
H. J. Gooding	Officer-in-Charge, West of Scotland Unit (Auchincruive)
Mrs Elizabeth J. Lindsay	ASO, Mycology Section
J. G. Lindsay	SO, Virology Section
Mrs Margot Aveyard	ASO, Virology Section
Mrs Carol Henderson	ASO, Zoology Section
Mrs Margaret Mauchland	Typist, Administration

### *Promotions*

M. M. Anderson	} SSO to PSO
J. M. Duncan	
I. M. Roberts	
D. J. F. Brown	SO to HSO

### *Retirements*

F. Robertson	EW, Estate Section
Mrs Sheena Y. Lawrence	Typist, Administration

### *Awards*

R. M. Brook	Ph.D., University of Dundee
A. Dickson	Ph.D., University of Dundee
R. L. S. Forster	Ph.D., University of Dundee

### Research Students

Helmy Wahdan (Horticultural Research Institute, Cairo) continued his studies on environmental effects on the growth and development of the strawberry. (Crops Research)

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

D. R. Ellerton (ARC post-graduate student) completed his studies into the causes of failure to emerge of barley seeds of low vigour and obtained a post with ADAS, Eastern Region, as a specialist advisor in plant pathology.

K. Forbes (SRC-RCCA post-graduate student, jointly with the Institute of Animal Genetics, Edinburgh, and the University of Edinburgh) continued his studies on the genetics of *Erwinia carotovora*.

T. M. O'Neill (SRC-RCCA post-graduate student, jointly with the University of Stirling) completed his studies on the epidemiology and biochemistry of host/pathogen interaction in smoulder of Narcissus, *Botrytis narcissicola* and obtained a post with ADAS, West Midland Region, as a specialist advisor in plant pathology.

Christine J. Whitehart (SRC-RCCA post-graduate student, jointly with the University of Aberdeen) continued her studies on the epidemiology of raspberry cane spot, *Elsinoe veneta*. (Mycology)

Sarah Dodd, an ARC research student, arrived in October to work on the genome nucleic acids of nepoviruses.

R. L. S. Forster, a New Zealand National Research Advisory Council post-graduate student, completed his studies on nepoviruses and returned to New Zealand.

J. C. Sequeira, from the Estacão Agrónomica Nacional, Oeiras, Portugal, continued his work on cassava latent virus, as a post-graduate fellow of the Calouste Gulbenkian Foundation.

P. M. Waterhouse, an ARC research student, continued his studies on aphid-transmitted carrot viruses. (Virology)

B. S. Griffiths continued his studies on the changes induced in root-tip galls by *Longidorus elongatus* and *Xiphinema diversicaudatum*.

Z. Stephan commenced studies on the biology and life cycle of *Meloidogyne ardenensis* in Scotland. (Zoology)

### Sandwich Course Students

Robert Haggart (Dundee College of Technology) assisted from April to September with studies on the toxicity to aphids of potato plants treated with granular insecticides. (Zoology)

### *Visiting Workers*

Tang Deng-yin (Institute of Geography, Peking) left in November after spending 10 months studying water uptake and loss from crops. His visit was under an agreement between the Royal Society and the Chinese Academy of Sciences.  
(Crops Research)

Elsbeth Endel from the Agricultural University, Wageningen, The Netherlands spent 3 months gaining experience of plant virology techniques.

Dr T. Tamada returned to the Hokkaido National Agricultural Experiment Station in October after spending a fruitful 18 months studying potato leafroll virus.  
(Virology)

Dr A. Bello (Instituto de Edafologia, CSIC, Madrid) worked for 1 month on the analysis of the geographical distribution of *Xiphinema* in relation to environmental factors in Spain.

Dr J. Coosemans (Laboratorium voor Fytopathologie en Plantenbescherming, Leuven, Belgium) spent 2 weeks in December studying *Longidorella* nematodes as possible vectors of nepoviruses.

Dr Maria Ivezic (Institute of Plant Protection, Osijek, Yugoslavia) spent 2 weeks in May and June studying techniques used in nematology.

Professor U. Wyss (Institut für Pflanzenkrankheiten und Pflanzenschutz, Hannover, Germany) spent 4 days in August discussing research on the dorsal oesophageal gland cell in *Xiphinema index* and its secretions into plant roots.  
(Zoology)

### *Sabbatical Leave*

J. A. T. Woodford departed in February to spend 14 months at Lembaga Penelitian Hortikultura, Lembang, Bandung, Indonesia as Entomology Specialist in the International Agricultural Advisory Service, Indonesian National Vegetable Research Programme.

### *Visits Abroad*

J. M. Duncan left the Institute on 1 October to spend 6 months working with Dr E. Seemüller, Biologische Bundesanstalt für Land- und Forstwirtschaft, Institut für Obstkrankheiten, Dussenheim, Federal Republic of Germany on various aspects of factors affecting the survival in soil of oospores of species of *Phytophthora*.

R. A. Fox visited the Institute 'De Haaf,' Wageningen, 20-21 May to attend a meeting of the Council of the European Association for Potato Research and a joint meeting of the Council with the Chairmen of the Association's various disciplinary sections. He returned to Wageningen on

2 June for a meeting of the Association's Disease Assessment Group at the Research Institute for Plant Protection (IPO). From 3-7 June he attended the EAPR Pathology Section Meeting held at IPO, and visited the Foundation for Agricultural Plant Breeding and 'Noordzeeolders' Station of the General Netherlands Inspection Service.

B. D. Harrison was an invited speaker at the NATO Advanced Study Institute on 'Active defence mechanisms in plants' held at Cape Sounion, Greece, from 21 April-3 May. Afterwards he visited the Benaki Phytopathological Institute, Athens. In December, he served on an academic jury of the University of Strasbourg and gave an invited lecture in the Institut de Biologie Moleculaire et Cellulaire in Strasbourg.

M. A. Mayo visited IBMC, Strasbourg, from 15 October to 3 November, at the invitation of Professor L. Hirth, to continue his collaborative research with Dr Christiane Fritsch and give an invited seminar. Financial support was provided by CNRS.

G. D. Lyon spent a sabbatical year, from mid-January onward, working with Professor P. Albersheim, University of Colorado, in an attempt to elucidate the mechanisms whereby *Erwinia carotovora* elicits phytoalexins.

M. C. M. Pérombelon visited the Laboratoire de Genetique des micro-organismes, Station de Pathologie Vegetale, Versailles, France, 18-20 February, in relation to a joint project on the genetics of *E. carotovora* supported by a NATO grant.

I. M. Roberts visited Oberkochen, Federal German Republic in January at the invitation of Carl Zeiss Ltd., to test a new model of electron microscope. In August, he attended Eurem 80, the Seventh European Congress on Electron Microscopy, held at The Hague. A travel grant was provided by DAFS.

P. D. Waister visited potato research centres at Corvallis, Oregon, at Aberdeen, Idaho, and at Pullman and Othello in Washington between 13 and 20 July, following the ISHS Symposium in Vancouver attendance at which was sponsored by the SNFU Forfar Branch and the SHRI Association.

J. A. T. Woodford visited the Asian Vegetable Research and Development Center, Taichung, Taiwan, 11-12 August.

### *Courses Attended*

T. J. W. Alphey, B. Boag and D. L. Trudgill attended the Association of Applied Biologists' Workshop on Nematicides held at Rothamsted Experimental Station, 5-6 June.

Janet E. Brinklow, Heather A. Ross and D. T. Mason attended a data management seminar at ERCC, Edinburgh, 16 October.

R. J. Clark attended an ERCC Graphics Course in Edinburgh, 3-7 March.  
J. B. Cowan attended the NCAE/NIAE Data Logging course at Silsoe, 15-18 September.

Ursula McKean attended a 2 day Lockheed/DIALOG Information Retrieval Service System seminar held in London on 2-3 June.

I. M. Roberts attended a course for occasional speakers at ABRO, Edinburgh on 17-19 June.

W. M. Robertson attended a specialised course on Transmission Electron Microscopical Society at Leeds University, 13-18 April.

C. E. Taylor attended a Senior Management Course at Brunel University, 17-21 November.

P. D. Waister attended an ARC Information Course, London, 9-11 April.

### *Course Organised*

A 3-week course on 'Crops as ecosystems' was given at Dundee University, with thirteen members of staff acting as lecturers.

### *Conferences at which papers were given*

5-7 February	ADAS Plant Pathologists' Technical Conference, Great Malvern.	
	B. D. Harrison	Virus classification and nomenclature, and some recent developments in plant virology.
20 February	Association of Applied Biologists, London.	
	S. C. Gordon	Integrated pest control in raspberries—new approaches.
25 March	Society for General Microbiology Virus Group, Cambridge.	
	D. J. Robinson	Replication of RNA-1 of tomato black ring virus independently of RNA-2.
25-26 March	ADAS Conference, University of Nottingham, School of Agriculture.	
	R. Thompson	Mixed crops of field beans and peas.
14-18 April	Sixth ARC EM Conference, GCRI, Littlehampton.	
	G. H. Duncan	Extraction of small amounts of material for electron microscopy.
	G. H. Duncan	Comparative counts of small particles in the electron microscope.
	I. M. Roberts	Freezing techniques for electron microscope specimens.

15-17 April	Association of Applied Biologists / British Ecological Society/Federation of British Plant Pathologists. Symposium on 'Wild plants in the ecology of crop pests and diseases,' York.
	A. F. Murant      The role of wild plants in the ecology of nematode-borne viruses.
21 April-3 May	NATO Advanced Study Institute, Cape Sounion, Greece.
	B. D. Harrison      Active resistance of plants to viruses.
5-9 May	International Society for Horticultural Science Third International Symposium on Flower Bulbs, Nyborg, Denmark.
	W. P. Mowat      The production of virus-tested Narcissus in Scotland.
	W. P. Mowat      Epidemiological studies on viruses infecting narcissus.
28 May	Scottish Diagnostic Virology Group, Glasgow.
	B. D. Harrison      Sensitive serological methods for detecting potato leafroll virus in potato plants and vector aphids.
2-4 June	International Conference on Vegetable and Flower Seed Production, Castrocaro, Forli, Italy.
	J. R. T. Hodgkin      Some aspects of sib production in F1 cultivars of <i>Brassica oleracea</i> .
2-7 June	Pathology Section Meeting, European Association for Potato Research, Wageningen.
	R. A. Fox      Interactions between tuber age, depth of inoculation and gangrene development.
9-13 June	International Seed Testing Congress, Vienna.
	D. A. Perry      Report of the vigour test committee, 1977-1980.
24-26 June	EEC Protein Group Seminar on Seed Legumes, Wageningen, The Netherlands.
	R. Thompson      Factors limiting growth and yield of <i>Vicia faba</i> .

- 6-13 July ISHS Symposium on Rubus Breeding and Machine Harvesting, Vancouver, Washington and Oregon.
- D. L. Jennings Recent progress in breeding raspberries and other *Rubus* fruits at the Scottish Horticultural Research Institute.
- H. M. Lawson Recent research on cane vigour control in Scotland.
- I. G. Montgomerie The pathogenicity of *Phytophthora* species to red raspberry.
- P. D. Waister Potential yield in red raspberry as influenced by interaction between genotype and cultural methods.
- B. Williamson Does spur blight (*Didymella applanata*) reduce the yield of red raspberries?
- 3-9 August The XVI International Congress of Entomology, Kyoto, Japan.
- J. A. T. Woodford Integrated control of *Resseliella theobaldi* and midge blight in red raspberry (*Rubus ideaus*).
- 15-18 August AAB/FBPP/SIPP Meeting, Dublin.
- M. C. M. Pérombelon Epidemiology and control of potato blackleg: a review of present concepts.
- 18-20 August Compstat 80 Conference on Computational Statistics, Edinburgh.
- P. B. Topham The place of a micro-computer in an agricultural research institute.
- 22 August Micro '80, Brighton.
- I. M. Roberts Electron microscope studies of tobacco rattle virus protein aggregates.
- 24-30 August The XV International Nematology Symposium, Bari, Italy.
- T. J. W. Alpey Automated nematode identification.
- T. J. W. Alpey The feeding behaviour of *Xiphinema diversicaudatum* on ryegrass treated with foliar application of oxamyl.

	T. J. W. Alphey	Computer mapping techniques for Beet Cyst nematodes in the UK.
	W. M. Robertson	Comparison of ultrastructure of the dorsal oesophageal gland cell in <i>X. index</i> starved for different periods.
	D. L. Trudgill	Criteria for assessing the transmission of viruses by longidorid nematodes.
	D. L. Trudgill	Differential transmissibility of arabis mosaic and strawberry latent ringspot viruses by populations of <i>Xiphinema diversicaudatum</i> .
	D. L. Trudgill	Tolerance of potatoes to potato cyst nematodes.
1-5 September	Third International Symposium on the Microbiology of Leaf Surfaces, Aberdeen.	
	M.C.M. Pérombelon	The ecology of erwinias on plant surfaces.
8-12 September	European Association for Potato Research, Physiology Section Meeting, Norwich.	
	P. D. Waister	Seasonal changes in net assimilation rate and relative growth rate of stem cuttings of potato.
16-17 September	ARC Photographers and Graphics Officers' Conference, WPBS, Aberystwyth.	
	M. I. McMaster	Sectional graphics.
17 September	Society for General Microbiology Virus Group, Leeds.	
	B. D. Harrison	Behaviour in protoplasts of temperature sensitive mutants of tomato black ring virus.
	M. A. Mayo	Specificity and some properties of genome-linked proteins of nepoviruses.
14 October	Edinburgh EM Group Safety Seminar, Edinburgh.	
	I. M. Roberts	Safety in electron microscopy.



11 November	LKB Symposium on Preparative Techniques, Glasgow. I. M. Roberts	Electron microscope serology— the technique and applications.
15-16 November	Boden-Wurtemberg Regional Advisers' Extension Conference, Federal Republic of Germany. J. M. Duncan	Detection of red core root disease of strawberry using a root tip test (in German).
18-20 November	British Crop Protection Conference — Weeds, Brighton. H. M. Lawson H. M. Lawson	Herbicide programmes for spring- planted strawberries. Strawberry runner control with dinoseb-in-oil.
26 November	Aberdeen EM Group, Aberdeen. I. M. Roberts	A high resolution shadowing technique using uranium.
16-17 December	ADAS Conference, University of Nottingham, School of Agriculture. 'The physiological processes important in determining pea yield and stability.' R. Thompson	Peas in the northern environment.
17 December	Association of Applied Biologists/Federation of Plant Pathologists, London. B. Boag L. M. Cotes D. L. Trudgill	Crop nematode interactions, Tolerance of early potato cultivars to potato cyst nematode and its relevance to chemical control. Raspberry replant disorders in Scotland.
17-19 December	Federation of British Plant Pathologists/Society for General Microbiology. Symposium on Plant Disease Etiology: 100 Years of Koch's Postulates, London. A. T. Jones W. P. Mowat D. A. Perry P. M. Waterhouse	Involvement of raspberry bushy dwarf virus in the etiology of raspberry yellows disease. Properties of tulip virus X. Carrot cavity spot and pectolytic bacteria: Koch's paradox? Purification and serology of carrot red leaf virus.

### *Conference Organised*

I. M. Roberts organised the Eighth Scottish Symposium on Electron Microscope Techniques, which was held in Dundee on 6 November. Invited and offered papers dealt with a range of technical developments and 16 trade firms exhibited equipment and literature.

### *Editorial Duties*

R. A. Fox	Member of Board of Editors of <i>Potato Research</i> .
B. D. Harrison	Editor of <i>Commonwealth Mycological Institute/ Association of Applied Biologists Descriptions of Plant Viruses</i> . Member of Editorial Board of <i>Journal of General Virology</i> . Member of Editorial Board of <i>Intervirology</i> .
A. T. Jones	Member of Editorial Board of <i>Annals of Applied Biology</i> .
H. M. Lawson	Member of Board of Editors of <i>Annals of Applied Biology</i> .
M. A. Mayo	Member of Editorial Board of <i>Journal of General Virology</i> .
A. F. Murrant	Editor of <i>Commonwealth Mycological Institute/ Association of Applied Biologists Descriptions of Plant Viruses</i> .
D. J. Robinson	Member of Editorial Board of <i>Journal of Virological Methods</i> .
C. E. Taylor	Associate Editor of <i>Journal of Horticultural Science</i> . Editor of <i>Nematologia Mediterranea</i> .
Pauline B. Topham	Assistant Editor of the <i>Lichenologist</i> . Editor of <i>Horticultural Research</i> .
D. L. Trudgill	Consulting Editor of <i>Plant and Soil</i> .
P. D. Waister	Associate Editor of <i>Journal of Horticultural Science</i> .
A. B. Wills	Joint Editor <i>Eucarpia Cruciferae Newsletter</i> .

### *Service on Committees*

T. J. W. Alpey	UK representative on the European Plant Parasitic Nematode Survey.
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 of the European Society of Nematologists.
M. R. Cormack	NFT Scottish Soft Fruit Panel.
A. Dale	NFT Scottish Soft Fruit Panel.
R. A. Fox	Council Member, European Association for Potato Research. Vice-Chairman, Pathology Section, EAPR. Chairman, Disease Assessment Group, EAPR (to July, 1980). Member (Administration) Symposium Committee, Crop Protection in Northern Britain.
B. D. Harrison	Association of Applied Biologists, President. International Congress of Virology, Joint Vice-Chairman of Programme Committee.
D. L. Jennings	NFT Raspberry Panel. NFT Scottish Soft Fruit Panel. SNSA Adviser to Committee.
A. T. Jones	Virology Group of Federation of British Plant Pathologists, Convener.
H. M. Lawson	ISHS Working Group on Weed Control in Vegetables.
D.K.L. MacKerron	Edinburgh User Friendly Database Management System Working Party.
W. P. Mowat	Scottish Bulb Technical Committee, Convener.
A. F. Murrant	International Society for Horticultural Science, Chairman of Working Group on Small Fruit Viruses.
D. A. Perry	Chairman, Vigour Test Committee, International Seed Testing Association.
C. E. Taylor	Journal of Horticultural Science Publications Committee. Potato Marketing Board—Member of Research and Development Committee. President, European Society of Nematologists Board of Management. ACAS Scientific Advisory Committee. Chairman, European Plant Parasitic Nematode Survey (European Science Foundation). NFT Advisory Committee. West of Scotland Agricultural College Glasshouse Advisory Committee.

University of Strathclyde/West of Scotland Agricultural College Horticultural Degree Advisory Board.

SNSA—Adviser to Committee.

SNSA (Flower Bulbs)—Board of Directors.

NSDO Advisory Committee.

Member of Scientific Council of the Laboratorio di Nematologia Agraria, National Research Council of Italy.

Editorial Board, Horticultural Research.

R. Thompson

SHRI/Scottish Colleges Liaison Group.

Pauline B. Topham

ERCC Research Council Users' Group.

P. D. Waister

ADAS Working Party on temporary shelter for field crops.

Fayside and Fife Branch Committee of the BA.

HEA Scottish Branch Committee.

NFT Scottish Soft Fruit Panel.

Dundee University Botanic Garden Committee.

K. N. Weaver

ADAS/ARC Ways and Means Panel. Crop establishment from seed.

A. B. Wills

British Association of Plant Breeders' Vegetable Crop Group.

### *Exhibitions*

14-18 April

'Four current techniques used for electron microscopy of viruses' at ARC EM Conference, Littlehampton.

19 April

Colour graphics of nematode ultrastructure, and cibachrome colour prints of biological and horticultural subjects were displayed at the Institute of Medical and Biological Illustrators Conference, Ninewells Hospital, Dundee.

23 April

'New black currants for the '80s' at the 1980 Auchincruive Horticultural Exhibition organised by WSAC. A display explaining the attributes of the SHRI new black currant cultivars.

18-21 June

'New black currants for the '80s' at a Science Fair in Craigie High School, Dundee, organised by the British Association Young Scientists.

- 18-20 August        'The use of GIMMS computer package to draw maps of nematode distributions in Europe' at the COMPSTAT International Symposium, Edinburgh.
- 26-28 August        'New black currants for the '80s' at Ayr Flower Show.

*Radio and Television*

B. D. Harrison and P. D. Waister discussed the work of the Institute on Radio Tay on 18 November.

D. L. Jennings discussed the 'Tayberry' on BBC Radio 2 on 11 November.

## INDEX TO PROJECTS

---

<i>Crops Research</i>	<i>Page</i>
01001 Effects of weather conditions on growth, yield and quality of soft fruit crops	37
01012 Ecology of new fruit crops for Scotland	50
01014 Physiological and cultural factors affecting the mechanical harvesting of soft fruits	48
01018 Control of growth, yield and quality of raspberries by cultural methods and choice of genotype	48
01019 Control of growth, yield and quality of strawberries by cultural methods and choice of genotype	49
01021-4 Weed ecology and control in soft fruit and vegetables	42
01029 Weed control in crop rotations	43
01030 Control of growth, yield and quality of vegetable crops by cultural methods and choice of genotype	44
01044 Statistics	50
01045 Computing (service)	51
01046 Agro-meteorological recording (service)	128
01049 Effects of weather conditions on growth, yield and quality of vegetable crops	39
01050 Control of growth, yield and quality of protein and other seed crops used for food manufacture	46
01051 Effects of soil structure on germination and emergence of vegetable seeds	41
 <i>Plant Breeding</i>	 <i>Page</i>
03001 Strawberry: breeding and associated genetic studies	54
03003 Strawberry: breeding systems at different ploidy levels	56
03006 Raspberry: breeding and associated genetic studies	57
03008 Breeding early, erect blackberries and other <i>Rubus</i> berries	58

03009	Breeding black currants for northern regions of the UK	58
03010	Brassicas: genetics of S-allele incompatibility system in <i>Brassica oleracea</i>	62
03011	Brussels sprouts: breeding hybrid cultivars	63
03012	Cabbage: breeding hybrid cultivars	65
03013	Brassicas: isoenzyme analysis in <i>Brassica oleracea</i>	66
03015	Brassicas: genetics and cytology of <i>Brassica oleracea</i>	66
03019	Calabrese breeding	65

### *Mycology*

*Page*

02001	Chemical and cultural control and economic importance of diseases of cane and bush fruits	86
02003	Shoot disorders of cane and bush fruits	80
02004	Chemical and cultural control and economic importance of strawberry red core	86
02005	Analysis of and screening for resistance to diseases of soft fruit	83
02010	Seed quality-soil interactions and their effects on seedling growth	75
02013	Biology of root diseases in field peas and beans	74
02015	Disorders of vegetables	77
02016	Chemical and cultural control of potato gangrene	89
02017	Biology of potato gangrene	69
02019	Gangrene, blackleg and soft rot and contamination of VTSC seed potato stocks	84
02022	Harvest disorders of soft fruit	81
02024	Autecology of the strawberry red core fungus	72
02026	The nature and implications of quiescent fungal and bacterial infections	76
02027	Studies of plant pathogens	78

<i>Virology</i>	<i>Page</i>
04001 Potato viruses, especially soil-borne viruses	103
04002 Viruses with nematode vectors and/or multipartite genomes	92, 93
04003 Viruses infecting raspberry	98
04004 Production of virus-tested raspberry stocks	100
04007 Viruses affecting umbelliferous crop plants	101
04010 Viruses infecting bulbous ornamentals	96
04011 Production of virus-tested bulb stocks	98
04014 Identification of viruses in relation to diseases of other crop plants	105
04021 Techniques for electron microscopy	106
<i>Zoology</i>	<i>Page</i>
05001 Ecology and control of horticultural and agricultural pests	120
05002 Biology and ecology of trichodorid spp. and their roles as virus vectors	114
05003 Chemical control of virus vector and other plant parasitic nematodes	111
05004 Feeding of <i>Longidorus</i> and <i>Xiphinema</i> spp. in relation to plant response and virus transmission	117
05005 Ultrastructure of nematode vectors of plant viruses with reference to their feeding apparatus	118
05007 Ecology of <i>Longidorus</i> and <i>Xiphinema</i> spp. in relation to their role as plant pathogens	115
05010 Assessment of the damage caused by potato cyst and other plant parasitic nematodes in Scotland	109
05011 Migratory plant parasitic nematodes associated with vegetable crops in Scotland	114
05012 Ecology and control of <i>Pratylenchus</i> spp. associated with soft fruit	113
05013 Control of aphids and virus diseases of potato, raspberry and bulbous ornamentals	119



## CROPS RESEARCH

P. D. WAISTER

---

The research programme on seed germination and seedling establishment was terminated during the year and the staff involved commenced work on potatoes. Under the leadership of Dr T. W. Hegarty this project has over the past 12 years produced very useful information on the extent to which pre- and post-sowing factors influence germination and growth. The advisory services and other research workers are now building on this information, both in applied and strategic studies.

Other redeployment of effort has been made in anticipation of the merger of the two institutes. Work on the effects of weather on soft fruits has been reduced and resources switched to arable crops, primarily potatoes. The programme investigating cultural methods for field vegetables has contracted over the past few years, but will be maintained at a level which it is hoped will allow us to deal with some of the more immediate problems identified by growers and advisers, particularly those problems that are peculiar to the northern environment or more acute in the north.

A series of meetings with a group of leading seed potato producers has helped in formulating objectives in research on crop physiology, and discussions with plant breeding staff at Pentlandsfield are continuing on the role of physiological research in relation to breeding objectives.

### CROP ENVIRONMENT

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

##### *Root environment of strawberries*

This experiment investigates the effect of clear and black polythene mulch on the temperature and moisture conditions in the root zone of strawberry cv. Cambridge Favourite, and the resulting effects on growth and yield. The mulched plants are grown on the ridges and the controls grown on the ridge and on the flat.

In this first cropping year the clear polythene treatment yielded 19.5 t/ha, 34% more than the unmulched flat controls. Yield from the black polythene treatment was intermediate between the two. The higher productivity came from increased truss numbers, not from greater berry size, and reflected the enhanced vegetative vigour resulting from higher soil temperature. Of particular interest in relation to production in Scotland was that the

period of cropping was not advanced, which would have been disadvantageous to those growers supplying late markets.

Soil moisture under the clear polythene was not limiting, there being no additional yield increment compared with plots trickle-irrigated under the mulch. Root excavation using monoliths showed that in all treatments rooting was extensive and this presumably helped in avoiding moisture stress. Roots exploited all but the surface 1 cm of the ridge, and also occupied the soil volume extending to at least 30 cm either side and 50 cm below each plant. In the flat-planted control, lateral extension and depth of rooting were also at least 30 and 50 cm respectively.

(D. K. L. MacKerron, P. A. Gill, P. D. Waister)

#### *Bud necrosis in black currants*

To determine the extent of the bud necrosis problem (Ann. Rept 1979, p. 30), a survey was conducted during the winter of 1979/80 with the help of ADAS and the East of Scotland College of Agriculture. Samples were collected from Kent, East Anglia, the West Midlands, the Borders and eastern Scotland. Ten shoots were taken at random from plantations of the cultivars, Baldwin, Ben Lomond and Ben Nevis and assessed for bud necrosis. Overall the level of necrosis was similar in the three cultivars at about 12%, but there were large differences between sites and there were genotype x site interactions.

The survey was repeated in October, 1980, at 10 sites selected from those sampled the previous year; a larger sample of 25 shoots was examined from the one cultivar, Baldwin. The level of necrosis was generally lower than recorded previously (1979: 20%; 1980: 14%), but again, there were large variations.

The ability of black currants to compensate for lost or damaged primary overwintering buds was examined in a plantation of Ben Lomond. Three treatments, all primary buds removed, alternate primary buds removed, and control, were applied to ten bushes. A single shoot on each bush was treated—except where alternate buds were removed when two shoots were treated—so that the total number of buds was similar for the bud removal treatments. The primary buds were carefully excised in mid-February, and the regrowth assessed in mid-June. There was a significant increase in the number of secondary overwintered buds which developed where primary buds were removed. This was greatest in the completely disbudded shoot, but still only represented a replacement of 15% of the total bud number. The compensation in fruit number was also small; where alternate buds were removed fruit number was 61% of the control and, where all primary buds were removed, only 6%.

It was suspected that a heavy fruit load might result in the diverting of substrates from the developing overwintering buds during the summer, so stressing the buds to the point where necrosis occurred. In a plantation of Ben Lomond that had shown 33% bud necrosis in 1979, three treatments

were applied to complete bushes. Each bush was either half-deblossomed, deblossomed, or defruited at the green fruit stage, and there was an untreated control. The degree of bud necrosis was estimated in early September, but was found to be too low in all treatments (5%) to permit identification of any treatment effect.

The influence of reducing the photosynthetic capacity of a shoot on the incidence of bud necrosis within that shoot, was also examined in the same plantation. Single shoots on 12 bushes were defoliated at 14-day intervals from late May until the mid August. The level of necrosis when recorded in September was similar to that found in the controls.

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

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

*Seasonal changes in growth of potato stem cuttings*

At fortnightly intervals throughout the season batches of second generation stem cuttings of cv. Pentland Crown were rooted and grown at 20°C for 2 weeks, and after a further week in a glasshouse with a minimum temperature of 12°C were placed outside on a capillary bed; a parallel batch was destructively sampled at the beginning of each outdoor period, for estimation of initial dry weight and leaf area.

After 2 weeks of exposure to outdoor conditions, dry weights and leaf areas were recorded and net assimilation rate and relative growth rates estimated. Thirteen sets of data spanning the period from 9 April to 8 October were used in regression analysis of growth on fortnightly means of daily mean temperature and total solar radiation. Net assimilation rate (NAR) and relative growth rate (RGR) increased linearly with mean daily temperatures between 8 and 14°C, and over the first six sample dates when radiation appeared to be non-limiting. For the remaining seven sample dates the level of radiation was decreasing, although temperatures remained high, and NAR and RGR were then linearly related to radiation values. The regression of mean NAR on temperature for the first six sample dates and radiation for the last seven sample dates accounted for 92% of the total variation. The corresponding regression for mean RGR accounted for 84%. Leaf relative growth rate (on an area basis), however, showed a continuing linear relationship with temperature ( $r=0.87$ ).

(H. A. Ross, P. D. Waister)

*Growth and light interception of potatoes*

Plots of the cultivars Maris Bard and Pentland Crown were established on normal field soil and in compost under 'maximum yield' (MM) conditions (Ann. Rept 1976, p. 31). Growth was monitored by regular destructive sampling, and light interception was measured at intervals using photon

sensors. An outbreak of blackleg in Maris Bard, which was particularly severe in the MM plots, invalidated growth comparisons in that cultivar.

Within a month of emergence leaf area indices (LAI) in both field and MM plots of P. Crown were greater than 3, and 99% of incident light was intercepted. Reflection of photosynthetically active radiation (PAR) was about 6% during the middle of the day, so absorbed PAR was a high fraction of incoming PAR. By mid-July the LAI in the MM plot had reached 8.2, exactly double that of the crop on field soil. The relationship between total dry weight increase and intercepted radiation was essentially linear in the field plots, but obviously departed from it in the MM plot after mid-July when the total dry weight in the MM plot did not increase further, though the canopy remained green and apparently healthy.

The luxury levels of nitrogen and the sustained soil moisture availability in the MM plot may explain the recorded late development of tubers. Whether this resulted in a reduced sink load and perhaps a depressed assimilation rate is not clear. However, though tuber bulking was delayed, tuber number in the MM plot was nearly twice that recorded in the field plot.

It is apparent that further maximum yield studies on potatoes will depend upon ensuring the provision of N at a rate consistent with maximising dry weight increase. This may or may not be the same as the optimal rate for increase in tuber dry weight.

(R. Thompson, D. K. L. MacKerron, H. Taylor)

#### *Response of potato to shelter from wind*

A pilot experiment on cv. Maris Piper on a neighbouring farm, using two 30m long windbreaks, gave some indication of a response in both tuber numbers and yield to protection from the prevailing south-west wind. Crop variability was too great to permit accurate determination of the level of response.

(D. K. L. MacKerron)

#### *Light interception by pea canopies*

Measurements of intercepted and absorbed photosynthetically active radiation (PAR) were made on canopies of leafy and tendrillate cultivars of peas. The study this year filled in a gap in previous work which had examined light distribution within these canopies in relation to leaf area distribution.

In mid-July the PAR interception by Filby (tendrillate) reached a maximum of 97% and was achieved with a total area index of 3.4, while Vedette (leafy) intercepted 99% of incident PAR with a total area index of 10.4. By early August the area index of Filby had fallen to 2.2 but the canopy stood 72 cm high and still intercepted 95% of incident PAR. The Vedette canopy, however, had lodged and was 30 cm high with the area index reduced to 3.5 with only 86% of incident radiation being intercepted.

(D. K. L. MacKerron)

### *Changes in freezing points of stored potato tubers*

An investigation was started on the significance of freezing points as indicators of tuber water status. Tubers of cv. Pentland Crown were placed in store at 2 and 16°C in mid-October, 1979. Samples of six tubers were removed at 10-day intervals up to the end of April, 1980. Transverse cores, 25 mm long and 20 mm in diameter, were taken at the rose, mid and heel positions. These were mopped dry, before a thermocouple was inserted into the centre. The temperature of the tissue was lowered at a rate of 1.3°C per minute, and the exotherms were monitored on a flat-bed recorder. Two discrete freezing points were recorded on each sample. The first was of brief duration and the second was on an extended time plateau. After a period of about 30 days from the start of storage, the freezing points maintained stable relative positions, those of the tubers from 2°C storage being below those from 16°C.

The experiment was repeated in 1980/81 with additional measurements of tuber water status, and chemical analyses to allow estimation of solute potentials from solute contents. Tubers were put into storage at 2 and 16°C on 9 November. Measurements of the freezing points were made on cores from three-tuber samples at weekly intervals. The freezing points were similar to those found in 1979/80.

The first freezing point was close to that of tissue previously frozen and thawed, suggesting that it is a measure of the freezing point of cell sap rather than extracellular water. The solute potential of thawed tissue measured with a thermocouple psychrometer was slightly higher (less negative) than that estimated from freezing points, but agreed well with preliminary calculations of solute potential from chemical analyses. The significance of the second freezing point will be investigated further. We thank the Macaulay Institute for Soil Research for the chemical analyses.

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

### 01051 *Effect of soil structure on germination and emergence of vegetable seeds*

#### *Integral impedance and soil moisture*

The relationship between integral impedance and soil moisture content was determined in a laboratory study using a medium sandy loam from SCRI, a fine sandy loam from Orkie Farm in Fife, and a silt loam from Kirton EHS in Lincolnshire. There have been cases of seedlings failing to emerge on all three soils because of high soil strength, the Kirton soil being prone to crusting and the Orkie soil to slumping after rainfall.

The soils were sieved, air dried and mixed to a moisture content of 19%. The soil was left to dry in 7.5 cm × 4 cm pots and when dry, transferred to a raintower and given rainfall treatments ranging from 15 minutes to 3 hours at an intensity of 16 mm/hr. Measurements of integral impedance and soil

moisture content were made shortly afterwards and periodically thereafter until the soil was air dry.

Plotting integral impedance on a log axis against gravimetric soil moisture content showed the contrasting behaviour of the different soils. The local sandy soils developed maximum integral impedance at a moisture content of 14-16% (SCR1) or 18-20% (Orkie) whereas integral impedance in the Kirton soil was at a maximum at air dryness.

Rainfall treatments in excess of 1 hour, or 1.5 hours in the case of Orkie soil, caused little further increase in integral impedance. In Kirton soil, however, there was a significant effect of rainfall duration when impedance was subsequently measured in soil that was air dry, but no effect when the soil was at more than 12% moisture content.

(K. N. Weaver)

#### *Compaction at seed depth*

Following a previous field experiment in which seedling emergence was found to have been reduced by compaction applied at seed depth, similar treatments were applied to calabrese seeds sown in soil troughs in the glass-house and the fate of the seeds was observed. A reduction of emergence was observed only when compaction at seed depth was applied in combination with a watering or surface compaction treatment.

Surface compaction reduced emergence more than watering and this was associated with a higher level of integral impedance.

(K. N. Weaver)

### WEED INVESTIGATIONS

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

##### *Herbicide evaluation*

Investigations continued into the tolerance by strawberry and raspberry of herbicides introduced for use in other crops to control perennial weeds.

Alloxydim sodium and fluazifop butyl proved adequately safe in both crops; 3, 6-dichloropicolinic acid had little or no adverse effect on strawberry plants as a post-harvest treatment, whereas oxadiazon applied at the same time caused rapid and early senescence of crop foliage. In raspberry, oxadiazon applied prior to cane emergence retarded the early growth of young canes. 3, 6-dichloropicolinic acid applied to the base of raspberry stools when the young canes were 10-15 cm tall, again caused leaf malformation in these canes, but this was rapidly outgrown; there was no effect on fruiting canes. This herbicide may be sufficiently safe to permit overall application in both crops when dense populations of thistles are present, but would be better used only as a spot treatment where infestations are light. Oxadiazon, however, is too damaging to both crops for use other



than as a spot treatment in which a degree of crop injury is accepted as the price of eradication of perennial bindweeds.

Pendimethalin, trietazine/simazine, propachlor/chlorthal dimethyl and ethofumesate were evaluated as pre-emergence residual herbicides in an established raspberry plantation. Ethofumesate delayed cane emergence and stunted early growth, but none of the others had any adverse effect, even at three times the suggested rate of application. Yield of fruit was unaffected by treatment. The safe herbicides may provide useful alternatives to simazine and bromacil in young plantations, on light soils and in circumstances where prolonged herbicide persistence in the soil is not wanted.

In herbicide evaluation experiments on swede and calabrese, pendimethalin applied after sowing virtually eliminated both crops; seedlings emerged normally and then died. The addition of chlorthal dimethyl to propachlor as a post-sowing treatment caused little increase in crop phytotoxicity in swede and calabrese. BAS 47902H was as safe as propachlor in swede, but more damaging in calabrese. Both crops were also treated with two potential perennial grass herbicides after singling, and in the absence of weeds. When applied at up to twice manufacturers' suggested rates alloxym sodium had no adverse effect on the growth or yield of either crop, but fluazifop butyl had a smaller margin of safety, causing reduced yield in both crops.

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

#### 01029 Weed control in crop rotations

##### *Volunteer crops*

Potato berries were planted in field plots in October, 1979, at four depths. In 1980, 62% of berries produced at least one seedling from 2.5 cm depth, 9% from 5.0 cm, <1% from 7.5 cm and none from 10.0 cm depths. Mean numbers of seedlings produced were 10 and six per berry from the two shallowest depths. Seedlings from the same berry competed strongly with one another. One or two eventually achieved dominance and grew on to produce tubers. Further seedling production from these berries following spring seed-bed preparation will be monitored over the next few years.

Records over two winters showed that even very small tubers from seedling plants are capable of surviving winter frosts. In both years almost 50% of tubers of 1 g weight, planted at 15 cm depth, produced plants in the following spring, while 10% survival was recorded from tubers weighing as little as 0.2 g each. Just over one-third of tubers in the 0.05-1.0 g range survived the near to average winter of 1977-78 at 5 cm depth, but complete kill occurred at this depth over the severe winter of 1978-79.

In experiments to examine the part that herbicide programmes in following crops might play in reducing field populations of volunteer crops, potato berries were planted in October, 1979, followed by spring sowing of barley,

field bean, oilseed rape, Italian ryegrass and white clover. A range of soil-applied residual herbicides was sprayed at normal field rates immediately following spring sowing. Dry soil conditions in spring, 1980, impaired herbicide activity and all species except potato and clover emerged rapidly and grew without evidence of injury. When substantial rainfall eventually occurred, herbicide symptoms appeared and growth was checked on certain plots. With potato and clover, seedling emergence did not occur until much later and rain fell when the plants were still small. In these circumstances herbicides having the greatest effect on crop growth were bromacil, ethofumesate, diuron, linuron and terbutryne/terbuthylazine (white clover), bromacil, cyanazine, lenacil and ethofumesate (potato seedlings), bromacil and lenacil (Italian ryegrass), simazine and lenacil (barley) and diuron (field bean). No herbicide treatment substantially affected oilseed rape. The experiment will be repeated over several years to observe the effects of seasonal variation in spring rainfall.

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

#### VEGETABLES AND ARABLE CROPS

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

###### *Calabrese — measured maximum (MM) yield*

Yields for MM plots in previous experiments have generally been greater than those from the controls and it was suspected that water supply, nitrogen supply or a combination of both was responsible. This year plants of cv. Corvet were grown in MM plots and in normal field soil with and without irrigation and extra nitrogen. Yields from all three plots exceeded 10 t/ha, and it appeared that even the control plot was adequately supplied with water through rain, and that the normal levels of nitrogen (250 kg/ha N) were adequate.

Unlike previous years, crops from the different soil treatments reached maturity at the same time, and direct comparison of spear rot for comparable weather conditions was possible. The highest levels of spear rot occurred in plants grown at the higher levels of fertility, with 93, 84 and 22% by number unmarketable for the MM, the high fertility field soil and the control plots respectively. It is clear from these figures that although particular weather conditions (cool and wet) seem to be required for development of the disorder, nutrition or water exert a major influence on the level of development.

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

###### *Potatoes — seed tuber preparation*

Pentland Crown is reported to be less responsive to change in storage temperature and to produce fewer shoots than other cultivars.



For the third successive year (Ann. Rept 1978 and 1979) tubers of Pentland Crown were stored at 2, 5, 9 and 16°C prior to planting. Unlike 1979 when there was only one lifting date of the parent crop, this year tubers were obtained from crops lifted on five occasions between 2 August and 17 October.

Averaged over lifting dates more stems developed from tubers stored at 2 and 5°C (24 stems/m<sup>2</sup>) than from tubers stored at 9 or 16°C (16 stems/m<sup>2</sup>); tubers from these latter two treatments were desprouted prior to planting. Early lifting of the parent crop depressed stem numbers in the subsequent crop; for example, lifting on 2 August gave stem numbers of 16 stems/m<sup>2</sup> and lifting on 13 September produced 24 stems/m<sup>2</sup> in the following crops, when averaged over storage temperatures. Total yields in increasing order of storage temperature were 52, 66, 51, 41 t/ha, which correspond quite closely to those from previous years. Corresponding values for seed yield were 32, 35, 25 and 22 t/ha. Comparisons within and between years indicate that yield and size grading may not be as directly dependent on stem number as some previous workers have suggested. Additional analysis is needed to explain the basis of these responses.

The relative importance of farm storage and origin of the seed stock on subsequent performance was examined with the cultivars Pentland Crown and Maris Piper. Tubers were obtained from each of six sources and stored either on the farm of origin or at 5°C at SCRI. There was remarkably little difference in yield arising from different storage treatments, with averages of about 64 t/ha for Pentland Crown and about 62 t/ha for Maris Piper. Size grading as reflected in the yields of seed sized (35-55 mm) tubers was influenced by storage treatment with 12% more seed from the SCRI stored seed than from the farm stored. Marked differences were found in total yield between sources, with a range of 59-68 t/ha for Pentland Crown and 57-65 t/ha for Maris Piper. Further investigation is required to establish reasons for such differences, which must have originated during the growing season of the parent crop.

The manipulation of tuber size in a potato crop is normally effected by control of stem density via planting rates. Although prediction of the number of stems that will develop in a given seed lot is not possible, an increased number would be welcomed as a means of saving on seed costs, especially for seed production. In preliminary experiments, treatment with tecnazene and rindite increased the numbers of stems which subsequently developed by up to 70% for tubers stored at 16°C. Although this difference was not reflected in total yield (50 t/ha), as would be expected it increased the yield of seed sized (35-55 mm) tubers, with 39 t/ha compared with 20 t/ha from the untreated control.

Experiments are planned to examine responses following more normal storage temperature regimes.

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

*Field beans — EEC joint cultivar trial*

Additional cultivars introduced into the trial were Herz Freya, Strubes Ackerbohne, Zwaan 21-1175, Deiniol, BTW and Diana. Three others, Wierboon, Minica, and Maris Bead, were grown for the third year. The yield of Zwaan was poor, at 2.5 t/ha, but yield of the other eight did not differ significantly and averaged 4.9 t/ha. Seed size varied from 950 g in Wierboon to 300 g in Diana and Herz Freya. Minica and Zwaan were heavily infected with chocolate spot, while Diana and Maris Bead were least affected. Excluding Zwaan, the earliest maturing cultivars were Herz Freya, Minica, Strubes Ackerbohne and Kristall.

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

*Field beans — cultivar observation plots*

Seven new breeding lines or cultivars selected for earliness of maturity were examined in small plots. A breeding line (C45) from the Royal Veterinary and Agricultural University, Copenhagen, which had been in-bred for several generations, and cv. Diana gave the highest yields, at 5 t/ha each. In both lines all pods were black on 90% of the plants by 3 October, but neither of these cultivars was as early as a line from PBI Cambridge which reached this stage of maturity on 19 September. The PBI line, however, produced a yield of only 2.2 t/ha and was very susceptible to chocolate spot which may have been related to its early maturation.

The line WFT (PBI) with a white seed coat and cv. Beryl were grown to produce fresh beans for processing trials in collaboration with ESCA and ELBA growers. The quality of the frozen samples of WFT was equivalent to that of Beryl. Because of limited amounts of seed low sowing rates were used and no attempt was made to assess yield.

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

*Field beans — competition and pod set*

In the previous 2 years marked effects on the yield per plant were obtained by changing the spacing of pot grown plants for short periods of time. The differences in yield per plant depended on the timing of the change in spacing and were associated with changes in different components of yield.

This year a breeding line (6-24) thought to be more uniform than those previously used, supplied by the Royal Veterinary and Agricultural University, Copenhagen, was used and the spacings were changed for periods of 12 days on seven occasions at 12 day intervals between 16 June and 27 August. Two plants were grown in each pot and pot spacings giving 5 and 100 plants/m<sup>2</sup> were used.

Yield of seed from the plants grown continuously at wide spacing was 14 g/plant ( $\equiv 70$  g/m<sup>2</sup>) and that from plants grown continuously at close spacing was 7.6 g/plant ( $\equiv 760$  g/m<sup>2</sup>). The greatest depression in yield for predominantly wide spaced plants was caused by close spacing between 22 July and 4 August and resulted in a yield of 7.4 g/plant ( $\equiv 37$  g/m). Relief from competition at this time in the predominantly close spaced plants resulted in a 29% increase in yield, with 9.9 g/plant ( $\equiv 990$  g/m). These results are in broad agreement with those obtained previously.

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

#### *Field beans — desiccation*

In previous experiments chemical desiccants have not been sufficiently effective in hastening the rate of drying of bean seeds, possibly because the chemicals have been intercepted by the foliage before reaching the stems and pods. This year the effects of cutting and stooking were examined. Plots were cut on six dates between 2 September and 17 October, and the controls from the standing crop were harvested on 29 October. There were no significant differences in yield between any of the treatments. As would be expected the first cutting date resulted in the earliest drying. However, even when cut on 2 September the rate of water loss did not differ from that of the standing crop (control) for about 3 weeks, after which, in the space of 2 weeks, seed from the cut plants had dried from 54% down to 23% compared with 56% down to 34% for the controls. Rain at this stage, about 21 October, rehydrated all plant parts and seed moisture content increased to between 34% and 45% for all treatments. A similar response was obtained last year when seeds which were almost dry enough to combine harvest, became rehydrated after rain. Earlier maturing cultivars would usually be exposed to better weather conditions for drying, but a more effective desiccation technique is still needed for years of poor drying potential such as 1980.

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

#### *Fodder peas — EEC joint cultivar trial*

Four cultivars of pea for combining were grown at the same European sites where the joint field bean experiment was undertaken. The highest yield at SHRI from crops sown on 4 April was obtained from cv. Amino with 5.8 t/ha compared with 4.3 t/ha for the control of cv. Maro. Some shedding of peas from the pods occurred and allowance for this increased the estimated yields of these two cultivars to 6.2 and 4.5 t/ha respectively. Although these yields are good, the plants were harvested at a seed moisture content of 30% on 27 August, and an acceptably low seed moisture content (i.e. 20%) was not attained before the plants began to decay through prolonged wet weather. In contrast, although field beans mature later, problems of rotting do not occur because of the open nature of the crop.

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

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

*National Fruit Trial, 1980*

Planted in April, 1980, this first stage NFT trial comprises the three standard cultivars, Glen Clova (with and without cane vigour control), Malling Jewel and Joy, together with six selections from the EMRS breeding programme and seven from the SHRI breeding programme.

(M. R. Cormack)

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

*Raspberry harvesting*

In 1979 the Agricultural Sciences and Littau harvesters were operated in plots of cv. Glen Isla, at 2 day and 7 day intervals, and harvested yields were compared with those from hand picked plots. To assess the residual effects of machine damage, all of these plots were harvested by hand in 1980. Averaged over harvest frequency the Agricultural Sciences harvester reduced yields by 66% compared with 35% for the Littau. Harvesting at 2 day intervals in 1979 resulted in a 64% decrease in yield in 1980, and at 7 day intervals a 37% decrease, averaged over machines. The losses were attributed to a combination of cane breakage in 1979, cane death during the winter, and reduction in yield per surviving cane. Though the Littau machine does appreciably less damage than the Agricultural Sciences, losses are unacceptably high, even following infrequent machine passes. The solution lies either in further machine modifications accompanied by chemical control of wound pathogens or in adopting the biennial cropping system.

The Littau harvester was used in a biennial cropping experiment formerly harvested by hand, to determine whether fruit removal and catching were affected by the absence of primocanes. Slightly more green fruits were removed in the biennially cropped plots, confirming previous observations with the Agricultural Sciences harvester. Catching was only marginally improved by the absence of young cane, indicating that the gap between the fishplates should be narrowed still further by tighter clipping of the fruiting cane support wires.

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

Detailed records were made of the fate of flowers and fruits throughout the harvest season in machine harvested and hand harvested plots of Glen Isla, Malling Jewel, and seedling 5/32. In past experiments the proportion of

fruit recovered by the machine from the cv. Glen Isla has been consistently poor though the quality of the sample is very good. Fruit recovery from Malling Jewel has been good, and seedling 5/32 shows low fruit retention strength which ought to aid mechanical harvesting. From detailed recordings in these three cultivars it is hoped to identify the characteristics determining the level of fruit recovery, and hence to set breeding targets. More than 20,000 laterals were examined during the course of this season's work and the results are still being analysed.

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

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

*Cultivars from the Pacific Northwest*

Planting material of the American cultivars was imported in 1979 and, though the plants were from a common source and in apparently good condition on receipt, the rate of establishment varied greatly between cultivars. Northwest, Shuksan and Totem grew very slowly and this was reflected in low yields in 1980. The most vigorous American cultivar, Olympus, yielded at the rate of 18.5 t/ha, ranking fourth behind the Institute's 69GU94 and Troubadour and the German cultivar Jurica, and well ahead of Cambridge Favourite (10.9 t/ha). In this first cropping year there was no crown barrenness and yields were largely determined by crown numbers. Defoliation was superimposed as an experimental treatment immediately after harvest. Truss counts made on growing plants did not correlate well with those made by destructive sampling, apparently because of the difficulty of tracing the origin of the peduncle in cultivars like Olympus and Jurica which have basal-branching trusses.

(M. R. Cormack)

*Origin and size of runners*

Runners were produced out of doors in UC compost at Auchincruive and at Invergowrie in 1978 and 1979. Productivity was greater at Auchincruive both in terms of numbers and size. Runners from both sources were planted at Invergowrie and cropped as matted rows. No differences were detected in their performance. More surprisingly there were no differences in yield or its components between plots established from large runners averaging 15 g fresh weight, and from small runners averaging 6 g.

(D. T. Mason, P. J. Dudney<sup>1</sup>)

---

<sup>1</sup> West of Scotland Agricultural College.

*Rubus species*

The blackberry Ashton Cross, a seedling from the wild species *R. bartonii*, yielded at the rate of nearly 20 t/ha, more than double that of any of the other 20 blackberry and hybrid berry cultivars in the collection. Its cropping season covered the period 21 August to 16 October, but 50% of the crop ripened in the 2 weeks between 12 and 26 September. Reasons for the relatively poor performance of the other cultivars include low vegetative vigour, cane death in the winter, poor drupelet set, and late fruiting. The only major agronomic failings of Ashton Cross are its thorny habit and its protracted fruiting period, though the latter may prove to be closely linked to high yield.

(M. R. Cormack)

*Vaccinium species*

For the past 5 years the highbush blueberry cultivar Bluecrop has consistently yielded at the rate of more than 9 t/ha. Vegetative vigour is much less than is commonly found in the same cultivar in the United States, so the fruiting framework takes longer to build up, but the ultimate yield potential appears to be good. Sensitivity to blossom frosts has not been adequately tested by the spring weather of the last few years.

(M. R. Cormack)

STATISTICS AND COMPUTING

01044 *Statistics*

*Statistics (service)*

The empirical study of the statistical properties of various diversity indices applied to the dry weight of weed species continued and showed that several were sufficiently 'well behaved' to be used for routine analysis.

Dr A. Bello<sup>1</sup> visited the Institute in July and studied the distribution of nematode species in Spain by cluster analysis techniques which he used to group both areas and species.

Much research in the Institute involves cultivar responses to various stimuli, which may be soil conditions, climate, pest or disease attack as well as management practice. Genotype-environment interaction analysis has provided a useful framework for interpreting crop responses in various disciplines.

A hands-on statistical package for the System One micro computer was written to our requirements by P. Smith<sup>2</sup>; it includes multiple regression with

---

<sup>1</sup> Instituto Edafología y Biología Vegetal, Madrid.

<sup>2</sup> Plant Breeding Section.

facilities for plotting and examining residuals, together with analysis of variance. It was deliberately restricted to small data sets since GENSTAT offers a wider range of facilities for larger ones. It has been embedded in a user-friendly program which allows data-entry, validation, and transformation followed by file formation. Its use was demonstrated at COMPSTAT 80, the Edinburgh Symposium on Computational Statistics in August.

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

#### 01045 *Computing (service)*

##### *Data capture*

A primitive form of automatic data capture, using serialisers and teletypes attached to electronic balances to produce papertape has become increasingly popular, in spite of its minimal facilities for error recovery; it has educated users in the advantages and problems of automatic recording.

Interfaces are to be constructed locally using PCBs supplied by Alwyn Breame<sup>1</sup>, who has kindly assisted in several aspects of data capture instrumentation.

A program was written for the System One microcomputer to collect data for a Brassica breeding trial. Weights and lengths are captured automatically; scores and plot identification are input manually. Summaries, validity checking, and checks for missing data are included. The data is merged with progeny identifiers and stored on disk for transmission to the ERCC for analysis on GENSTAT. Listing on input and a papertape copy are produced on the teletype. This is the first 'intelligent' data capture program used at the Institute. It is hoped to expand this type of work in conjunction with users, since it offers them flexible control of their data and eliminates transcription errors.

The digitising programs for the Tektronix have been much used for measuring lengths and area on micrographs, tracings and charts and for direct measurement from the microscope using a drawing tube. Equipment and programs are being improved and we are grateful to I. Bilsland<sup>2</sup> for his interest in our projects.

Usage of both the System One and the Tektronix has built up over the year, and they are now heavily used.

(J. B. Cowan, R. J. Clark)

##### *Information Retrieval*

A seminar on Personal Bibliographies and Indexes was given by Dr M. Cross<sup>3</sup>, A. T. Jones<sup>4</sup> and R. J. Clark in December. The programs and facilities available were outlined and the advantages and problems discussed.

---

<sup>1</sup> AVRI.

<sup>2</sup> Graphic Information Systems Ltd.

<sup>3</sup> ERCC.

<sup>4</sup> Virology Section.

The Institute mailing list has been placed on file and address labels for the Annual Report and Association publications and circulars are now to be printed automatically.

It has been decided to add keywords to new entries for the raspberry bibliography. The bibliographies for black currants and some aspects of Botrytis research are being maintained.

The exact form of the data base for the European Plant Parasitic Nematode survey is under discussion. Individual countries collect their data in various forms and it seems probable that a number of smaller files in various formats will be maintained for participants, as well as a master file consisting of limited but standard information summarising distributions.

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

#### *Computing service facilities*

There have been major changes in computer use, which have occurred with remarkably little disturbance to users. Use of the batch service based on NUMAC ceased except for one user, who kept access for continuity in analysing a long term experiment. The introduction of the ICL 2980 at Edinburgh with its improved batch facilities, the upgrade to our PDP 11/10 reported last year, and an increase in the number of terminals available has greatly increased both the proportion of interactive use of the mainframe and the number of jobs detached by users themselves into the batch queue. As a result the figures for the number of jobs and of variates analysed could not be collected as in previous years. The number of variates analysed has fluctuated between 8000 and 9600 a year since 1973. Usage of the 2980 at the ERCC is monitored by asking users to type LOG instead of STOP to log off at the end of an interactive session; their usage is then automatically recorded. The usage figures (Table I) include interactive sessions and a value for the number of batch jobs.

This increase in interactive sessions and the move to automatic data capture has reduced card preparation to some extent and even more the use of cards as a storage medium; it is hoped to continue this trend as equipment becomes available for key-to-disk.

The Tektronix has been used as a graphics terminal to the ERCC to produce graphs for growth analysis, to display changes in soil moisture with depth and time using SYMVU, and to produce sampling frames with random lines for estimating root length.

A Printronix P300 printer was purchased at the end of the year as the machine in use was becoming increasingly liable to breakdown and difficult to service. A grant from the European Science Foundation for equipment for the European Plant Parasitic Nematode Survey allowed upgrading of the Tektronix, the addition of a hard copy unit and provision of a DIABLO daisywheel printer terminal. This last has already proved its value by producing high quality printing for square grid maps and other uses.

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



TABLE I—COMPUTER USAGE, 1980

	2980		Tektronix		System One	
	Occasions	%	hours	%	hours	%
Crops Research	768	28·2	156	33·7	114·2	26·8
Mycology	106	3·8	13	2·8	15·4	3·6
Plant Breeding	766	28·1	21·5	4·6	264·4	61·9
Virology	92	3·4	142·5	30·8	—	—
Zoology	159	5·8	119·5	25·8	27·3	6·4
Statistics Group	679	24·9	—	—	—	—
Others	157	5·8	10	2·2	5·5	1·3
	<hr/>		<hr/>		<hr/>	
	2727		462·5		426·8	

## PLANT BREEDING

D. L. JENNINGS

---

The ARC Programme Review Group considered the Section's breeding programmes in March and recommended that the plant breeding effort of the new institute should be concentrated on fewer crops; they, therefore, recommended that the breeding of strawberries should be terminated and that of horticultural Brassicae should be phased out. These recommendations were accepted. The phasing out of strawberry work coincided with the resignation of H. J. Gooding in December, and the transfer of breeding material to Long Ashton Research Station has started. R. J. McNichol will be responsible for completing the assessments of current material from this programme, but will transfer to Invergowrie in 1982 to strengthen the *Rubus/Ribes* team. Work on horticultural Brassicae will continue until completion of the immediate objectives of the projects.

Several notable breeding successes are reported. Two new raspberries were released for propagation prior to naming as new cultivars; advanced selections of strawberries and black currants gave promising results in yield trials and in processing tests; and two autumn maturing savoys were selected from NIAB Breeders trials and entered for NIAB Performance trials and National Listing.

Studies of juice quality in black currants show advantageous relationships between flavour, colour and ascorbic acid content and suggest that it may be possible to predict flavour ratings from laboratory determinations of the other attributes.

### 03001 *Strawberry: breeding and associated genetic studies*

---

#### *Screening for disease resistance*

Eleven cultivars and four SHRI selections planted in May, 1979, were assessed in June, 1980, for their ability to grow on land heavily infested with red core. Neither the Californian cultivars Aiko, Aliso, Cruz, Dequoia, Toro and Tufts, the French cultivars Bordurella, Gariguette and Vernie, nor the Belgian cultivar Hapil approached the level of field resistance shown by Cambridge Favourite. The susceptibility of Hapil gives cause for concern as its importance is increasing in Kent and it is considered a possible alternative to Cambridge Favourite. Selection GU94 and breeding line Q13 (a major source of resistance to red core in the programme) were given identical scores for red core resistance that were not significantly lower than that of Cambridge Favourite; EW30, a late fruited selection, was given the same score as Cambridge Favourite. Even WT17, which is a selection bred from Gorella with extremely attractive desert fruit suitable for the fresh market, but which is rated highly susceptible to red core, showed more resistance than Hapil.

### *Primary selections*

Family 73NY (Redgauntlet x DK26) was the most promising of those planted in 1979 and fruiting for the first time in 1980. Twelve selections were made from the 600 seedlings planted. This family was from one of a group of Redgauntlet-derived crosses made with the objective of combining Redgauntlet's double-cropping habit and large bright fruit with improvements in fruit shape, flavour, red core resistance and yield. Such a cultivar would be suitable for protected cropping and PYO.

### *Advanced selections*

The results of trials at NFT Brogdale were encouraging for four of our selections. A late, large-fruited selection, EW30, was the second heaviest cropper in one trial while DK60 produced an earlier and heavier crop than Pantagruella. Selection DK60 has occasionally produced malformed fruit at Auchincruive but this has not been reported from the south. Seedling AF86 yielded well and was interesting for its good flavour and sparse foliage which facilitates picking. Selection G55, a sibling of the cultivars Saladin, Silver Jubilee and Tantallon, produced large, very attractive dessert fruit. These four selections are being propagated at Brogdale for planting in multicentre trials.

Fruit from a 1000 plant plot of GU94 near Montrose were sent for commercial freezing tests at Eskfood Limited, Montrose. The interior of the berries from this selection start to redden when the exterior is still white. The berries are also very easy to decap. Preliminary results indicate that the fruit is suitable for freezing as sliced or diced products and for yoghurt production.

W. A. Baxter & Sons Ltd., of Fochabers, reported that DZ66, an exceptionally firm, dark fruited selection with high field resistance to red core, is a possible alternative to imported Senga Sengana, and 3500 plants were propagated to provide for commercial assessment.

### *Fruit quality testing*

Seven selections and 11 cultivars were assessed for freezing quality after blast freezing and storage in a domestic deep freeze for 6 months and thawing for 24 hours. Replicated determinations were made of drip loss, colour and pH. None of them was as dark red as the American cultivars Shuksan and Totem, which had 'L' values of 18.7 and 18.3 on the Gardner colour difference meter; Tantallon and GU94 were the nearest with values of 25.4 and 22.4 respectively, and Cambridge Favourite was the palest with a value of 30.8. The highest pH was recorded for GU76; this may account for the sweet flavour of this selection. It was preferred by consumers and therefore may suit PYO operations where flavour and attractive fruit are more important than good travel qualities. It is being tested in a PYO trial at Luddington EHS. GU76 had high drip losses on thawing and it is unlikely

to be suitable for freezing as a whole berry. Thawed fruits of Cambridge Favourite and Redgauntlet were poor as usual, while the high quality of Silver Jubilee was matched only by Totem.

### *Mechanical harvesting*

The prototype strawberry harvester purchased from Smallford Planters Ltd. in 1979 was evaluated on various planting arrangements, including flat matted beds, discrete spaced plants and raised matted beds. On this site, where severe red core infestation reduces the foliar canopy, the best results were obtained on the raised plantings, where the foliage was more dense and helped to hold the fruit trusses off the ground. This enabled the fingers to raise the fruit above the cutter bar. However, the trusses in all matted bed plantings were lying in a random fashion, and those lying in the direction of travel of the machine were not lifted by the fingers. It was therefore decided to plant flat-top ridges with a single row of very closely spaced plants for harvesting in 1981. This should aid pick-up because it should result in the trusses being borne on either side of the plants and at right angles to the direction of travel.

As the season progressed, and new improved fingers were supplied by Smallford Planters Ltd., the percentage of the crop harvested was raised from 20-30% to 75-85% and in one instance reached 95% for a plot of Redgauntlet. The cultivars Montrose and Redgauntlet were the most suitable for lifting mechanically, because of their long trusses, but Redgauntlet has short pedicels which made it unsuitable for mechanical singulating and decapping.

With the termination of the strawberry breeding work at Auchincruive it is anticipated that future evaluation of selections for suitability for machine harvesting will be continued by the West of Scotland Agricultural College (WSAC).

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

### 03003 *Strawberry: breeding systems at different ploidy levels*

No further work on this project was done. The breeding lines were put into a germplasm reserve and the seed stored in anticipation of the project being continued by WSAC. The two programmes concerned were (i) the *Fragaria vesca* programme for the evaluation of selected lines (mainly 10x) for flavour and growth characteristics: these may be exploited by seed firms; and (ii) the Recurrent Selection programme, a long term project to obtain F1 hybrid cultivars or possibly true breeding lines with commercial prospects.

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

Following the continued good performance of our two leading raspberry selections, 6820/54 and 7210/204, the Scottish Panel of the NFT recommended that they be released as new cultivars. The recommendation was accepted and applications for Breeders Rights for them were made jointly by SHRI and NSDO. Material was released for propagation and the first canes for commercial planting should be available in 1982.

### *Yield Studies*

Variation in the number of nodes present below the tipping height of canes (150 cm) was studied in 21 progenies of nine parents. Principle component analyses showed that high numbers of nodes were associated with canes of relatively thin diameter and short height. The second vector of this analysis revealed an association of high node number with thick canes which was unrelated to cane height. The relative importance of this second vector varied, but it was relatively high in families related to the parents 741B11 and 7325C4. Genetic analyses identified these as the two parents which contributed most to the presence of high node numbers in these families: it should therefore be possible to select for high node number without changing cane height in progenies of these parents, but greater progress would occur if selection for high node number was combined with selection for canes of moderate height.

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

### *Genotype x Environment Interactions of Yield Components*

The growth and productivity of four North American and four British cultivars is being studied at SHRI and at Abbotsford, British Columbia. The plants established more slowly at SHRI and produced shorter and thinner canes in 1979. Three of the North American cultivars had thinner canes than the British ones.

In 1980, the SHRI plants gave their first crop while the Canadian ones were in full production. The fruiting canes of the SHRI plants had more nodes and lateral-bearing nodes, but the number of laterals present was similar because there were more nodes with multiple laterals on canes of the Abbotsford plants. This could be attributed to the differences in cane growth in 1979.

(A. Dale, H. A. Daubeny<sup>1</sup>, Barbara M. M. Tulloch)

---

<sup>1</sup> Agriculture Canada Research Station, Vancouver, British Columbia.

### *Disease Resistance*

The previous report described an experiment which indicated that raspberries with glabrous canes (gene *H*) suffered less from *Botrytis cinerea* than those with sub-glabrous canes (gene *h*) because of unidentified factors operating after infection and not because of an escape mechanism. This conclusion was supported by the results of another experiment which also showed that the incidence of *B. cinerea* on the fruit was significantly less on plants with hairy canes.

In further experiments using mycelial inocula the smallest lesions of both *B. cinerea* and *Didymella applanata* again occurred in families of raspberry hybrids related to *Rubus occidentalis* (black raspberry) *R. pileatus* and *R. crataegifolius*. Evidence of resistance to *B. cinerea* in the fruit was also obtained for a F1 progeny of *R. pileatus* x raspberry. This progeny was also remarkable for its resistance to mycelial inocula of each of our three main pathogens *B. cinerea*, *D. applanata* and *Leptosphaeria coniothyrium*.

### 03008 Cane Fruit: breeding early erect blackberries and other Rubus berries

The blackberry selections fruiting in 1980 showed that progress has been made in selecting for spinelessness and early flowering but not in rate of ripening, and the late season emphasised that both components of earliness are required for successful blackberry growing in Scotland. Rapid ripening was therefore emphasised in the new progenies produced, and hybrids of cv. Ashton Cross, the quickest ripening cultivar at Invergowrie, were used extensively as parents. Seed from open-pollinated flowers of spine-free Oregon-bred selections was also introduced: these selections are notable for early ripening as well as excellent fruit quality and they have a dominant form of spinelessness.

To produce a spine-free hybrid of the Tayberry type, a second generation was planted of the cross of a Tayberry-like hybrid with US1362, a septaploid thornfree hybrid. This progeny segregated 1:1 for a dominant form of spinelessness. A low proportion of spine-free or near spine-free segregates were obtained from a first backcross to the raspberry of both diploid and tetraploid *R. parviflorus* x raspberry hybrids. The inheritance of spinelessness in this material appeared to be complex, and segregation in the first backcross was for the presence of soft hair-like spines rather than for complete spinelessness as in *R. parviflorus* and its F1 hybrids.

(D. L. Jennings, Eleanor Carmichael)

### 03009 Bush Fruit: breeding black currants for northern regions of the UK

Several problems caused concern during the year. Following the occurrence of rogue plants in the original stock of cv. Ben More it was disconcerting to discover a relatively high proportion of apparent mutant plants or shoots

in stocks of 13 hybrids propagated in March. Another problem was the occurrence in two plots of unusually severe symptoms of reversion virus. To avoid any risk of disseminating a possible new strain of this virus, all the plants in the vicinity were burned and all the material distributed in winter, 1979-80, was destroyed. This involved a considerable loss of small nuclear stocks of the leading selections and we are indebted to ADAS and DAFS officers for their co-operation in solving this problem. Finally, paraquat injury so seriously affected the fruit set of 4000 hybrids in their first year of cropping that it precluded any early assessment of them.

### *Importations and Distributions*

A wide range of wild black currant ecotypes or their hybrids was imported from Sweden and the USSR to increase the range of donor parents available for breeding for frost tolerance.

Material of our leading selections was sent for testing in New Zealand, Denmark, Sweden and West Germany.

### *Regional Trials and Commercial Assessments*

In contrast with 1979, Ben More flowered 15 days later than Baldwin at Luddington EHS and 21 days later at NFT, Brogdale. At both centres it outyielded Baldwin by 5 t/ha and was harvested 2-3 weeks later. Neither spring frost nor low temperatures during flowering caused damage. A late flowering Ben More hybrid at the NFT attained full flower on 29 May, 12 days later than Ben More, but it was picked on the same date (12 August), only 12 days later than Baldwin and Ben Lomond. The accumulated yields of seven late-flowering Ben More hybrids and an erect, late-flowering Westra x (Goliath x Ojebyn) hybrid in their second year of cropping exceeded or equalled that of Ben Lomond (11.3 t/ha). At Luddington EHS the branches of this Westra hybrid characteristically collapsed under the weight of crop. Two of the high yielding Ben More hybrids were notable for their combination of upright habit and free-spurring, strong branches.

Two high-yielding, late flowering Ben Lomond hybrids in the NFT—P8/11/7 and P9/8/7—were rated moderately highly at SRI for juice quality. If their flavour is judged satisfactory in 1981 tests they may be suitable for juice processing, as they ripen in succession to Ben Lomond.

Another two selections were amongst the earliest to ripen at NFT. One of them (P10/20/5) flowered relatively late and ripened very early on 14 July; the other (P7/7/19) flowered 2 weeks earlier. The picking season for this group of hybrids therefore extended over about a month from the earliest ripening to the latest ripening Ben More hybrid.

Several selections are being propagated for a large-scale commercial assessment in Norfolk of their suitability for juice processing, machine harvesting and mechanical pruning. They are all notable for high juice colour and ascorbic acid content, though berry size and yield are only

moderate in some instances. They include 243/7, two of its hybrids with Westra and two of its hybrids with 240/18. The erect Westra hybrids will provide information on the suitability of this plant type for mechanised management, and the others provide contrasting flavours.

#### *Juice quality: Colour and ascorbic acid content*

The colour densities of 369 juice samples were measured on an SP6-300 Pye Unicam spectrophotometer. The samples were diluted to 5% v/v at pH 1 and to 10% v/v at pH 3 after adjusting to standard specific gravity; their optical densities were measured in a 2 mm cell at E515 nm and E430 nm. Polymeric colour density was also measured in 39 of the samples, but it contributed so little to juice colour that further routine measurements were discontinued. A copigmentation index, E515 at pH 3/E515 at pH 1, was calculated for each sample. This measures the ratio of anthocyanin colour at juice pH 3 to that at pH 1 and is a valuable discriminant for highly coloured samples.

Measurements were also made of ascorbic acid content (adjusted to standard specific gravity (AAsg), titratable acidity, % soluble solids (% sucrose), specific gravity, juice yield per 100 g fruit and mean berry weight.

Although different measurements of colour were used for the first time, the following relationships between the eight variables, as revealed by principle component analysis, were broadly in agreement with previous results. Two components describe the relationships between juice yield per 100 g fruit and acidity and two describe the relationships between AAsg per 100 g of fruit and juice colour:

- (1) large berries tended to produce a large volume of highly coloured juice with a high copigmentation index, a low pH, a low % sucrose and average AAsg and titratable acidity.
- (2) small berries tended to produce a smaller volume of highly coloured juice with a high copigmentation index, a low pH, a high % sucrose and titratable acidity and above average AAsg.
- (3) high AAsg, moderately high colour, pH and copigmentation index were associated with low titratable acidity, low % sucrose and an average juice yield from small berries.
- (4) low AAsg, titratable acidity and small berries were associated with high colour, high % sucrose and pH, moderately high copigmentation index and juice yield.

Seventy-five (30%) of the juice samples were rated highly for colour (E515 at pH1 > 1.50), 52 (14%) for high AAsg (> 200 mg AAsg/100 g juice), and 9 (2.4%) were comparable to 243/7 for a desirable combination of colour and AAsg.



## Flavour

Thirty-six of the best juice samples were judged for flavour by an experienced tasting panel at Beecham Products. A sample of Baldwin was rated 7.0 and the others ranked by comparison: three hybrids of 243/7, 240/18, 243/7 and Ben Lomond were rated superior to it. The flavour scores were not correlated with either spectral measurements or copigmentation index, but they were significantly correlated with AAsg/100 g fruit ( $r=0.48$ ). In a principle component analysis of AAsg/100 g fruit, juice colour, flavour score and copigmentation index, the second and third components accounted respectively for 22 and 19% of the variance. The second component described an almost ideal relationship where a high flavour rating was associated with high juice colour, a high copigmentation index, and moderately high juice yield and AAsg/100 g fruit; the third component described a relationship where it was associated with high AAsg, moderately high titratable acidity and % sucrose, low juice yield/100 g fruit, low pH and low juice colour. The flavour scores were correlated only with the values obtained for the second and third components ( $r=0.71$  and  $0.39$  respectively), which together accounted for nearly two-thirds of the flavour variance.

All the analyses support the previous conclusion that 243/7 is outstanding both as a potential cultivar for juice processing and as a parent. Improvements are now required in plant habit and branch strength. Since the above analyses suggest that in certain genotypes good flavour is associated with highly coloured juice and in others with high ascorbic acid, selections with good habit and strong branches are being sought which show either one of these juice-quality combinations. The aim is to produce a range of 243/7 hybrids spanning an extended ripening season and showing improvements in plant habit and branch strength which allow machine harvesting and pruning with minimal injury. In the short term this improvement is being sought from a combination of a modified Westra-type habit with the strong branches of certain Ben More hybrids, but for the long term new germplasm from related species is being exploited. However, progress in 1980 with material related to a strongly branched *R. sanguineum* hybrid was impeded by poor seed germination.

## Disease and Pest Resistance

Progenies related to Sunderbyn II, *R. laxiflorum* and *R. sanguineum* segregated for a non-sporulating form of resistance to American gooseberry mildew. They flowered in 1980, but failed to set fruit. Further crosses between both Sunderbyn II and *R. laxiflorum* hybrids and 243/7 were made to combine this resistance form with high juice quality.

Notable improvements in plant habit occurred in two-year-old progenies of Ben More x gall-mite resistant black currant x gooseberry hybrids.

(M. M. Anderson, Judith T. Thomson)

### *Tolerance of spring frosts*

Further study of the tolerance of black currant flowers to induced frosts confirmed that Ben More and its allies are more tolerant of frosts than other cultivars tested.

### *Loss of immature fruits*

To study the effect of cold, but not freezing, temperatures on losses of immature fruit, plants of 12 cultivars were exposed to 5°C for 2 days at one of three growth stages: grape stage, first flower and full flower. The losses were significantly greater on treated than on untreated plants, but Baldwin, Magnus, Kerry, Seabrooks Black and Ben More were the only cultivars where this difference was significant for plants treated at the grape stage; of these cultivars, the first three are particularly susceptible to spring frosts. Baldwin lost significantly more fruit from plants treated at first flower, and Magnus and Kerry were the only cultivars which had significant fruit losses when treated at any of the three stages. Thus the cultivars which lost the most fruit when subjected to cool temperatures during spring were the ones which are particularly susceptible to spring frosts.

(A. Dale, Barbara M. Tulloch)

### 03010 *Brassicac: genetics of S-allele incompatibility systems in Brassica oleracea*

#### *Sib production in hybrid cultivars of cabbage and Brussels sprouts*

Commercial seedsmen continue to express concern about the percentage of sibs found in hybrid cultivars, and in order to try to assess the overall significance of the problem information was sought from commercial plant breeding companies in the UK and Holland on the occurrence of sibs in commercial productions of hybrid seed.

Five companies reported on the sib percentages of seven cabbage and 16 Brussels sprout cultivars produced between 1968 and 1979. The information was supplied in different forms but could always be classified by cultivar, parent line, type of S-allele in parent, year and country of production, and production environment (field or glasshouse).

The survey showed that sibs continue to be present in many seed lots at commercially unacceptable levels. Between 1976 and 1979 sib percentages exceeded 10% in the seed from both parents in almost a third of the hybrid productions examined. In addition there were wide and unpredictable fluctuations between different productions of the same cultivar, sib levels from some parents ranging from 5% to over 50%.

Analysis showed that the most important factor affecting sib percentages was the parent used. Some parents frequently gave seed lots with high sib contents whilst others always gave seed with few sibs. When hybrids had a common parent it usually gave very similar percentages of sibs in the

different combinations in which it was used. Differences between years or country of production were not significant, but seed produced under glass contained significantly more sibs than that produced in the open.

The results also suggested that considerable over-production of hybrid seed was necessary in order to produce a sufficient quantity with an agronomically acceptable proportion of sibs.

(J. R. T. Hodgkin)

#### *The nature of the incompatibility reaction*

The discovery that rishitin (a potato phytoalexin) inhibited potato pollen germination (Ann. Rept., 1978) suggested that there might be analogies between the S-allele incompatibility reaction and a plant's fungal defence mechanisms. To investigate stigmatic activity 0.1 gm *B. oleracea* stigmas were collected 20-24 h after being pollinated. The ethyl acetate soluble fraction of the stigmatic extracts was subjected to chromatography on silica TLC plates in methanol and chloroform (4:96). After drying the plates were sprayed with a spore suspension in Czapek Dox solution of *Cladosporium cucumerinum*. After 4 days only slight inhibition of fungal growth was seen and there were no measurable differences between the effects of stigmas pollinated with compatible or incompatible pollen or the unpollinated controls.

(J. R. T. Hodgkin, G. D. Lyon<sup>1</sup>)

#### *Plants suitable for self-incompatibility research*

Rapid flowering *B. alboglobra* lines obtained from P. Williams of Wisconsin University were self pollinated and their S-alleles analysed. Many of the plants were completely self-compatible but plants homozygous for two S-alleles were identified among those which flowered 60-70 days after sowing. These have been crossed with plants homozygous for dominant S-alleles to produce lines with a range of S-alleles which can be studied within 2 months of sowing instead of after a year as at present. A programme was started to produce male sterile S-homozygotes which do not require the removal of anthers before dehiscence as is now necessary for many purposes.

(J. R. T. Hodgkin)

#### 03011 Brussels sprouts: breeding hybrid cultivars

##### *Yield components*

Studies on inheritance of yield components have provided progenies which combine yield enhancing characteristics from the cultivars used in the initial experiments. Plants from the best progenies selected in 1978 (Ann.

---

<sup>1</sup> Mycology Section.

maturing lines split earlier than usual and later types did not mature by mid-December, though all were sown on 7 April.

Overwintering inbreds of all the lines survived well and produced enough seed, even though some showed severe *Alternaria brassicola* infection.

Unreplicated observation plots were grown of 380 savoy, white cabbage and Celtic-type hybrids produced from a partial half-diallel in 1978. Some Celtic-type lines were satisfactory agronomically and were left for winter hardiness assessment.

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

#### 03015 *Brassicac: genetics and cytology of Brassica oleracea*

Although there is increasing cytological evidence for the accepted view that the nine chromosomes of the *B. oleracea* genome derive from an ancestral member of six, gene mapping studies have not revealed any homologies. Experiments using trisomics to locate genes and linkage groups on particular chromosomes are in progress and further genetical data are being sought on major genes and their linkage relationships.

Examination of segregation for seedling markers in nine families did not reveal any linkages. Among previously unrecorded gene combinations now shown not to be linked were  $gl^b$  with A and  $Hr^D$ , and  $gl^{e2}$  with c-1 and a pg gene. Further sowings were made of some families previously grown in 1979. In one group of these, recombinations between Fn and c-2 was estimated at  $40.4 \pm 4.3$ . The same group also consistently showed linkage ( $45.0 \pm 4.1$ ) of Fn and a hairy-foilage gene, probably Hr-1, though all previous evidence gave no indication of linkage. Compared with previous years more field plants survived the winter and flowered, so flower characteristics could be observed in families already assessed for morphological markers (Ann. Rept, 1979). White petal (Wh) was linked in backcross and  $F_2$  families to fused cotyledon (fc), the best estimate of recombination being  $34.3 \pm 5.5$ . Wh was not linked to a male sterile gene (ms), nor to nine other markers. In a related family ms was linked to leaf excrescence (le).

(A. B. Wills, P. Smith)

#### 03013 *Brassicac: isoenzyme analysis in Brassica oleracea*

Studies on electrophoretic variation were initially stimulated by the need for a rapid, objective means of assessing sib frequencies in hybrid cultivars. Routine assessments by acid phosphatase analysis are now done by several breeding companies and co-operation with them in applying the technique has continued. Acid phosphatase phenotypes were investigated in some new or difficult hybrid stocks from such companies and the applicability of the technique to the material was demonstrated. Although successful with most cultivars the method does not recognise the sibs in all, particularly those bred from cultivar groups with a narrow genetic base. Therefore the

search for useful alternative enzyme systems has continued with examination of the electrophoretic variation of myrosinase in seed extracts. Considerable activity was detected after incubating gels with sinigrin substrate but resolution of the barium sulphate precipitate was poor. Clearer results might be obtained by modifying extraction and staining procedures and work on both aspects is continuing.

Zone 1 acid phosphatase (acp-3) from cotyledon and leaf extracts give patterns consistent with dimeric enzyme structure, since homozygotes have only a single band and most heterozygotes have three. Inconsistencies in heterozygote patterns were examined in some segregating families. The results confirmed that acp-3<sup>b</sup> is dominant to acp-3<sup>a</sup> (Ann. Rept, 1978), the heterozygote having only a single band, b. They also showed two types of behaviour for acp-3<sup>c</sup>/3<sup>d</sup> heterozygotes. In one family they gave clearly resolved bands c and d without an intermediate hybrid band, but in all the other eight there was a stained area with no discrete bands.

Acp-1 (seed zone 2), acp-3 and S-allele genotypes were identified in an F<sub>2</sub> family produced by selfing Brussels sprout cv. King Arthur. The S-locus was inherited independently of both acid phosphatase loci.

Homoeologues of acp-1 and acp-3 of *B. oleracea* have been found in *B. campestris* (Ann. Rept, 1978) and more alleles have been identified in the latter than in the former species. Thus allelic bands with mobilities (relative to Brilliant yellow) of 0.60, 0.63, 0.66, 0.75 and 0.78 have been recognised in cotyledon extracts. Poorly resolved staining and absence of well-defined bands, similar to that described above in *B. oleracea*, was found in 0.75/0.78 and 0.60/0.63 heterozygotes. The number of alleles and the relative frequencies of homozygous and heterozygous genotypes varied among cultivars. All bands and most of the possible combinations were found in 169 seedlings of cv. Debra, while 223 seedlings of cv. Snowball were less variable due to the absence of band 0.66. The most frequent band in Debra was 0.75 and in Snowball, 0.63. Relative band frequencies differed from random mating expectations for both cultivars, there being an excess of homozygotes. This excess may result from partial inbreeding, and methods of estimating the proportion of selfing are being examined. By contrast, very few phenotypes were found in several cultivars, for example, Ballater, which derive from a narrow genetic base and a possibly high level of selfing. The number of bands in Chinese cabbage was very restricted but too few cultivars were examined to determine whether this restriction is of recent origin.

Examination of seed and cotyledon extracts of some plants of synthetic *B. napus* revealed bands with the same mobilities as those in the parent species. *B. napus* is an amphidiploid hybrid, but more seed bands were found in the newly made synthetics than in a number of established cultivars, though the variety of seedling phenotypes in the latter is consistent with introgression from *B. campestris* having taken place.

The recognition of S-linked or S-specific substances would have considerable practical and theoretical value and attempts are being made to separate glycoproteins, reported to be S-allele specific, from stigmatic homogenates. Access to equipment for isoelectric focussing of proteins and chromatofocussing is necessary for this work and has generously been given by the Department of Obstetrics and Gynaecology, Ninewells Hospital.

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

## MYCOLOGY

R. A. FOX

---

Extensive investigations, both here and by staff of the Agricultural Scientific Services, Department of Agriculture and Fisheries for Scotland, have shown that the bacteria associated with the potato blackleg/soft rot complex are far more ubiquitous than had hitherto been supposed. Using enrichment culture techniques, *Erwinia carotovora* sub sp. *carotovora*, has been shown to occur widely not only in association with crop plants and in arable soils but in association also with weeds and their rhizospheres and in surface water far removed from arable areas. *Erwinia carotovora* sub sp. *atroseptica*, commonly regarded as host-specific and, at least in north temperate regions, to be the sole cause of blackleg in the field, has also proven to be widely distributed although it occurs much less commonly and in numerically smaller populations than the sub sp. *carotovora*.

Continuing investigations of post-planting lesion development in seed tubers infected by *Phoma exigua* var. *foveata*, the gangrene pathogen, have shown the potential importance of cryptic lesions in maintaining continuity of the infection cycle in apparently healthy stocks. Analogies with and knowledge of other diseases suggest that there is much useful information to be gained by extending these studies to post-planting disease development among other largely tuber-borne diseases.

Phytoalexin elicitation in the potato by *Erwinia carotovora* has been shown not necessarily to be a relatively simple single step process, whereby an identifiable compound provokes the production/release of a phytoalexin, but rather a complex chain of reactions that the pathogen only initiates—the chemical outcome being determined by characteristics of the host.

### SOIL MICROBIOLOGY AND ROOT DISEASES

#### 02017 Biology of potato gangrene

##### *Lesion development in planted tubers*

The results of experiments on the effects of soil moisture and temperature on the spread of gangrene lesions in planted seed tubers (Ann. Rept, 1978, p. 71-72; 1979, p. 64), showed that rots expanded rapidly during shoot extension, particularly if the soil was dry; at flowering, spread had ceased and rots were delimited by a corky dry zone. This apparent association between host development and lesion spread was investigated in the glass-house using two root temperature regimes, 15°C and ambient temperature.

Tubers stored at 3°C since harvest were inoculated with *Phoma exigua* var. *foveata* 6 weeks prior to each of two planting dates (P1, 15 May; P2, 9 June) and kept at 3°C until 13 days before planting when their dormancy was broken by transferring them to 15°C. The longitudinal cross-sectional areas of the lesions were measured at planting, emergence (8 days), mid-height (28 days), and at flowering (49 days). Plant growth at each sample date was assessed by shoot number and length. In the 25 days between inoculation dates, tuber physiology had so changed that at planting dates P1 and P2 mean lesion areas differed by 13%. At emergence, lesions had not extended in the 15°C treatment but they had increased by 25 and 28% in the P1 and P2 tubers respectively held at ambient temperature (16-20°C) which also stimulated growth, the shoots being nearly double the length of those at 15°C. In contrast, at the second sample date 3 weeks later, lesion expansion had ceased in tubers growing at ambient temperatures, but had increased by 19 and 17% for P1 and P2 respectively in tubers at 15°C where the haulm continued to grow more slowly than with ambient soil temperatures. At flowering, rots in the 15°C tubers had not further increased in mean area in the P2 tubers and had increased only slightly in the P1 tubers.

The results suggest that at soil temperatures of *ca.* 15°C, rots in planted tubers may continue to spread until the onset of flowering, the expansion being most rapid during shoot extension. At higher soil temperature initial rot expansion is rapid, coincident with faster emergence and shoot growth, but it ceases within 4 weeks before the haulm is fully grown. However, even then the area of the rots may equal that reached after 7 weeks at 15°C. Soil temperature may therefore influence the rate and duration of lesion spread indirectly through its effect on the rate of haulm development and the concomitant changes in the seed tuber, and possibly directly by influencing the rate of wound barrier development. The ultimate effect is to influence the amount of inoculum available to contaminate progeny tubers.

#### *Lesion development in buried tubers*

In previous glasshouse studies, inoculated tubers with uniform size rots were selected to reduce within-treatment variation, the numbers of replicates being limited by space in the glasshouse. In commerce, most lesions at planting are cryptic and the initiation of their spread may be affected by factors different from those which enhance expansion of already 'active' lesions.

Tubers were inoculated and incubated at 3°C; after 1 week half the number of tubers were transferred to 22°C to inhibit pathogen growth and so give cryptic lesions whilst the others were left at 3°C for active lesion extension to continue. After a further 8 days incubation tubers, with either cryptic or active lesions, were buried in buckets containing either sterile sand or a non-sterile soil/sand mix. The buckets, initially stored for 3 weeks at 5°C to simulate early spring soil temperatures, were thereafter divided be-



tween two temperature regimes, 12 and 20°C, and lesion areas measured after a further 4 weeks.

Lesions which developed from the cryptic infections showed marked variation in size in contrast to the relatively uniform size of those that had developed from active infections and the latter, on average, had mean cross-sectional areas three times that of the former. The low temperature stimulated lesion development, the differences being most marked following cryptic infection, with mean areas of 1.6 and 2.4 cm<sup>2</sup> compared to active lesion development of 5.1 and 5.7 cm<sup>2</sup> for 20 and 12°C respectively. Surprisingly, rots were bigger in the sand/soil mixture than in the sterile sand alone with respective mean areas of 2.4 and 1.6 cm<sup>2</sup> for cryptic and 6.4 and 4.3 cm<sup>2</sup> for active lesions in the sand and sand/soil mixtures respectively. Counts of the numbers of pycnidia present per unit surface area of rot showed that their numbers were also higher in the sand/soil treatments than in sand alone and also higher in tubers stored at the lower temperature. The effect was more obvious in lesions derived from active infections, those from cryptic infections being fewer and more variable in number. Observations from *in vitro* experiments had previously shown that pycnidial development may be both induced and enhanced by covering cultures of *P. exigua* var. *foveata* with field soil and a similar reaction apparently occurred on the surface of rots in the sand/soil mixture.

An important outcome of this experiment was evidence that, despite large variations in lesion size, the development of lesions from cryptic infections tends to be similar to that from active infections and the results of previous experiments based on the latter can be validly interpreted as applying to what happens in practice.

#### *Wound barrier formation in inoculated tubers*

Further studies on factors affecting the spread of lesions induced in tubers by inoculation with *Phoma exigua* var. *foveata* showed that very little suberization develops in the area immediately bounding the lesion. Some lignification also occurs in those cells penetrated by hyphae and whose contents have disintegrated. The limited deposits of suberin and lignin may cause spread of the pathogen to be slowed rather than halted because hyphae are able to spread further into living tissue beyond the zone of dead cells which provide no more than a temporary barrier. Macroscopic examination of lesions stained for suberin may give an impression of an apparently massive wound barrier because of compression of the layers of dead cells, but it would be more appropriate to refer to this zone as one of temporary inhibition.

#### *Cryptic lesions in leaves*

Previous results showed that both *Phoma exigua* var. *foveata* and *P. exigua* var. *exigua* could be isolated from apparently healthy leaves of field and glasshouse grown plants (Ann. Rept., 1979, p. 64-65). To substantiate these results, ca. 3000 leaf samples were removed from plants, cv. Pentland

Crown, grown in the field from either healthy seed tubers or tubers inoculated with the var. *foveata*. The samples were taken from four replicate plots at monthly intervals throughout July, August, September and October. They were allowed to wilt and then leaflets were removed, sterilized in 10% Chlorox, dried aseptically and then plated in Petri dishes. To enhance surface contact with the selective medium, it was made soft by reducing the agar concentration to 0.5%, this also allowed the medium to remain moist for periods of up to 3 months.

Levels of detection of *P. exigua* var. *foveata* in leaves—of 1, 0, 3 and 3% for July, August, September and October respectively—were similar for plants grown from both inoculated and uninoculated tubers and were lower than those in 1979 when, especially among the early samples, levels were higher from plants grown from inoculated compared with uninoculated seed tubers. *Botrytis cinerea*, which can inhibit the growth of *P. exigua* var. *foveata* *in vitro*, was consistently recovered from ca. 47% of leaves sampled and the presence of this fungus as well as levels of ca. 20% of the fast growing species *Rhizopus mucor* in the later samples may have adversely affected detection of the gangrene pathogen.

Inoculation of trichomes of detached leaves showed that pycnospores could germinate and penetrate them but movement of the fungus into the leaf tissue was not detected until senescence when the fungus spread rapidly throughout the leaf. Similar results could not be obtained with attached leaves, spread of the fungus being limited to the trichome although pycnidia were sometimes formed at the base.

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

#### 02024 *Autecology of the strawberry red core fungus*

The effect of fungicides on oospore survival and germination was examined by incorporating singly captafol (Sanspor), dichlofluanid (Elvaron), aluminium ethyl phosphonate (Aliette), and metaxyl (Ridomil) at 10 and 100 ppm in 1% distilled water agar (DWA) using two batches of oospores extracted from two different lots of infected roots. Although germination in the controls was ca. 20 and 50% for the two batches, their responses to the fungicides were similar. There were no differences between the controls and the non-systemic fungicides captafol and dichlofluanid in the numbers of oospores entering the earliest active phase of germination before germ tube emergence but all the spores entering this stage on captafol and most on dichlofluanid subsequently lysed or aborted before forming a germ tube. By contrast 60-70% of the active spores in the controls produced a germ tube followed by the formation of a sporangium(-ia) or of a limited mycelium. A few dead spores were present in all treatments but most other spores, which did not enter the active stage, appeared to be viable. Some of them germinated when later transferred to fresh DWA with no fungicides.

The lysed spores in the fungicide treatments often appeared to have a double-wall structure of two concentric thin unconnected walls, the outer possibly being the outer wall of the original spore and the inner wall perhaps being formed during spore germination. Synthesis of a new wall by germinating oospores has been observed in other oomycetes.

In agar containing the systemic fungicide aluminium ethyl phosphonate, there were more dead oospores at 100 ppm than at 10 ppm but the numbers in the latter were no greater than in the control. At 100 ppm spores became active more slowly although the total number of active spores was by the end of the experiment the same as on the DWA alone. Most active spores germinated at 10 ppm but at 100 ppm most of them lysed, although some germ tubes formed even at this latter concentration. Aluminium ethyl phosphonate at 10 ppm and 100 ppm lowered the pH of DWA from *ca.* 6.5 to 5.8 and 4.3 respectively—decreases not effected by the other fungicides.

Metalaxyl at both 10 and 100 ppm decreased the rate of germination and reduced the total numbers of active spores all of which soon lysed but it did not affect the proportion of dead non-germinated spores.

Spores also germinated on DWA alone and on DWA buffered with 0.1 M  $\text{KH}_2\text{PO}_4/\text{NaOH}$  (pH 6.5) and containing aluminium ethyl phosphonate. The buffer maintained the pH above 6.0 so that the effect of the fungicide was no longer confounded with its effect on increased acidity. There were no differences between DWA alone and buffered agar alone. All the active spores on unbuffered agar containing 100 ppm of the fungicide lysed, but there were no differences in the numbers of active spores that germinated on buffered agar containing the fungicide at this concentration and the numbers that germinated on DWA or buffered agar without the fungicide. Single oospore isolates were established in culture from spores that had germinated in the presence of 10 (buffered and unbuffered agars) and 100 ppm (buffered agar only) aluminium ethyl phosphonate.

Concentrations of 0.005, 0.01, 0.025 and 0.05 M  $\text{KH}_2\text{PO}_4/\text{NaOH}$  in 1% agar at pH 6.5 were used to test the effect of buffer concentration; no differences were observed between the three lowest concentrations and the DWA controls but the highest concentration reduced the numbers of spores germinating from *ca.* 50 to 35%. The lowest concentration of buffer was used to test the effect of pH in agars ranging from pH 5.5 to 7.7 on germination of oospores from two single zoospore isolates. Although one isolate gave consistently higher germination levels than the other there was no overall effect of pH on germination levels.

Ninety single oospore isolates were obtained from roots previously infected with one isolate that had originated from a single zoospore. In all of them the colony morphology was similar to that of the parent isolate but there were wide variations in growth rates, the fastest growing growing more than twice as quickly on agar as the slowest, the growth rate of the parent isolate being similar to the fastest growing progeny. There was also a wide

variation in the intensity of sporulation between some isolates, although all produced some sporangia and zoospores.

(J. M. Duncan)

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

*Biology of Botrytis fabae in bean*

A phytotoxic fraction extracted from bean leaves infected with *B. fabae* was rapidly eluted with water from ODS hypersil in a high pressure liquid chromatograph (HPLC). Other, non-toxic, compounds had longer retention times or eluted only with methanol. Analysis at the Food Research Institute showed that amino acids formed only 1.5% of the toxic fraction eluted from the HPLC on a weight basis. Toxic activity was not lost from the supernatant after treatment with Dowex 1-X8 or Dowex 50W-X8, suggesting that the amino acids may be non-toxic impurities or were derived from other, non-toxic, compounds. The supernatant was ninhydrin negative. These results, together with others obtained previously, indicate that the toxin may be largely polysaccharide.

The mean number of lesions visible to the naked eye in 1 cm<sup>2</sup> of adaxial leaf surface of ten randomly-selected field bean leaflets taken from a farm near Inchtute, Perthshire, on 20 August, 1980, was 69.3 ± 19.9. There were about twice as many even smaller lesions, some consisting of only a single brown cell and some of only part of a cell. Most lesions were confined to the epidermis. When 100 leaf pieces each with a lesion visible to the naked eye were surface-sterilised and placed on malt extract agar, *B. fabae* was recovered from eight, *Botrytis cinerea* from 15 and *Cladosporium* spp. from 80 pieces. When similar leaf pieces without lesions were placed on agar, *B. fabae* was not isolated at all, *B. cinerea* was recovered from two and *Cladosporium* spp. from 36.

Five *B. fabae* isolates from each of two locations were grown on agar on an aluminium temperature gradient block and exposed to 12 h near UV irradiation per day. The optimum temperatures for sporulation of isolates from near Inchtute and from near Cambridge were 17.2 and 17.4 (SED ± 0.12) °C respectively.

Chocolate spot disease severity scores based on MAFF monthly disease summaries were allotted to the eight agricultural advisory regions in England and Wales for each year from 1951 until 1972 and the mean score over the 21-year period was calculated for each region. The average mean of daily mean temperature for May, a month during which chocolate spot often becomes established, was estimated from a map in the Climatological Atlas of the British Isles for a point close to the centre of each region. The correlation coefficients between mean daily temperature for May, and between chocolate spot severity score and the 1960 bean acreage

for the eight regions were +0.90 ( $P < 0.001$ ) and +0.32 (NS) respectively, suggesting that spring temperatures are important in the development of the disease.

Conidia from cultures of *B. fabae* on agar were dusted onto plastic slides and kept above saturated salt solutions to control humidity in sealed containers immersed in temperature-controlled water baths. Spores were held above solutions of zinc nitrate (42% rh), sodium nitrate (66% rh) or sodium bromate (92% rh) at either 10 or 22°C. At irregular intervals conidia were washed off the slides, suspended in water and ca. 1000 spores were spread over the adaxial surface of each of four detached bean leaves per treatment. The inoculated leaves were kept in water-saturated air at ca. 20°C and lesions counted after 24 h. The rate of loss of infectivity was greatest at 42% rh and least at 92% rh, and greater at 22°C than at 10°C. Parallel studies in which stored conidia were immersed in fluorescein diacetate solution for 10 min. and the accumulation of fluorescent fluorescein assessed visually suggest that either plasmalemma damage or esterase activity, or both, were directly related to loss of infectivity.

(J. G. Harrison)

#### *Fusarium acuminatum* in bean

*F. acuminatum* was isolated from the blackened roots of wilted field bean seedlings grown out-of-doors in UC compost. Identical disease symptoms developed 17-53 days after pouring an aqueous culture suspension of *F. acuminatum* over the surface of compost in which healthy bean seedlings were growing. Uninoculated plants did not develop disease symptoms. *F. acuminatum* was re-isolated from the diseased plants. *F. acuminatum* has not previously been recorded as a pathogen of *Vicia faba*.

(J. G. Harrison)

### 02010 *Seed quality—soil interactions and their effects on seedling growth*

#### *Barley seed production and seedling emergence*

The seed lots which had been hand and combine harvested on three dates and subjected to the deterioration treatments described previously (Ann. Rept, 1979, p. 68) were sown in the field on 7 April. The plots were either exposed to normal weather conditions or maintained at field capacity by trickle irrigation. Hand and combine harvested seeds produced similar numbers of seedlings in normal and wet soil conditions if they had received no deterioration treatment, but after deterioration emergence from both combine and late harvested seeds was less than from the hand and timely harvested seeds. The percentage of viable seeds which produced seedlings was relatively constant for all seed treatments in a normal seed bed (mean = 83.7%) and did not correlate with the germination percentage of the seed

lots ( $r=0.27$ ), while in wet soil conditions, the proportion correlated well with germination ( $r=0.67$ ,  $P=<.001$ ). The results showed that hand and timely harvested seeds were resistant to deterioration and that viable, deteriorated seeds were more sensitive to adverse soil conditions than non-deteriorated seeds.

(D. A. Perry)

*Causes of barley seed mortality in wet soil*

Although a physiological mechanism was postulated as the primary cause of death of barley seed in wet soil (Ann. Rept, 1979, p. 69), fewer seeds died in sterilized than in non-sterilized soil and after application of Hg-containing fungicides. Among the fungi isolated from dead seeds and inoculated to viable seeds, *Fusarium equiseti*, *Penicillium* sp., *Mortiere!la* sp. and *Chaetomium* sp. increased the mortality of deteriorated seeds only in high moisture levels. They were probably accentuating the lack of oxygen available to the seed and were not directly pathogenic. In contrast, *F. culmorum* was directly pathogenic to deteriorated and non-deteriorated seeds and it preferentially invaded the distal end of the endosperm. Embryos of non-deteriorated seeds were more resistant to infection than those of deteriorated seeds.

(D. R. Ellerton)

PLANT AND PATHOGEN PHYSIOLOGY

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

Attempts were made to isolate a heat-stable phytoalexin elicitor from cells of *Erwinia carotovora* var *atroseptica* (*E. atroseptica*) grown in nutrient broth. A bioassay, based upon the elicitation of terpenoid phytoalexins in potato tubers, failed to detect an elicitor but extraction of anaerobic rots of potato tubers inoculated with *E. atroseptica* showed that the protein fraction, which was precipitated by saturated ammonium sulphate, would elicit the phytoalexin rishitin when placed in wells in potato tubers. The supernatant fraction remaining after ammonium sulphate precipitation did not elicit phytoalexins. Work carried out in collaboration with Professor P. Albersheim<sup>1</sup> showed that, using a soybean cotyledon elicitor assay, a partially purified protein fraction containing polygalacturonic acid lyase (PG lyase), which was obtained from culture filtrates of *E. carotovora* grown in a liquid medium with pectin as a carbon source, was a very effective phytoalexin elicitor. PG lyase was precipitated from culture filtrates with an equal volume of cold acetone and purified on a CM Sephadex C-50-120 column developed with a gradient from 50 mM to 1 M acetate buffer pH 5. The further purification of PG lyase is being carried out in collaboration with K. Davis<sup>1</sup>.

---

<sup>1</sup> University of Colorado.

Purified cell walls of soybean have been shown to contain a heat stable endogenous elicitor which can be solubilised by acid hydrolysis (Hahn & Albersheim, pers. comm.). The partially purified PG lyase did not release this endogenous elicitor from purified cell walls *in vitro* and it was surmised that PG lyase may have elicited phytoalexins by releasing (or activating) a plant enzyme which is in turn capable of releasing the endogenous elicitor from the plant cell walls. This endogenous-elicitor-releasing enzyme (EE-releasing enzyme) was shown to exist in soybean stems (which were frozen and thawed at 25°C/1 hr) after comminuting in 50 mM acetate buffer pH 6 containing 10 mM 2-mercaptoethanol, and partially purifying on Bio-Gel P6 and DEAE Sephadex columns. This EE-releasing enzyme not only elicited phytoalexins when tested on the soybean cotyledon elicitor assay, but also released endogenous elicitor from purified cell walls *in vitro*. Elicitation by EE-releasing enzyme was maximal when it was assayed in acetate buffer pH 6. EE-releasing enzyme activity (determined as phytoalexin elicitation) was inhibited if the cut cotyledons used in the elicitor assay were exposed to the air for as little as 30 minutes before applying the enzyme to the cotyledons. This suggested that an enzyme inhibitor (possibly associated with polyphenol metabolism) was produced rapidly at the cut surface. The decreased cotyledon response after cutting was not observed when the glucan phytoalexin elicitor from cell walls of *Phytophthora megasperma* var. *sojae* was applied to cut cotyledons even after exposure to the air for up to 3 h (B. Hodgson<sup>1</sup>, pers. comm.). This showed that the enzyme inhibition has a direct effect on the EE-releasing enzyme and not on the enzymes involved in phytoalexin biosynthesis.

The EE-releasing enzyme extracted from plant tissues is to be examined further with a view to assessing its importance in host/pathogen interactions.

(G. D. Lyon)

## 02015 Disorders of vegetables

### *Cavity spot of carrots*

Two experiments were carried out on local farms with a history of severe cavity spot outbreaks to examine the effects of soil cultivation on the incidence of symptoms. At East Scryne, Carnoustie, carrots cv. Red Cored Chantenay were sown in single rows or in three-row mini beds at normal canning crop populations on 29 April. Immediately after sowing the inter-row spaces were cultivated with tractor mounted tines penetrating the soil to ca. 10 cm. Later in the season, a three pronged hand cultivator was used twice. There were four replicates of the cultivated and non-cultivated plots. Carrots were harvested from three 1 m lengths of rows on 28 October, washed, weighed and the incidence and severity of cavity spot assessed. There were significantly fewer roots with moderate and severe lesions from

---

<sup>1</sup> University of Colorado.

the cultivated compared with the non-cultivated plots, (9.0 and 14.5% SED $\pm$ 2.0) respectively and disease indices weighted for severity of lesions likewise showed a significant reduction, (14.7 and 19.5 SED $\pm$ 1.56) respectively. There was no significant difference in the total numbers of roots with cavity spot suggesting that cultivation affected the development of lesions rather than their initiation. There was no difference in disease incidence or severity between single rows and mini beds, nor any interaction between cultivation and row spacing. Dilution plate counts of anaerobic pectolytic *Clostridium* spp. showed that there were  $8.1 \times 10^3$  and  $2.1 \times 10^3$  colony forming units (CFU)/g of rhizosphere and surrounding soil respectively, indicating that multiplication of the bacteria had taken place on the root surface. However, there were no significant differences in the number of CFU in either soils or rhizospheres of roots in cultivated or non-cultivated plots.

In a second trial at East Seaton, Arbroath, attempts were made to improve aeration on an established crop of carrots growing at a high population on a 1.2 m wide bed. On 1 July and 1 August three cultivation treatments were carried out: (1) surface layer disturbed with tine cultivator, (2) hand fork inserted *ca.* 10 cm deep between rows, (3) hand fork inserted *ca.* 30 cm deep to make cracks between rows. At harvest on 21 October a mean of 48% roots were affected but there were no differences between any of the cultivation treatments and the non-cultivated control.

Thanks are due to W. H. Porter, Esq., and G. B. Norrie, Esq., for providing land and facilities for these trials.

(D. A. Perry, T. G. Rubens<sup>1</sup>)

## 02027 *Studies of plant pathogens*

### *Survival of E. carotovora on leaves, on soil and in water*

Results obtained in previous years (Ann. Rept, 1978, p. 87; 1979, p. 82) on the persistence of antibiotic resistant strains of *Erwinia carotovora* sub sp. *carotovora* (Ecc) and *Erwinia carotovora* sub sp. *atroseptica* (Eca) on potato leaves were confirmed. In addition, the bacteria survived equally well on barley and grass leaves. As before the numbers were usually too low to be enumerated under dry weather conditions but they could be detected by an enrichment procedure.

Deposition of aerosols containing erwinias generated by rain impaction on blackleg stem lesions occurred apparently at a low frequency because even after heavy rain in July and August less than 5% of leaflets from healthy plants were contaminated from an adjoining plot <2 m distant in which 80% plants were diseased. Leaf contamination increased on plants where there was no adjacent blackleg in September, but the numbers of bacteria

---

<sup>1</sup> East of Scotland College of Agriculture.



were not high. The bacteria were also detected on leaves of weeds within a potato crop at the same time. Ecc was, on average, three times more frequent than Eca.

The presence of the bacteria in soil at a depth of *ca.* 10 cm and in the rhizosphere of weeds and crops was monitored in fields at SHRI not under potato cultivation in 1980 and with different past cropping histories. Numbers of bacteria were low and enrichment procedures were necessary to detect them. They were not detected in March-April except in fields where potatoes were grown in 1978 and 1979 and they remained either absent or at low levels until September-October when a sharp rise to over 50% positive samples was recorded from most fields. Detection tended to fall later. Similar high levels of detection were found when commercial farms in Perthshire and Aberdeenshire were sampled in October. The bacteria were more readily detected in the rhizosphere of weeds and crops, especially Brassicae, than in soil and Ecc was apparently one hundred times more numerous than Eca. An unexpectedly high proportion of samples (*ca.* 50%) from lochs, streams, and rivers, some of them far away from arable areas, were contaminated mostly by Ecc when examined between September, 1980, and February, 1981.

(M. C. M. Pérombelon, R. Lowe)

#### *Genetics of E. carotovora*

Clones of *E. carotovora* sub sp. *carotovora* strain 193 which had acquired the plasmids RP<sub>4</sub> and R68.45 from *E. coli* strain AB1157 RP<sub>4</sub> and *P. aeruginosa* strain PA08 R68.45 respectively and were sensitive to the male specific phage PRRI were crossed with diauxotrophic recipient strains of 193 str<sup>R</sup> nal<sup>R</sup> (*his*<sup>-</sup> *arg*<sup>-</sup>, *his*<sup>-</sup> *leu*<sup>-</sup>, *his*<sup>-</sup> *ser*<sup>-</sup>, and *his*<sup>-</sup> *trp*<sup>-</sup>). Mating was done on filter membranes at 28°C for 5 h and the transconjugants were counter selected on minimal medium supplemented with one or the two amino acids necessary for growth of recipient strains and with streptomycin or naladixic acid. The frequency of gene transfer mediated by both R plasmids was low, ranging from 10<sup>-6</sup> to 10<sup>-8</sup> when streptomycin was present and about 10 times less in the presence of naladixic acid which probably inhibited further mating when the bacteria were plated on the selective medium. Co-transfer of the unselected marker was tested on *ca.* 50 transconjugant colonies and the results suggest that the procedure could be used to establish linkage relationships between marker genes.

(M. C. M. Pérombelon)

#### *Autoecology and characterisation of pectolytic Clostridium spp.*

Dilution plate counts of the numbers of CFU of pectolytic *Clostridium* spp. in the rhizosphere and adjacent soil of a number of carrot crops confirmed previous results (Ann. Rept, 1979, p. 70) which indicated that these strictly anaerobic bacteria multiplied on root surfaces. In samples taken during 1980 the numbers of CFU in SHRI soils varied between 4.4 and 23.5 × 10<sup>7</sup>/g dry soil while the R:S ratios varied from a minimum of 1.8

on raspberry roots to a maximum of 8.2 on turnip roots. The numbers of CFU in the soils and rhizospheres of the carrot experiments reported elsewhere (p. 77) also showed an increase from 6.3 to  $23.1 \times 10^3$ /g of dry soil at East Scryne and from 2.1 to  $8.1 \times 10^3$ /g at East Seaton. None of the soil cultivation treatments applied to these experiments significantly affected the populations suggesting a localised root surface effect.

A collection of 55 isolates of obligately anaerobic pectolytic bacteria was made during the studies described above. All the isolates were capable of rapidly rotting carrot disks in anaerobic conditions and they all required a simple sugar for *in vitro* growth. The frequency of spore production was variable from very rare to abundant but all the spores observed were oval and borne sub-terminally. The frequency of clostridial forms and the amount of mucilage produced in culture also varied. Most of the isolates produced dense discrete, creamy to white colonies on nutrient agar supplemented with 1% glucose but five formed pink colonies. The isolates grew on modified gelatine agar plates (0.25% glucose added) but not all of them were able to hydrolyse gelatin (78% positive). The isolates grew well in liquid culture with 1% glucose at 28°C but there was a range from equivalent to no growth when incubated at 10°C. These preliminary results show that there are several distinct forms of bacteria present in the collection.

(D. A. Perry)

#### EPIDEMIOLOGY AND ETIOLOGY

##### 02003 Shoot disorders of cane and bush fruits

###### *Cane diseases of raspberry*

###### *Cane blight*

The wounds made by the fruit catching plates of the Agricultural Sciences harvester and the Littau harvester are now considered to be the principle infection court for *Leptosphaeria coniothyrium* (Ann. Rept, 1979, p. 76-77). A new catching system developed at the Scottish Institute of Agricultural Engineering uses rubber belts which move backwards at a speed identical to the forward speed of the SIAE harvesting test rig. The belts cause no overt wounding or bruising of young canes, but to evaluate their influence on the incidence of cane blight, young canes of the cultivars Glen Clova, Glen Isla, Malling Jewel and Malling M were inoculated with mycelium and pycnospore suspensions ( $3.0 \times 10^6$  spores/ml) of *L. coniothyrium* in plots harvested by the test rig and the Littau on 16, 22 and 28 July; as controls, plots not harvested mechanically were wounded by scalpel and similarly inoculated.

The incidence and severity of vascular lesions, the emergence of lateral shoots and the potential yield of the inoculated canes are to be assessed in 1981.

(B. Williamson)

### *Raspberry root disorders*

A possible relationship between stunting of young raspberry plants and root infection by the black rot fungus, *Thielaviopsis basicola* was investigated following the frequent detection of this species on roots of poorly grown plants in soils associated with growth suppression by nematodes.

Suspensions of endoconidia were watered on to the surface of compost in 15 cm pots containing young raspberry plants (30-45 cm height) growing in a cool glasshouse. When compared with controls, the growth rates for 15 plants each of the raspberry cultivars Glen Clova, Glen Isla, Malling Admiral, Malling Jewel and Malling Promise showed no significant differences in height when measured at weekly intervals from 7 May-28 July. However, root examination showed a pronounced cultivar interaction; typical black root rot symptoms were obvious in all Glen Clova plants but no symptoms were seen in any of the other cultivars. Nevertheless, *T. basicola* was detected in samples of compost taken from the roots of all plants of all cultivars by using a carrot baiting technique. After 4 days incubation, the numbers of positive samples were 15, 10, 8, 4 and 3 respectively from 15 plants each of Glen Clova, Malling Promise, Malling Jewel, Malling Admiral and Glen Isla, but after a further 2 weeks incubation all samples proved positive.

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

### 02022 Harvest disorders of soft fruit

#### *Fungal colonisation of raspberry flowers and fruits*

Further investigations of *Botrytis cinerea* on raspberry flowers and fruit showed that the epidemiological pattern in 1980 was similar to that found in the previous 3 years. Following surface sterilization, the incidence on flowers rose from 6% in early June to 47% in mid-July after the onset of fruit ripening. On buds, the incidence remained low, not exceeding 4%. In any one sample the level of cryptic infection was markedly influenced by the stage of flower maturity; the overall rate of recovery of *B. cinerea* was 8% for just-opened flowers, 20% for mature flowers and 79% for old flowers. When the sepals, carpels, and stamen rings were separately sterilized and cultured, the numbers of *B. cinerea* colonies developing from the sepals was consistently low. The levels of stamen and carpel infection was related to the stage of flower development; when immature, most infection was detected in the stamens but in older flowers the carpels yielded most. This pattern would be expected if conidia were first trapped by the anthers as the sepals opened and then later caught by the sticky receptacles of the styles—perhaps also carried there by insect pollinators.

The enlarging carpels may also become infected by contact with previously infected stamens.

Fruit at various stages of ripeness were sampled from mid-June to early August, surface sterilized, and transverse sections cultured on malt agar plates as described previously (Ann. Rept, 1979, p. 78). Up to the end of June *B. cinerea* occurred significantly more frequently on the base sections, which included the decaying sepals and stamens, than in the mid- and tip-sections. Later samples also showed this distribution except in very immature berries in which the tip sections had a higher incidence than those from the base. The proportion of fruit found infected was always high, ranging from 80-100% and was unaffected by either the stage of maturity of the date of collection. However, when cultured separately the plugs were found to be virtually sterile apart from the basal rosette which was always infected. The fruit shells, as expected, had a somewhat higher incidence of *B. cinerea* towards the base.

If the styles of the drupelets were singed by dipping the shells briefly in industrial methanol and flaming, the incidence of infection decreased dramatically from 70 to 5% in late July samples and from 95 to 18% in early August samples. Less drastic methods of surface sterilization which did not destroy the ends of the styles only partly reduced the incidence; thus 67% yielded *B. cinerea* after immersion for 2 min in industrial methanol followed by rinsing in sterile water.

For most harvest dates the identity and frequency of commonly occurring fungi on culture plates of flowers and fruits was noted. Species of *Cladosporium* proved to be the most ubiquitous colonisers showing equal or higher infection rates than *B. cinerea*. In young flowers infection was superficial being reduced by surface sterilization but in older flowers it was not. The rate of colonization by *Cladosporium* spp. increased, as the season progressed, somewhat faster than that of *B. cinerea* though later the levels were similar but there was no evidence that prior colonization by *Cladosporium* spp. either hindered or enhanced infection by *B. cinerea*. In young flowers the highest incidence of *Cladosporium* was on the stamens but as the flowers matured it became higher in the carpels, a pattern like that of *B. cinerea*. Yeasts, usually *Sporobolomyces* spp., were seen in 4-50% of cultures from flowers but they were less often present in fruit cultures (<10%). Other fungi were detected in relatively low numbers; both flowers and fruit yielded species of *Alternaria*, *Epicoccum*, *Phoma*, *Fusarium*, *Penicillium*, *Leptosphaeria*, *Mucor* and *Verticillium*. *Penicillium* spp. and *Epicoccum* spp. were isolated from flowers throughout the season, *Epicoccum* being associated mainly with older flowers. Infection by *Alternaria* was not detected until late June and isolates of *Phoma* spp., particularly *P. macrostoma* were also detected more often in late samples. Fruit was only rarely infected by *Alternaria* spp. and they were also surprisingly free of *Rhizopus* infection.

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

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

Pairs of cultivars with similar ratings for susceptibility (determined by standardised tests in a controlled environment) were cropped for the first time in a field experiment. The six cultivars represented susceptible, moderately susceptible and slightly susceptible ratings and were grown with and without control measures in heavily infested soil and in non-infested soil. Analyses of the data to examine differences in yield within pairs due to site were initiated.

Isolates of the pathogen were obtained from an area of severely stunted plants in a commercial plantation of Cambridge Vigour. When young plants of the same cultivar were challenged with four of these isolates their response was rated as susceptible to two and moderately susceptible to the others. In the same standardised test, similar plants were only slightly susceptible to an isolate previously considered the most virulent to Cambridge Vigour. Some other cultivars (Aberdeen, Marmion, Saladin, Siletz, Silver Jubilee, Tamella, Templar, Totem, Troubadour) rated either moderately or slightly susceptible to a composite of races in earlier experiments were susceptible when challenged with one of the new isolates.

Strawberry seedlings recovered from a resistance screening test in which they were rated as moderately susceptible were more resistant (slightly susceptible) when tested as young runner plants.

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

Five cultivars and three selections were evaluated for root susceptibility to a composite of races in experiments which included Cambridge Favourite (susceptible) and 53Q13 (slightly susceptible) as standards. Differences in susceptibility between the cultivars Aromel, Grandee, Ostara, 59DB54 and Cambridge Favourite were not significant. The cultivars Elvira, Trellisa and 69 EW30 were rated moderately susceptible and 71ED30 slightly susceptible.

(D. M. Kennedy)

*Verticillium wilt of strawberry*

Severe wilt symptoms in plants due to adverse growing conditions invalidated all tests and emphasised the need for rapid vegetative growth to differentiate degrees of susceptibility.

(D. M. Kennedy)

*·tamen blight of raspberry*

Inoculation of axillary buds on 17 cultivars selections or *Rubus* species by hypodermic injection of a spore suspension of *Hapalosphaeria deformans* resulted in 20-90% diseased inflorescences the following year. The culti-

vars Glen Clova, Malling Orion and selections M26 and M28 had  $\geq 50\%$  while the least affected were cv. September, the selection M30 and a derivative of *Rubus strigosus* with 20-26% diseased inflorescences. There was little relation between the mean % number of diseased inflorescences on a host and the mean % number of diseased flowers/inflorescence except for the three least affected which had also the lowest % number (35-39) of diseased flowers. Using the same technique, infection was established for the first time in *Rubus phoeniculus* and in a derivative of *R. loganobaccus*.

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

02019 Gangrene, blackleg and soft rot and recontamination of VTSC seed potato stocks

*Blackleg etiology: field studies*

The weather during the 1980 growing season favoured blackleg symptom expression and some experiments partially failed because often all plants were diseased by mid-season. Nevertheless, data were obtained to demonstrate again the dependence of the pattern of blackleg development on rainfall distribution and soil water status.

In an experiment to test the relative susceptibility of four cultivars, the levels of blanking and of blackleg in July following a dry spring averaged less than 1%, in contrast to 1979 (Ann. Rept, 1979, p. 81) but similar to 1978 (Ann. Rept, 1978, p. 86). However, in August after several prolonged periods of high soil water status, disease incidence in plots planted with seed inoculated with similar numbers of the pathogen had increased substantially. The percentages of plants affected by blackleg in the cultivars Bintje, Up to Date, Golden Wonder and Pentland Crown were 98, 69, 59 and 32 respectively, corresponding to previously observed results. Few additional plants developed blackleg in September. Crop yields were inversely proportional to blackleg incidence and were 21 and 72% of those from non-inoculated seed plots of the cultivars Bintje and Pentland Crown respectively.

In agreement with results obtained in 1979 (Ann. Rept, 1979, p. 81), blackleg incidence in plants of the cultivar Bintje grown from seed which were stored over winter in moist peat after inoculation was 44% greater than from inoculated seed stored in open trays where they suffered from dehydration. Wounded seed produced 28% more blackleg plants than unwounded seed whether stored in peat or in trays.

When seed of the cultivar Bintje were inoculated with *E. carotovora* sub sp. *carotovora* (Ecc) or *E. carotovora* sub sp. *atroseptica* (Eca) alone or with both bacteria in equal proportions, typical blackleg symptoms developed only when Eca was present and the disease incidence was reduced

by half when both pathogens were present. Both Ecc and Eca were isolated from stem lesions only on plants grown from seed inoculated with the two organisms and Ecc was present alone in some atypical wet brown stem rots which were found more often in September than earlier. The forms of bacteria isolated from the daughter tubers and healthy stem bases in July and August depended on which forms had been inoculated to the seed tubers. However, by September Ecc predominated in plots planted with seed inoculated with both bacteria as well as those inoculated with Ecc alone.

(M. C. M. Pérombelon, R. Lowe)

#### *Contamination of crops by erwinias from different sources*

Previous results (Ann. Rept, 1968, p. 34; 1976, p. 66-67) have shown that contamination of progeny tubers prior to harvest originated from the mother tubers and from the phylloplane. To determine the relative importance of the two sources, contamination in a commercial crop was monitored during the growing season. Contamination occurred only after the mother tubers had rotted extensively in early August, while the phylloplane remained uncontaminated until September. Thereafter leaf contamination increased and was widespread by the end of the month. Whereas Eca tended to outnumber Ecc in both the rotting mother tubers and on the daughter tubers in August, leaf contamination was almost entirely by Ecc (97%) and it is notable that the bacteria on progeny tubers by the end of September were predominantly Ecc (76%).

(M. C. M. Pérombelon, R. Lowe)

#### *Contamination of VTSC stocks by E. carotovora*

The annual survey of VTSC stocks in the process of multiplication initiated in 1972 was continued on two commercial farms and involved the examination of 20 stocks and over 600 tubers. Bacteria were detected as before by the tuber test which involved inducing decay under wet and anaerobic conditions at 22°C (Ann. Rept, 1978, p. 82), but, in addition, the rotted tissue was plated on Crystal Violet Pectate (CVP) selective diagnostic medium as well as on Stewart's medium. The former was more than twice as efficient as the latter on which detection was often obscured by overcrowding by other bacteria. Estimated contamination levels in 13 of 15 stocks in their third to fifth year of multiplication were >80% and <30% on CVP and Stewart's media respectively. However, contamination in the first two multiplication years was <50% irrespective of the medium used. Contamination levels differed between farms especially in stocks in their fourth and fifth multiplication years as found in previous years (Ann. Rept, 1979, p. 82-83). Of 600 isolates obtained from both farms ca. 55% were Eca.

(M. C. M. Pérombelon, L. Hyman)

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

One pre-harvest and two post-harvest sprays of the systemic fungicides triforine, triadimefon, benomyl and imazalil were applied to machine-harvested plots of raspberry cv. Malling Jewel to control cane blight in 1979. Assessment in February, 1980, of canes wounded by catching-plates showed that benomyl, triforine and triadimefon reduced the incidence of vascular lesions from 44% in unsprayed plots to 13, 19 and 24% respectively (Ann. Rept, 1979, p. 83). Benomyl, triforine and triadimefon, but not imazalil significantly increased yield of fruit from 4.4 t/ha in unsprayed plots to 6.8, 6.0 and 5.7 t/ha. There was a corresponding reduction in the number of dead canes from 15.8% in unsprayed plots to 1, 2 and 6% in plots treated with benomyl, triforine and triadimefon respectively and a significant, though less important, reduction in cane death (8%) in imazalil treated plots. Benomyl, triforine and triadimefon also significantly increased yield per metre of cane, probably by reducing the number of partially dead canes.

The 5-6 week interval between the pre-harvest and the first post-harvest spray was shortened in 1980 by using a programme beginning with a single spray of benomyl the day before a machine harvest followed by two post-harvest sprays with triforine, triadimefon or benomyl. An additional treatment included a mid-harvest spray with benomyl after three picks followed by a triadimefon post-harvest spray. To reduce the risk of tolerant strains of *Leptosphaeria coniothyrium* or *Botrytis cinerea* the contact fungicide dichlofluanid was used for the fruit botrytis programme during flowering. The incidence of cane blight in this trial will be assessed in spring, 1981, and yields recorded in summer.

(B. Williamson)

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

*Chemical control*

Plots of the cv. Cambridge Favourite planted in April 1977 and treated annually with dichlofluanid, LS74783 or SN66752 gave higher yields than untreated ones. In contrast to the first two cropping years, the increases were significant for only two treatments involving LS74683 applied as a pre-plant root soak augmented by foliar sprays. Total yields from plants sprayed once (in September) or twice (in September and March) were similar but fruit was larger following the spring foliar spray at four out of eight harvest dates. In adjacent disease assessment plots re-planted in April



1979 and examined 12 months later there was a significant decrease in disease severity in all treated plants except those which received a soil drench of SN66752. There was no significant difference in disease severity following a single or double foliar spray of LS74783 when evaluated by the proportion of diseased main roots.

The efficacy of pre-plant root soaks (4 h) and total immersion treatments (1 and 4 h) were examined with the cv. Cambridge Favourite planted in September and lifted 6 months later. There was no significant difference in the decrease (69-94%) in disease severity achieved by 4 h root soak in LS74783 or metalaxyl or by a 4 h total immersion in metalaxyl. No disease was recorded in plants totally immersed for 1 h in LS74783.

Pre-plant root soaks or total immersion treatments in LS74783 or water were compared to autumn soil drenches using runners stored under adverse conditions for several weeks before planting in May into wet, compacted soil previously treated with dazomet. Total immersion in water resulted in almost twice as many dead plants as root soaking. The addition of LS74783 increased mortality when plants were totally immersed but not when only the roots were immersed. Plants which survived the pre-plant treatment in LS74783 grew better than untreated ones when unusually early symptoms of red core occurred at the beginning of July. Twelve months after planting there was no significant decrease in disease severity in plants which had received only a pre-plant total immersion for 4, 8 or 16 h or a root soak for 4 h in LS74783. Soil drenches of captafol or metalaxyl in September resulted in significantly less disease and metalaxyl gave significantly better control than captafol. The mean per cent number of diseased roots in untreated plants was higher (70%) than those in similar soil (48%) which had not been treated with dazomet and which had not been wet and compacted at planting time. Plants which had had a pre-plant root soak for 4 h in LS74783 had significantly more roots than those in any other treatments except a pre-plant total immersion for 4 h in LS74783 and the captafol soil drench.

Runners of the cv. Cambridge Favourite planted in May and treated with foliar sprays of LS74783 in September and March or metalaxyl soil drenches at different rates in September were assessed for disease 12 months later. There was a significant decrease (40-64%) in disease in all treatments and the control achieved by foliar sprays of LS74783 and metalaxyl soil drenches of 0.02 or 0.03 g a.i. in 100 ml water/plant was similar. A soil drench of 0.09 g a.i. in 300 ml water/plant gave significantly better control than 0.01 g a.i. in 100 ml water/plant but was not significantly better than the other treatments.

An investigation was made of phytotoxic symptoms following a pre-plant root soak treatment for 4 h in LS74783 (0.3% a.i.) observed in field experiments at SHRI in one year (1979) out of three, and in commercial trials. Plants of the cv. Cambridge Favourite were root-soaked for 1, 2, 3 or 4 h

before planting in pots containing JI No. 1 and were inoculated 3 d later with zoospores of *Phytophthora fragariae*. A second inoculation was done 14 d later and the experiment terminated after 5 wk. Significant decreases in disease severity occurred only after 3 or 4 h root soaks. However, both treatments were associated with slight leaf scorching and substantial amounts of root damage not present when soaking times were shorter. Air drying the roots for 0.5 h before planting had no significant effect on the efficacy of LS74783 or on the amount of root damage.

Plants of the same cv. were root-soaked for 4 h in LS74783 containing 0.05, 0.1, 0.2 or 0.3% a.i. before planting into pots with a peat/sand compost and zoospores were added 3 or 13 d afterwards. When disease severity was evaluated 5 wk later the interaction between concentration of a.i. and date of application was non-significant and all treatments significantly decreased disease to the same extent. Some leaf scorching and decreased vigour occurred at 0.3% a.i. but roots were not damaged.

The effects of different concentrations of LS74783 (0.05, 0.1, 0.2, 0.3, 0.4% a.i.) on disease control were evaluated when foliar sprays were applied to the cv. Cambridge Favourite growing in pots containing a peat/sand compost. Both upper and lower leaf surfaces were sprayed to run-off when leaves were wet or dry, 3 or 13 d before zoospores were applied to the compost. After 5 wk there was a significant decrease in disease severity at all concentrations of fungicide when averaged over the other treatments. There was a significant improvement in disease control when the higher concentrations (0.2, 0.3, 0.4% a.i.) were used and when leaves were dry before spraying. Treatments were generally more effective when roots were challenged with zoospores 13 d afterwards.

In another pot experiment drenches of metalaxyl were applied to the cv. Cambridge Favourite in a peat/sand compost to give 0.01, 0.03, 0.06, 0.09 or 0.12 g a.i./plant. Treatments were applied 3 or 13 d before roots were challenged with zoospores and plants evaluated for disease severity 5 wk later. Each quantity of a.i. applied 3 d before the zoospores, significantly decreased disease severity to the same extent and had no adverse effect on plant growth. None of the treatments applied 13 d before the zoospores decreased disease severity and plants receiving 0.6 g a.i. or more were less vigorous.

LS74783 applied as a soil drench (0.6 g a.i./plant) to the cv. Cambridge Favourite significantly decreased disease severity in daughter plants rooted into a peat/sand compost and challenged with zoospores. Mother plants were treated when attached daughter plants had produced (a) leaves only (b) leaves and a few roots (c) mature crowns and root systems. In a fourth treatment (d) daughter plants at stage (c) were severed from the parent 3 d after the chemical was applied and before inoculation. In replicate experiments disease control was achieved in (a) and (b) but in one experiment it occurred in (c) and (d). Similar experiments with metalaxyl

(0.06 g a.i./plant) indicated no significant decrease in disease severity in daughter plants.

Isolates of the fungus recovered after six passages through plants treated with metalaxyl retained sensitivity to the chemical.

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

#### 02016 *Chemical and cultural control of potato gangrene*

##### *The effect of date of haulm destruction and harvest*

Many years' previous experiments showed that early haulm destruction dates and short intervals between them and harvest usually lessen the incidence of gangrene evident at the end of the storage period. However, both between and within years there have been anomalies not all of which have been adequately explained and some not at all. Moreover, the final incidence of gangrene appears sometimes to be affected by interactions between the dates of harvest and dates of grading.

Last year haulm was destroyed on 15 August ( $K_1$ ) and 27 September ( $K_2$ ), each followed by 10 ( $H_1$ ) and 20 ( $H_2$ ) day intervals to harvest. Control (N) plots were harvested on nine occasions, the first ( $N_1$ ) 10 days before the first date of haulm destruction, and other plots at 10 day intervals ( $N_{1-9}$ ). Samples from most plots were examined at various times for inoculum levels on the surface of the periderm, for tissue susceptibility by inoculating at two depths (2 and 6 mm), for the interaction of surface microflora and tissue susceptibility by inflicting standard wounds on the tubers, and relationships were then sought between those results and those of gangrene incidence in the spring following grading and either storage at fixed low temperature (3°C) or storage within a straw bale store at ambient temperatures.

##### *Inoculum levels on the tuber surface*

Among the no-defoliation treatments, the periderm population of *P. exigua* var. *foveata* at harvest was low in early August ( $N_1$ ) and decreased during the month ( $N_2$  and  $N_3$ ) falling to its lowest level in early September ( $N_4$ ). Thereafter the level increased to a plateau in mid and late September ( $N_5$  and  $N_6$ ) and decreased slightly in October ( $N_7$ ,  $N_8$  and  $N_9$ ). Following haulm destruction the numbers of propagules increased significantly especially on the earlier harvested tubers ( $H_1$ ) following  $K_1$  and in  $H_2$  following  $K_2$ . The increase was due, in part, to the development of pycnidia on the dead haulm and in part to the lowered resistance of the periderm and surface tissues of the tubers to infection following haulm destruction.

When some N samples were examined from both storage regimes in December, population levels had increased on the samples harvested in early and mid season but had decreased markedly on the last sample ( $N_9$ ). The changes were not uniform as there had been a greater increase in  $N_6$  than in  $N_3$  although the latter had been in store for 17 weeks in contrast to 13 weeks for the former. The overall pattern was similar for both storage

regimes but the proportion of positive samples was considerably lower after ambient temperature storage than after 3°C.

### *Tissue susceptibility*

Harvested tubers were surface sterilized and dilute liquid inocula applied to wounds either 2 or 6 mm deep to give an indication of differences between surface and internal tissue susceptibility when incubated for 75 days at 3°C. Measurements were made of the surface and the longitudinal cross-sectional areas of the rots.

The internal rots in tubers from the no-defoliation treatments steadily decreased in size as the season progressed but there were large fluctuations in the size of surface lesions on tubers from particular early harvests. These were probably related to immature periderm being more readily affected by the rapid environmental fluctuations that occur near the surface of the drill. As the periderm matured there was less variation and the decrease in surface susceptibility paralleled those of the internal decreases. At early harvests the deep wounds caused larger rots than the shallow wounds but these differences in susceptibility tended to diminish so that by the end of October both depths of wounds induced similar sized lesions. It may thus be inferred that at late harvest serious wounds may be of less consequence than similar wounds at early harvest.

Following early haulm destruction, tissue susceptibility decreased compared to the corresponding no-defoliation treatment but following late haulm destruction the results were similar probably because the haulm was already becoming senescent and the physiological state of the tubers would have been little altered by haulm destruction.

### *Gangrene incidence following standard wounds*

Sub samples of 42 tubers per plot from each harvest were given standard wounds and stored for 75 days at 3°C to induce gangrene lesions. In the no-defoliation treatment the incidence fell from 15% in the first samples to 9% at the end of the season with slight fluctuations in level in between. Following both haulm destruction treatments, and especially late destruction, the incidence of gangrene lesions in tubers harvested after both the 10 and 30 day harvest intervals was higher than for tubers in comparable no-defoliation plots (e.g.  $K_2H_2 = 19\%$ ;  $N_8 = 9\%$ ).

Samples from the no-defoliation plots were again examined in early December after storage at 3°C or ambient temperatures. Tubers from the low temperature store developed incidences of 9, 17 and 11% respectively for early ( $N_3$ ) mid-season ( $N_6$ ) and late ( $N_9$ ) harvests but those kept at ambient temperatures had lower incidences of 4, 8 and 8% respectively. The last series of figures were lower than the corresponding figures obtained following treatment immediately after harvest supporting the concept of benefits obtained by storage at warmer ambient temperatures. In contrast, the cold store figures of 17 and 11% were higher than the figures obtained immediately following harvest demonstrating the low temperature inhibition

of wound periderm formation usually assumed to be a major factor in gangrene development.

#### *Incidence of gangrene in April following grading in December*

Levels of gangrene were high in tubers stored at 3°C ranging from 13-22% infection and correspondingly low ranging from < to 5% in tubers stored at ambient temperatures. The patterns of incidence differed from those usually found because there was a large mid-season increase corresponding with the N<sub>0</sub> and N<sub>7</sub> harvests in early and mid-September. This trend was present but on a much reduced scale among tubers stored at ambient temperatures. The effect of early haulm destruction significantly reduced incidence in both following harvests but there were little differences between the harvests following the second haulm destruction and the corresponding no treatment plots.

#### *Inter-relationships among the factors examined*

The results of the various assessments on tubers from plants which had not been treated may briefly be summarised as follows.

At harvest, the periderm populations were high in the mid-season samples but low for early and late harvests; tissue susceptibility declined steadily with delay in harvest date from mid-season onwards. The disease potential—assessed by standard wounding—showed the same trend as that for the periderm populations, the two sets of data being significantly correlated ( $r=0.87$ ) indicating that either the declining tissue susceptibility had a negligible effect or that the effect of the pathogen population was depressed in the late harvest samples due to increases in the surface antagonistic microflora.

During storage between harvest and December, periderm populations increased and tissue susceptibility decreased except in the late-harvested samples in which the periderm populations apparently decreased but tissue susceptibility remained unchanged. These changes were reflected in the results of the disease potential tests in which the highest levels of gangrene developed in the mid-season samples. In later samples, a higher tissue resistance and possibly an increased antagonistic microflora may have depressed lesion initiation and development. In earlier samples, although both the inoculum load and tissue susceptibility were high the tubers were relatively soft due to dehydration in store and the standard wounds difficult to inflict thus possibly reducing the number of potential sites for lesion initiation.

The incidence of gangrene in the bale store was very low, never exceeding 5% and was rarely above 2% but the trends were similar to those in the cold store and the possible disproportionate rise in incidence in the late harvested samples may be associated with progressive decreases in ambient store temperature so that these samples did not benefit from a wound-healing environment.

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

Although much is now known about the kinds of organism that carry viruses from plant to plant, the processes involved in transmission by these vectors, and the ways in which vector specificity is determined, are not nearly so well understood. During the past year two pieces of research on aphid-borne viruses have provided some new insight into such questions. Application of enzyme-linked immunosorbent assay (ELISA) to the detection of potato leafroll virus in aphids enabled their virus content to be measured accurately and showed that the virus is remarkably stable in aphids but does not multiply detectably in them. Experiments of other kinds showed that the reason carrot mottle virus is transmitted by aphids from plants also infected with the aphid-transmissible carrot red leaf virus is because a novel kind of particle is produced that contains the RNA of carrot mottle virus inside a protein coat provided by carrot red leaf virus. When other members of the luteovirus group, such as potato leafroll virus, are substituted for carrot red leaf virus, new aphid-transmissible virus complexes are produced and the coat protein of the new helper virus determines their vector specificity. Such novel associations occurring by chance may enable a virus to exploit new ecological niches.

Among other results, work on tobacco rattle virus suggested that the two parts of its genome may have evolved at different rates, raspberry bushy dwarf virus was shown to cause raspberry yellows disease, virus-free plants of a further three important *Narcissus* cultivars were produced by twin-scale therapy, and mechanical defoliation was found to have opposite effects on the spread of different viruses in *Narcissus*.

The Siemens Elmiskop I electron microscope was dismantled after 18 years' excellent service and sent to ADRA for use as spares. It was replaced by a JEOL JEM 100S machine which was commissioned in December.

## TOBRAVIRUSES

04002 *Viruses with nematode vectors and/or multipartite genomes**Comparison of genomes of tobacco rattle virus (TRV) strains*

TRV has a bipartite RNA genome and its many strains have been placed in two groups, serotype I/II and serotype III, mainly on the basis of serological properties of the virus particles. Strains ORE-Y and SYM are both in serotype I/II, but are serologically not closely related; strain CAM is in serotype III, and is only very distantly related to ORE-Y and SYM.

Hybridization experiments using complementary DNA (cDNA) copies of the RNA species of strains ORE-Y and SYM detected no homology between the nucleotide sequences of their RNA-2 species, which include the coat protein gene. In contrast, the nucleotide sequences of their RNA-1 species were found to be very similar. Indeed, heterologous and homologous cDNA-RNA hybrids differed in melting temperature by less than 4°C, indicating that the heterologous hybrids contained few mismatched sequences. No homology was detected between either RNA species of strain ORE-Y and the corresponding species of strain CAM. Thus within this group of strains, comparison of RNA-2 sequences supports the conventional serological assessment that they are not closely related to one another, whereas comparison of RNA-1 sequences suggests very close relationship between the two serotype I/II strains, while maintaining the distinction of these from the serotype III strain. This situation could be the result of more rapid evolution of RNA-2 than of RNA-1.

(D. J. Robinson)

#### NEPOVIRUSES

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

###### *Homologies among RNA species of tomato black ring virus (TBRV)*

Hybridization experiments using complementary DNA copies have compared the nucleotide sequences of the genome RNA species of two closely related strains (A and S) of TBRV. These strains both originate from Scotland, and are serologically indistinguishable in gel double-diffusion tests. In neither strain were any sequences common to the two parts of the genome detected; a homology of about 250 nucleotide residues would have been detectable. The RNA-1 species of the two strains were found to differ in about 10% of their sequences, whereas the RNA-2 species did not differ detectably.

Preparations of strain S also contain a non-genomic, satellite RNA. No homology was detected between the sequences of this satellite RNA and those of either of the genome RNA species of strain S. However, because all preparations of the satellite RNA are contaminated with small amounts of genome RNA, the possible existence of sequences common to satellite RNA and either or both of the genome RNA species cannot be entirely ruled out. Any such sequences must amount to less than about 160 nucleotide residues shared by satellite RNA and RNA-1, and about 120 nucleotide residues shared by satellite RNA and RNA-2. Indeed it remains possible that a sequence of up to 120 nucleotide residues could be common to all three RNA species.

(D. J. Robinson, S. M. Dodd)

###### *Genome-linked proteins*

Previous evidence showed that both species of genome RNA of every nepovirus tested are covalently linked to a small protein, and that the

infectivity of the RNA is decreased or abolished when this protein is hydrolysed by treatment with Pronase or proteinase K. For example, either of the enzymes almost completely inactivates the infectivity of TBRV-RNA. In further work to study the nature of the infective material which survives treatment with these enzymes, isolates were propagated from each of five of the few lesions induced by proteinase K-treated TBRV-RNA. RNA of these isolates was no more resistant to proteinase K inactivation than the original RNA sample, indicating that the survivors of protease treatment are not genetical variants of the virus. The RNA of arabis mosaic virus lost about 95% of its infectivity when treated with either proteinase K or Pronase, whereas only 30 to 90% of the infectivity of raspberry ringspot virus (RRV) RNA was removed. Moreover, no additional loss of infectivity occurred when protease-treated RRV-RNA was re-treated with the same enzyme, or when the enzyme concentration was increased fivefold. Similar results were obtained when infectivity was assayed on either *Chenopodium amaranticolor* or *C. quinoa*.

RRV-RNA treated with proteinase K retained more infectivity than that treated with Pronase, and whether treated with a mixture of the proteases, or with one followed by the other, the infectivity of the RNA decreased to that of RNA treated once with Pronase. One interpretation of these results is that proteinase K did not remove all the amino acid residues in the genome-linked protein and that the residues remaining following proteinase K treatment but removed by Pronase contribute to RNA infectivity. This would suggest that the genome-linked protein of RRV increases the probability of infection by the RNA, and that the greater the length of polypeptide attached to RNA, the greater the effect of the protein.

(H. Barker, M. A. Mayo)

Genome-linked proteins are not confined to nepoviruses; for instance they have recently been found in two members of the southern bean mosaic virus group. Further work showed that the infectivity of RNA from particles of a third virus in this group, lucerne transient streak, is abolished by incubation with proteinase K, suggesting that this virus too has a genome-linked protein needed for infection. No evidence was obtained for polyadenylate sequences in the RNA. These properties seem characteristic for members of the southern bean mosaic virus group.

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

#### *The small RNA species in cultures of strawberry latent ringspot virus (SLRV)*

Whereas particles of the MJ strain of SLRV contain two RNA species, those of the type (T39) strain contain in addition a RNA species of mol. wt.  $0.4 \times 10^6$ . Further tests showed that the bulk of this species binds to oligo(dT) cellulose, and that it is ten to twentyfold more efficiently iodinated by mixtures of sodium iodide and chloramine T than is RNA from tobacco



mosaic virus. This suggests that this species, like the genome RNA species of SLRV, contains polyadenylate and is covalently bonded to a protein. In these features it also resembles the satellite RNA of TBRV, and seems likely itself to be a satellite RNA.

(M. A. Mayo, H. Barker)

#### *Cross protection between strains of raspberry ringspot virus*

Further tests were done to investigate the effect of an existing infection with one virus strain (the protecting strain) on the behaviour of a second strain (the challenge strain) inoculated subsequently. RRV strains E and S, and the pseudo-recombinants produced by reassorting the two genome parts of these strains, were used. Recovered leaves of *Nicotiana benthamiana* plants systemically infected with the protecting strain were inoculated with the challenge strain. The results were assessed by (a) preparing protoplasts at intervals after the challenge inoculation and staining them with strain-specific fluorescent antibody to virus particles, and (b) counting the particles in leaf extracts that attached to electron microscope grids coated with strain-specific antibody. In several of the combinations tried, the challenge strain multiplied detectably in leaves already infected with a protecting strain, but such multiplication was invariably much less than in previously uninfected control leaves. In some instances the challenge strain multiplied when only one of its two genome parts differed from those of the protecting strain.

In total, the results indicate that elements of the replication system of the challenge strain need to differ somewhat from those of the protecting strain for the challenge strain to multiply to an appreciable extent. Both genome parts seem to carry determinants controlling the specificity of these elements of the replication system.

(H. Barker, B. D. Harrison)

#### *Relationships among nepoviruses*

Myrobalan latent ringspot virus (MLRV) and grapevine Hungarian chrome mosaic virus (GCMV) are classified in the nepovirus group because of their particle properties; evidence for their transmission by nematodes is very weak. Both are reported to be distantly related to tomato black ring virus (TBRV). Electrophoresis of glyoxylated RNA in 0.75% agarose gels showed that GCMV has two RNA species indistinguishable in mol. wt. from those of TBRV ( $2.69 \times 10^6$  (RNA-1) and  $1.66 \times 10^6$  (RNA-2)). However, in MLRV the mol. wt. of RNA-1 was found to be  $2.81 \times 10^6$  and that of RNA-2 to be  $1.99 \times 10^6$ . Gel-diffusion tests with several antisera to English and Scottish serotypes of TBRV confirmed a distant serological relationship between TBRV and GCMV but not between TBRV and MLRV. Nor was any relationship found between TBRV and MLRV in experiments in which virus/antiserum mixtures were analysed by density gradient centrifugation, a technique that can detect extremely distant

relationships. Immunosorbent electron microscopy tests also showed that if any relationship exists between MLRV and TBRV it is at the limit of detection by this technique and far more distant than could be detected by gel diffusion precipitin tests. We conclude that published evidence of a relationship between MLRV and TBRV is incorrect.

MLRV possesses a third RNA species (RNA-3) of mol. wt.  $0.48 \times 10^6$ , which by analogy with the RNA-3 of TBRV has been assumed to be a satellite RNA, although no evidence for this has been produced. By extracting RNA-1 from the band produced in polyacrylamide gels and inoculating it to plants a RNA-3-free culture of MLRV was established. MLRV RNA-3, although non-infective alone, could be re-introduced into the RNA-3-free culture. It is concluded that MLRV RNA-3 is a satellite RNA. Particles of satellite-containing isolates have several buoyant density components additional to those found in satellite-free isolates; they presumably contain different numbers of molecules of satellite RNA.

In further tests to assess the extent of the relationship between GCMV and TBRV (Scottish serotype), the RNA-1 and RNA-2 of each virus were separated and inoculated to *Chenopodium murale* plants separately and in all possible combinations of RNA-1 and RNA-2. Inocula containing RNA-1 and RNA-2 from the same virus were very infective but each RNA species on its own, and mixtures of heterologous species, were only weakly infective. No evidence was obtained that GCMV and TBRV are sufficiently closely related to be able to form pseudo-recombinants.

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

A New Zealand isolate of the seed-borne Australian lucerne latent virus (ALLV) was shown to be serologically indistinguishable from an Australian virus isolate (TN) but unrelated to a second Australian isolate (SM), originally thought to be a strain of ALLV. This second isolate also was unrelated serologically to crimson clover latent virus. Further studies on the properties of isolate SM are hindered by low yields of virus from herbaceous plants.

(A. T. Jones)

#### VIRUSES OF FLOWER BULBS

##### 04010 Viruses infecting bulbous ornamentals

###### *Tulip virus X (TVX)*

Continuing studies on two isolates of TVX confirm that it is a definitive potyvirus which apparently has not been described previously. Although the particle length (500 nm) and particle composition (one protein species of mol. wt.  $23 \times 10^3$ ; one RNA species of mol. wt.  $2.05 \times 10^6$ ) suggest that the cultures contain only one virus, the consistent occurrence of two sedimenting components (sedimentation coefficients re-estimated at 102 S and 118 S)

raised the possibility that the cultures may contain two viruses. However, several lines of evidence indicated that the virus particles aggregate end-to-end, and calculations showed that dimers of 102 S particles would sediment at about 118 S. Various treatments were tried to disaggregate the virus particles, but none was successful.

(W. P. Mowat)

#### *Previously unreported viruses from tulip*

Two viruses with filamentous particles obtained from tulips grown in Australia are being studied under licence.

One of the viruses, obtained from a tulip plant with necrotic lesions in its leaves, was identified as potato virus X, and tulip plants manually inoculated with a Scottish potato isolate of the virus developed chlorotic flecks and streaks in their leaves. This seems to be the first record of PVX infecting tulip.

(W. P. Mowat)

Isolates of the second virus have filamentous particles *ca.* 750 nm long and were obtained from plants with broad chlorotic streaks in leaves, resembling a symptom which occurs in tulips grown in Europe. The isolates were transmitted by inoculation of sap to several species of Chenopodiaceae and Solanaceae but to few species in other families. The virus could not be transmitted to *Lilium formosanum* by inoculation with sap or by aphids, suggesting that it is not tulip breaking virus, the only virus with similar particle morphology recorded from tulip. No serological relationship was found by immunosorbent electron microscopy to any of nine potyviruses, including potato virus Y and bean yellow mosaic virus.

(W. P. Mowat, G. H. Duncan)

#### *Virus spread in Narcissus*

Trials in 1978 suggested that more spread of narcissus yellow stripe virus (NYSV) occurred in plots allowed to senesce naturally in the field than in those lifted before senescence was complete. Because of the significance of this result in relation to the normal UK practice of biennial lifting, a further trial was made at Invergowrie in 1979 to compare the spread of NYSV in plots of cv. Rembrandt defoliated on 10 July with that in plots allowed to senesce naturally in the first year after planting. The incidence of NYSV at planting was 7%; it increased to 8% in the defoliated plot and to 12% in the non-defoliated plot. These observations indicate that NYSV can enter bulbs at a late stage of growth and suggest that defoliation in the first year after planting would minimize the spread of aphid-transmitted viruses in *Narcissus*, but this may incur a yield penalty.

In previous tests (Ann. Rept, 1978, 1979) narcissus mosaic and narcissus tip necrosis viruses did not spread from infected to adjacent healthy plants and their natural modes of spread were not discovered. However, when

healthy and narcissus tip necrosis virus-infected plants of cv. *Sempre Avanti* were planted alternately in rows in a box, and their leaves beaten with a cane to simulate flailing, all the healthy plants were found to be infected when tested in the following year. Thus the use of flails to defoliate *Narcissus* before lifting is suspected as a means of spreading not only narcissus tip necrosis virus but also narcissus mosaic virus, which likewise occurs in high concentration in leaves at the end of the growing season.

(W. P. Mowat)

#### 04011 Production of virus-tested bulb stocks

##### *Virus-tested Narcissus*

Virus-tested mother plants of the cultivars Golden Harvest, Carlton, *Sempre Avanti*, Fortune and King Alfred obtained either by meristem-tip culture or by twin-scale therapy were propagated by twin-scaling in the first stage of propagation at SHRI. Twin-scale therapy also provided virus-tested mother plants of the cultivars Yellow Cheerfulness, Rembrandt and Dutch Master.

The fifth annual batch of virus-tested clones chosen by the Scottish Nuclear Stocks Association (Flower Bulbs) Ltd. was released by SHRI in August to ESCA and NSCA for further multiplication. This issue of bulbs, weighing 28 kg. consisted of two clones of Carlton, one of *Sempre Avanti* and one of cv. Red Devon.

The second batch of virus-tested clones to have completed the second stage of propagation at ESCA and NSCA was released to the Scottish Nuclear Stocks Association (Flower Bulbs) Ltd. for field propagation. This issue consisted of about 17,000 bulbs of Carlton and *Sempre Avanti* and, as expected, no infection with narcissus mosaic virus or narcissus tip necrosis virus could be detected by testing leaf samples by ELISA.

(W. P. Mowat)

The field site for this planting was selected and treated with the nematocide Telone II, as in the previous year.

(W. P. Mowat, T. Alphey<sup>1</sup>)

#### RUBUS VIRUSES

#### 04003 Viruses infecting raspberry

##### *Performance of aphid-resistant cultivars*

Previous field experiments have established the value of genetic resistance to the aphid *Amphorophora idaei* in restricting the spread of viruses transmitted by this vector in small plots of raspberry. To assess the perform-

---

<sup>1</sup> Zoology Section.

ance of such material under commercial conditions, the incidence of raspberry leaf mottle virus (RLMV) was recorded in successive years in two plantations of cv. Malling Delight. This cultivar contains gene A<sub>1</sub> for resistance to *A. idaei* and is sensitive to infection with RLMV, so that the incidence of infection can be assessed by visual inspection. During a 3 year period, only three plants out of 4000 became infected in one plantation and only 37 out of 8000 in the other. Most infections occurred at the periphery of the crops. The degree of aphid resistance of such cultivars therefore seems adequate to control virus spread in field conditions in eastern Scotland.

(A. T. Jones)

#### *Effects of aphid-borne viruses latent in raspberry*

A pot experiment was started to assess the effects of latent infection on growth of the raspberry cultivar, Malling Jewel. Plants were raised from root cuttings of ungrafted control plants and plants graft-inoculated with black raspberry necrosis (BRNV), raspberry leaf mottle (RLMV) or raspberry leaf spot (RLSV) viruses, or with all three viruses together. The total number of cuttings obtained from roots of infected plants was somewhat smaller than from healthy plants. The number of shoots produced in the first 32 days after planting, expressed as a percentage of the total number produced, was: healthy, 73%; BRNV-infected, 28%; RLMV, 38%; and BRNV + RLMV + RLSV, 34%. Thus shoot production was delayed by infection.

(A. T. Jones)

#### *Raspberry yellows disease*

Further studies on raspberry yellows disease, using the yellows-sensitive red raspberry selection 13/74 mentioned in last year's Report, provided additional evidence of the involvement of raspberry bushy dwarf virus (RBDV) in this disease. Previously indexed, virus-free plants of 13/74 were graft-inoculated with sources of black raspberry necrosis virus (BRNV) or RBDV, or with scions from a yellows-affected field-grown plant of 13/74 known to contain BRNV plus RBDV. Fifty-four of 56 propagants from plants grafted with the yellows disease source showed an intense leaf yellowing; none of 65 propagants from plants grafted with the BRNV source or of 23 propagants from ungrafted 13/74 control plants was yellowed. These results confirm that RBDV is a causal agent of yellows disease.

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

### *New virus in raspberry from Canada*

In tests on clonal *Rubus* material held under SHRI's voluntary *Rubus* quarantine system, a sap-transmissible virus was detected in raspberry cv. Tweddell imported from Canada. The virus infected many herbaceous test plants systemically but symptomlessly. It induced sporadic faint local and systemic symptoms in *Chenopodium quinoa* but was best detected and assayed using *C. murale*, which developed necrotic local lesions and systemic mottle or necrosis. Infectivity in *C. quinoa* sap survived dilution to  $10^{-4}$  but not  $10^{-5}$ , heating for 10 min at 55°C but not 60°C, and storage for 16 days at -15, 4 or 20°C. Partially purified preparations contained isometric particles ca. 28 nm in diameter, some of which were penetrated by negative stain. Infective *C. murale* sap failed to react with antisera to any of the nepoviruses recorded in raspberry. No other virus with these properties is known to occur in *Rubus*.

(A. T. Jones, S. Badenoch)

### *A virus disease of Tayberry*

Symptoms that were typical of aphid-borne viruses common in red raspberry were induced in *Rubus* indicator plants by graft inoculation with scions from field-grown Tayberry plants showing chlorotic leaf blotching and decreased vigour. However, no symptoms developed in healthy Tayberry plants graft-inoculated with authentic isolates of any of these raspberry viruses. This suggests either that the disease in Tayberry is caused by multiple virus infection or that the viruses or virus strains occurring in Tayberry differ from those recorded in red raspberry. The Tayberry viruses may also occur in blackberry because symptoms resembling those referred to above were induced by grafting healthy Tayberry with scions of blackberry cv. Bedford Giant plants showing chlorotic vein-mottling.

(A. T. Jones)

### 04004 Production of virus-tested raspberry stocks

During the year, five imported samples of *Rubus* spp. and 25 selections from raspberry breeding programmes (six from EMRS, 19 from SCRI) were indexed for virus. The most noteworthy result was the detection of a new virus in material from Canada (see above); this illustrates the value of the current testing practice.

In an attempt to find easier methods for the detection of viruses in *Rubus*, the reaction of 12 *Rubus* spp. to graft inoculation with each of the common aphid-borne raspberry viruses was recorded. None of these species developed good diagnostic symptoms or was a better indicator of virus infection than *R. henryi* and *R. occidentalis*.

(A. T. Jones)

04007 *Viruses infecting umbelliferous crop plants**Mechanism of transmission of carrot mottle virus (CMotV) by aphids*

Antiserum to carrot red leaf virus (CRLV) was used to confirm the hypothesis that the dependence of CMotV on CRLV for transmission by aphids depends on the packaging of CMotV nucleic acid in CRLV coat protein. Partially purified preparations of virus particles were made from chervil plants mixedly infected with CRLV and CMotV by the purification procedure developed for CRLV alone. The preparations contained isometric particles *ca.* 25 nm in diameter which were indistinguishable in the electron microscope from those of CRLV. When centrifuged in sucrose density gradients, the preparations produced a single light-scattering zone identical to that produced by CRLV alone. However, fractions from the zone were infective for both CRLV and CMotV when assayed by aphid injection and were infective for CMotV when assayed by manual inoculation of *Nicotiana clevelandii*. Prior treatment of the preparations with CRLV antiserum removed the light-scattering zone and abolished the CMotV infectivity, whereas treatment with normal serum had no such effect. Treatment with chloroform also had no effect on infectivity of CMotV, whereas it destroys the infectivity of CMotV in extracts from singly infected plants.

In a second type of experiment, extracts from aphids (*Cavariella aegopodii*) carrying both CRLV and CMotV were injected into virus-free aphids, which transmitted both viruses to test plants. However, prior treatment of the extracts with CRLV antiserum prevented transmission not only of CRLV but also of CMotV; treatment with normal serum or chloroform did not prevent transmission of either virus.

In studies described in last year's Report CRLV was shown to be serologically distantly related to several luteoviruses, including beet western yellows virus (BWYV) and potato leafroll virus (PLRV). In tests to ascertain whether these two luteoviruses can substitute for CRLV in assisting the transmission of CMotV by aphids, *Physalis floridana* plants were infected with BWYV or PLRV by means of aphids (*Myzus persicae*) and then inoculated manually with CMotV. Control plants were inoculated separately with BWYV, PLRV or CMotV. When these plants were used as sources, *M. persicae* transmitted CMotV from plants that also contained BWYV or PLRV but not from plants containing CMotV alone. They failed to transmit CMotV when allowed to feed first on a plant infected with either BWYV or PLRV, and then on a plant infected with CMotV alone, or *vice versa*. These studies show that not only can transmission of CMotV be assisted by luteoviruses other than CRLV but also that the vector specificity of CMotV is that of the helper virus with which it is associated. This finding is consistent with the idea that the vector specificity of CMotV is determined by the coat protein of the helper virus.

(P. M. Waterhouse, A. F. Murant)

### *Aphid transmission of heracleum latent virus (HLV)*

Further tests showed that HLV is transmitted by the aphid *Cavariella aegopodii* in the semi-persistent manner from naturally infected hogweed plants. It was also transmitted by aphids fed on a hogweed plant that was infected first with HLV by manual inoculation and then with the closterovirus HV6 by means of aphids. In contrast, no transmission occurred when the aphids fed first on the source of HV6 and then on hogweed containing HLV. These results indicate that the HV6 culture contains a helper virus that is needed for aphid transmission of HLV, but it is not clear whether the helper virus is HV6 or an undetected contaminant in the HV6 culture. The mechanism of helper action seems different from that described for other semi-persistent viruses.

(A. F. Murant)

### *New virus isolates from umbelliferous plants*

Two new isolates of CRLV were obtained from field grown carrots and one from a wild plant of cow parsley (*Anthriscus sylvestris*). They behaved similarly to the stock laboratory isolate in enzyme-linked immunosorbent assay and in symptoms and host range, all isolates failing to infect *Cryptotaenia japonica* or parsley. Isolates of CRLV reported from parsley (Frowd & Tomlinson, *Ann. appl. Biol.* 72, 177, 1972) may therefore be host-range variants or may even be unrelated to CRLV, as may a Japanese isolate that infects parsley and *C. japonica* (Ohki, Doi & Yora, *Ann. phytopath. Soc. Japan* 45, 74, 1979). However, numerous attempts to isolate a virus resembling CRLV from field-grown parsley plants were unsuccessful.

Several other viruses were detected in umbelliferous plants during these studies. Two isolates of parsnip yellow fleck virus (PYFV) were obtained from carrot (the first recorded natural infections) and one from *Anthriscus sylvestris*; all were of the A421 serotype. These isolates were transmissible from carrot by manual inoculation of sap but not by *Cavariella aegopodii*, presumably because the plants did not contain the helper virus, anthriscus yellows (AYV), to which carrot is apparently immune. However, aphids already carrying AYV could acquire the PYFV isolates from carrot and transmit them to carrot or chervil test plants.

Plants from a patch of stunted carrots in a crop near Cambridge, sent by Mr S. A. Hill, ADAS, Cambridge, showed mosaic and vein clearing symptoms with some leaf distortion and necrosis. They were found to be infected with a strain of celery mosaic virus (CeMV), a virus not previously recorded from carrot in the UK. Two other isolates of CeMV were obtained from parsley sent by S. A. Hill from Colchester, Essex. Interestingly, all three CeMV isolates gave numerous necrotic local lesions in *Chenopodium amaranticolor* and *C. quinoa*, unlike any isolates previously reported in Britain.

(P. M. Waterhouse, A. F. Murant)



*Effect of ribonuclease on infectivity of carrot mottle virus (CMotV)*

Falk *et al.* (*Virology* 96, 239, 1979) claimed that the infectivity of lettuce speckles mottle virus (LSMV) in leaf extracts is inactivated by pancreatic ribonuclease at 100 ng/ml, and suggested that the virus lacks a nucleoprotein particle in the usual sense. However, earlier work with CMotV (Murant *et al.*, *J. gen. Virol.* 4, 329, 1969), an apparently similar agent, had indicated that its infectivity is resistant to low concentrations of ribonuclease (0.25 ng/ml) that abolish the infectivity of free RNA. The effect of ribonuclease on CMotV infectivity in leaf extracts was therefore examined in more detail. Inactivation of infectivity was not detected when extracts were incubated for 30 min at room temperature with 0.25 ng ribonuclease/ml, but infection was inhibited increasingly with increase of concentration of ribonuclease in the inoculum from 1 to 500 ng/ml. Infectivity could be recovered from non-infective mixtures of leaf extract and ribonuclease by treatment with phenol. It is concluded that ribonuclease acts as an inhibitor of infection but not as an inactivator of CMotV infectivity, and that the virus RNA may well occur in particles with protective coats that contain virus-coded protein.

(D. J. Robinson)

POTATO VIRUSES

04001 *Potato viruses, especially soil-borne viruses*

*Behaviour of potato leafroll virus (PLRV) in aphids*

Enzyme-linked immunosorbent assay (ELISA) was adapted for the efficient detection and assay of PLRV in aphids. Best results were obtained when aphids were extracted in 0.05 M phosphate buffer, pH 7.0, using the 'micro-mortar' technique (Ann. Rept 1979, p. 108), and the extracts were incubated at 37°C for 1 h before starting the assay. Using batches of 20 green peach aphids (*Myzus persicae*), about 0.01 ng PLRV/aphid could be detected. The virus could also be detected in single aphids allowed a 1 day acquisition access period on infected potato leaves. The PLRV content of aphids increased with increase in acquisition access period up to 7 days. A maximum of 7 ng PLRV/aphid was recorded and the aphids usually accumulated about 0.2 ng PLRV per day. The PLRV content of *M. persicae* fed on infected potato leaves decreased with increasing time after transfer to turnip (immune to PLRV). The decrease occurred in two phases, the first rapid and the second very slow. In the first phase the decrease was faster, briefer and greater at 25 and 30°C than at 15 and 20°C. Thus no evidence was obtained that PLRV multiplies in *M. persicae*. The results are compatible with a model in which much of the PLRV in aphids during the second phase is in the haemocoel, and transmission is mainly limited by the rate of passage of virus particles from haemolymph to saliva. The vector relations of PLRV and other luteoviruses would therefore

reflect (a) the restriction of virus particles to phloem tissue, (b) their ability to pass from gut to haemocoel and from haemocoel to saliva, and (c) their stability in the gut, haemocoel and saliva.

The potato aphid (*Macrosiphum euphorbiae*), which is more numerous than *M. persicae* in many potato crops in Scotland, transmits PLRV to test plants much less efficiently than *M. persicae*. Its inefficiency as a vector could not be ascribed to failure to acquire or retain PLRV, or to the degradation of virus particles in the aphid. Probably only few PLRV particles pass from the haemolymph to saliva in this species.

Several findings indicated that there are factors, other than the concentration of PLRV in plants and the amount of PLRV in aphids, that affect transmission by the aphids. First, PLRV was acquired by *M. persicae* more efficiently from leaves on young potato plants than from young or old leaves on older plants. Secondly, when aphids were allowed the same acquisition access period, and then caged singly on *Physalis floridana* seedlings for 3 days, transmission of PLRV by an aphid was not strongly correlated with its PLRV content. Thirdly, although the concentration of PLRV in potato leaves was only slightly affected by differences in temperature in the range 15-30°C, and PLRV was acquired by aphids more readily at 15°C than at 30°C, a slightly larger proportion of the aphids kept at 30°C transmitted the virus than of those at 15°C.

In other trials, the value of ELISA for use in epidemiological studies on PLRV was examined. The virus content of *M. euphorbiae* collected from PLRV-infected potato plants in the field increased from early June to early July, and then decreased. PLRV was detected both in spring migrants collected from the plants and in summer migrants caught in yellow water-traps. PLRV was also detected in *M. persicae* collected from infected plants in July and August, and in trapped summer migrants, but their PLRV content was less than that of *M. euphorbiae*, and in some instances was too small for unequivocal detection. These results emphasize the importance in PLRV spread of aphids infesting crops early in the growing season, especially before roguing.

(T. Tamada, B. D. Harrison)

#### *Strains of potato leafroll virus (PLRV)*

More than 30 isolates of PLRV were obtained from more than 20 potato cultivars. All were detected readily in potato foliage by ELISA. The isolates that differed in virulence or aphid transmissibility were compared in more detail. Those that caused severe symptoms in *Physalis floridana* or *Claytonia perfoliata* tended to reach greater concentrations in these species than those causing milder symptoms. However, virulence for one species did not necessarily parallel that for the other.

Two isolates that were readily transmissible by *M. persicae* were transmitted somewhat more frequently by *Macrosiphum euphorbiae* than were several others, but none was transmitted readily. A third isolate was trans-

mitted only seldom by *Myzus persicae*. The inefficiency of its transmission could not be ascribed to failure of virus uptake or retention, or to its instability in the aphid, and it was poorly transmitted by aphids allowed to feed through membranes on purified preparations of virus particles. However, gel-diffusion serological tests did not detect any difference between its particles and those of any of the readily transmissible strains tested, which themselves could not be distinguished from one another.

(T. Tamada, B. D. Harrison)

#### *Properties of potato leafroll virus (PLRV) RNA*

There is little information on the structural features and biological properties of the RNA of luteoviruses, and these were therefore examined for PLRV. RNA extracted from PLRV particles was able to infect tobacco mesophyll protoplasts, suggesting that the RNA is positive-stranded.

When the virus RNA was reacted with sodium iodide and chloramine T, and then purified by treatments that disrupt non-covalent bonds, the RNA became about twentyfold more radioactive than similarly treated RNA of tobacco mosaic virus. About half the radioactivity became soluble in 70% ethanol after the PLRV-RNA was treated with protease but about 97% remained insoluble in 90% acetone when the RNA was treated with ribonuclease. This acetone-insoluble material migrated in 20% polyacrylamide gels as a broad band corresponding in position with a polypeptide of mol. wt. about 7,000. PLRV therefore has a small protein covalently attached to its RNA; however, the protease-treated RNA was infective for tobacco protoplasts and there was no evidence that the protein is required for infection. Luteoviruses are the fourth group of plant viruses in which there is evidence that one or more members have genome-linked proteins.

Little radioactivity in preparations of <sup>125</sup>I-labelled PLRV-RNA was bound to oligo(dT) cellulose and, in contrast with nepovirus RNA, reverse transcriptase did not copy PLRV-RNA into complementary DNA when oligo(dT) was used as a primer. There is therefore no substantial polyadenylate sequence in PLRV-RNA.

(M. A. Mayo, H. Barker, D. J. Robinson, T. Tamada, B. D. Harrison)

### OTHER VIRUSES

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

##### *Properties of cassava latent virus (CLV)*

Investigations were started on the particle properties and biological behaviour of this geminivirus. *Datura stramonium* was found to be a local lesion host useful for quantitative assays, and *Nicotiana benthamiana* was a

good host in which to propagate the virus. When infected *N. benthamiana* was grown at controlled temperatures ranging from 15 to 30°C, CLV concentration was greatest in systemically infected leaves collected 3 wk after inoculation from plants kept at 25°C.

CLV particles were purified by a method that involved extraction in buffer containing a reducing agent, clarification with chloroform, precipitation with polyethylene glycol, and further concentration and purification by differential high- and low-speed centrifugation and sedimentation in sucrose density gradients. The purified preparations were used to prepare an antiserum which had a precipitin titre of 1/400 against CLV in gel-diffusion tests and gave a negligible reaction with extracts from uninfected plants. It was used satisfactorily to detect CLV in herbaceous test plants and in naturally infected cassava by ELISA. Tests with fluorescein-conjugated antibody showed that the particle antigen of CLV, like that of some other geminiviruses, is concentrated in the nuclei of systemically infected plants.

(J. C. Sequeira, B. D. Harrison)

#### TECHNIQUES

##### 04021 Techniques for electron microscopy

###### *Factors affecting immunosorbent electron microscopy (ISEM)*

Carbon, pyroxylin (a nitrocellulose plastic) and carbon-coated pyroxylin were compared in ISEM tests as support films on electron microscope grids. When exposed to infective sap, antiserum-treated films trapped many more particles of narcissus mosaic, tobacco rattle or tomato black ring viruses than untreated films. Within each group of films (antiserum-treated or not), fewest particles were trapped on pyroxylin and most (up to twice as many) on carbon. Carbon-coated pyroxylin films gave intermediate results. When untreated films were stored for about a week before exposing them to infective sap, considerably fewer than half as many particles were found on pyroxylin than on carbon films, and the particles were less evenly distributed over the film surface. Carbon films seem best for ISEM.

Further tests were done to compare the attachment of particles of seven viruses (including viruses in the nepovirus, potexvirus, potyvirus and tobnavirus groups) to carbon films treated with normal serum, heterologous antiserum or homologous antiserum, or not treated with serum. The results showed that, when either infective sap or a mixture of purified virus and virus-free sap was used as the test sample, about half as many particles attached to films treated with normal serum as to untreated films. However, there were up to threefold differences in particle numbers on films treated with either normal serum or antiserum to viruses in other taxonomic groups,

and these particles were less evenly distributed than on untreated films or films treated with homologous antiserum. Particles on films treated with normal serum or antiserum to an unrelated virus seem less firmly attached than on films treated with homologous antiserum or on those not treated with serum, and the number of particles retained seems more easily affected by the details of the experimental procedure. It is concluded (i) that only consistent increases of threefold or more in numbers of particles trapped on antiserum-treated films, as compared to the number on normal serum-treated films, can be considered as evidence of serological relationship between a test virus and the virus used to prepare the antiserum; and (ii) that in practice it is important to know the number of particles that attach to untreated films because this provides an indication of whether the films treated with normal serum have behaved satisfactorily.

(I. M. Roberts)

#### *Use of protein A in immunosorbent electron microscopy (ISEM)*

It was recently reported by other workers that pretreatment of support films with protein A from *Staphylococcus aureus* can be used to increase the number of virus particles trapped in ISEM tests. Tests were made to evaluate this procedure, using protein A at 0.001-0.1 mg/ml, and sap containing particles of raspberry ringspot virus or tobacco rattle virus. When carbon-filmed grids were floated for 30 min at 37°C on drops of protein A solution at 0.01-0.001 mg/ml before washing and transferring to drops of antiserum, larger numbers of particles were trapped than when using protein A at 0.1 mg/ml. The period of washing to remove excess protein A had little effect. Grids pre-treated with protein A at 0.01 mg/ml before treating with antiserum trapped up to three times more virus particles than grids treated with antiserum alone. Thus the use of protein A does offer some advantage in increasing the number of virus particles trapped, but this procedure takes longer and does not seem worthwhile for routine tests, because a further two-threefold increase is small in relation to the increases of several hundredfold already obtainable by the existing procedure.

(I. M. Roberts)

#### *Effects of specimen preparation on measurements of virus particles*

In a series of comparative tests, the sizes of virus particles were measured from electron micrographs, recorded and classified using a ID-TT-20 Tektronix digitizer linked to a 4051 graphic system. Particles of an English isolate of pea early-browning virus negatively stained with 2% ammonium molybdate or 2% sodium phosphotungstate (pH ranges from 5.0-8.0) had essentially the same two modal lengths of 82 and 196 nm, whereas particles

stained with 1 or 2% uranyl acetate were longer (94 and 213 nm), and had less uniform widths and rounded ends suggestive of partial disruption. These effects of uranyl acetate were not prevented by fixation with 5% glutaraldehyde before negative staining. These results emphasize the need to test several negative stains when particles are to be measured.

(G. H. Duncan, D. J. Robinson)

Three methods were used to examine the end-to-end aggregates of particles of tulip virus X that occur in purified preparations. All aggregates from monomers to tetramers were found in samples negatively stained with ammonium molybdate or rotary shadowed with uranium at an angle of 45°. Their modal lengths were sharply defined in frequency distribution plots, and were the same for both procedures. In contrast, in specimens stained with sodium phosphotungstate only monomers, dimers and trimers could be found, and the standard deviations of their modal lengths were greater.

(G. H. Duncan, W. P. Mowat)

## ZOOLOGY

D. L. TRUDGILL

---

Control of potato cyst nematodes (PCN) in seed potatoes has traditionally relied upon crop rotation, soil sampling to avoid infested land, and good hygiene. Recent trials show, however, that large reductions in the numbers of PCN can be obtained at some sites by using a fumigant nematicide prior to growing a nematode resistant cultivar of potato. These, and related studies, provide farmers with more positive means for managing infested fields.

Laboratory and field trials show that fumigants can give good control of root-lesion nematodes attacking raspberries, but that part of the resulting improvement in raspberry growth may be due to damaging fungi also being controlled.

Noteworthy progress has been made on studies of nematode transmission of viruses where a high degree of specificity between vector and virus has been demonstrated; on the effect of feeding by longidoroid nematodes on plant roots; on histochemical and histological techniques for examining changes in plant roots related to nematode feeding; and on tolerance to the damage caused by PCN.

In entomology, studies continue on the spread of potato leaf-roll virus (PLRV) and control of *Myzus persicae*, the main vector of PLRV; so also do the field investigations into more effective means of applying pesticides.

## NEMATOLOGY

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

#### *Tolerance to damage by potato cyst nematode (Globodera rostochiensis)*

Studies on differences between potato cultivars in their tolerance to damage by potato cyst nematodes (PCN) have continued. Previously we showed that in heavily infested soils some cultivars yield less than others but that soil treatment with a nematicide increases their yield proportionately more than for the higher yielding cultivars. In two further field trials the effects of applying different amounts of nematicide and of different levels of infestation of PCN were examined. As in previous years the nematode resistant cultivars Maris Piper and Pentland Javelin tended to have their yield increased less by nematicides than non-resistant Pentland Dell,

Pentland Crown and Maris Peer. Also, as the level of infestation of PCN increased the yields of the resistant cultivars were decreased less than those of the non-resistant. Pentland Dell appeared to be slightly less tolerant than Pentland Crown.

The basis for the difference in tolerance between some resistant and non-resistant cultivars was examined in laboratory and glasshouse tests. No consistent differences were found in the numbers of PCN larvae hatched from cysts by root diffusate for the different cultivars or in the numbers of larvae invading their roots. However, in the resistant cultivars many of the larvae that invaded re-emerged into the soil, and most of those that remained inside the roots developed as males, or died.

Examination of the effect of PCN attack in an experiment using 30 cm pots showed that 8 weeks after planting, the root growth of four cultivars regarded as relatively intolerant had been slowed more than had that of four comparatively tolerant cultivars. Whether this was due to differences in the sensitivity of roots to damage or to differences in the ability of plants to compensate for root damage is unclear. However, it was observed that lateral roots were more severely damaged than main roots and that two of the most tolerant cultivars (Maris Piper and Cara) had a tendency to produce a greater ratio of main to lateral roots.

(D. L. Trudgill, L. Cotes)

#### *Control of potato cyst nematodes*

Analysis of data has been completed from field trials in which a Rumpstads Combiject was used to treat two fields with liquid fumigants prior to growing the nematode-resistant cv. Pentland Javelin and the non-resistant cv. Ulster Prince.

At a site infested with *G. rostochiensis* both dichloropropene (Telone II, 225 l/ha) and metham-sodium (Sistan, 114 l a.i./ha) applied in October, 1978, decreased the numbers of migratory nematodes by more than 90% and markedly reduced the hatch of PCN (Ann. Rept 1979, p. 113). When populations of PCN were measured after harvest in 1979, the populations in untreated plots growing Ulster Prince had increased from 52 larvae to 165 larvae/g soil. In plots treated with dichloropropene and metham-sodium there were 48 and 97 larvae/g soil respectively.

In plots growing resistant Pentland Javelin the final populations for untreated, dichloropropene, and metham-sodium were 8, 1 and 1 larvae/g soil respectively. Yields of Ulster Prince and Pentland Javelin from treated plots were almost identical, metham-sodium and dichloropropene doubling the yield of Pentland Javelin and more than trebling the yield of Ulster Prince compared with the yield in untreated plots.

At a second site, where some *G. pallida* may have been present, identical treatments were applied. In plots growing Ulster Prince final population were similar (122-134 larvae/g soil) in untreated and fumigated plots. In



plots growing Pentland Javelin final populations were 70, 11 and 20 larvae/g soil for the untreated, dichloropropene and metham-sodium treated plots respectively. The initial population of 24 larvae/g soil and the yield of Ulster Prince was almost doubled by metham-sodium and dichloropropene. The fumigants increased the yield of Pentland Javelin by *ca.* 40%.

(T. J. W. Alpey)

Dichloropropene applied with the Combiject was also tested at a site lightly infested with *G. rostochiensis*. Six plots were treated in September, 1977, and in 1978 all the treated and six untreated plots were planted with the resistant Maris Piper. Six untreated plots were also planted with swede. When these plots were re-sampled in 1980 the mean numbers of viable cysts in a 500 g soil sample in the untreated plots growing swedes had decreased from 3.3 to 1.3. In plots growing Maris Piper the mean number of viable cysts decreased from 2.8 to 0.3 per sample and in samples from plots treated with dichloropropene no viable cysts were found. However, in a pot (10 cm) test using soil from these plots the mean number of new cysts formed on Pentland Crown were 12 in soil from the swede plots, 0.7 in soil from the plots growing Maris Piper and 0.5 in soil from the fumigated Maris Piper plots. No differences in yield were obtained even though the site was heavily infested with *Longidorus elongatus*, *L. leptocephalus* and *Pratylenchus negectus*. However, there may have been some phytotoxicity as dichloropropene gas could still be smelt at planting.

(D. L. Trudgill)

#### 05003 Chemical control of virus vector and other plant parasitic nematodes

##### *Oxamyl applied to the foliage*

Studies on the action of foliar applied oxamyl (Vydate L) on *Xiphinema diversicaudatum* were continued. Single seedlings of ryegrass (*Lolium perenne*) were grown in small pots containing sterilised soil and 20 *X. diversicaudatum*. The grass leaves were submerged in either oxamyl solution 6000 ppm or water for 3 days and then subsequently for 1 day during each of the following 4 weeks. At the end of the experiment fewer nematodes were recovered from soils containing oxamyl treated seedlings and significantly fewer root tip feeding galls had been formed. When a similar experiment was performed on ryegrass seedlings growing in agar, treatment with oxamyl sometimes had little effect on the feeding activity of *X. diversicaudatum*.

(T. J. W. Alpey, W. M. Robertson)

### *Effect of aldicarb and oxamyl on L. elongatus*

The level of control of *L. elongatus* obtained with aldicarb and oxamyl has varied markedly between different field trials. It was suspected that this was due to differences in the condition of the nematodes at the time of treatment and the effect of starving nematodes prior to treatment with aldicarb and oxamyl was examined in a small plot experiment. For 6 months prior to treatment equal numbers of random plots were kept fallow or were maintained under a ryegrass/clover mixture. In April all plots were cultivated and replicated plots were left untreated or treated with aldicarb (Temik, 3.3 kg a.i./ha), oxamyl (Vydate, 5.6 kg a.i./ha) or quintozene (Botrilex, 89.6 kg a.i./ha). The whole area was then sown with a ryegrass/clover mixture and the numbers of nematodes determined every 6 weeks.

Quintozene rapidly decreased numbers of *L. elongatus* to less than 15% of the numbers in the untreated plots and prevented any increase in numbers during the first 18 weeks of the experiment. Oxamyl and aldicarb gradually decreased numbers of *L. elongatus* until 12 weeks after treatment when treated plots contained less than 40% of the numbers in the untreated. Vydate was slightly more effective than aldicarb and the level of control was slightly greater in those plots which had been previously fallowed. Between 12 and 18 weeks numbers of *L. elongatus* increased in all plots except the Vydate plots which had been previously fallowed.

(T. J. W. Alpey)

### *Effect of aldicarb on Pratylenchus penetrans*

In previous experiments aldicarb has proved very effective for controlling *P. penetrans* in the presence of a host. In this replicated experiment pots (15 cm) were filled with infested soil, and some treated with aldicarb (Temik, 6.0 mg a.i./pot). Some treated and untreated pots of soil were planted with raspberry cv. M. Jewel, and further treated and untreated pots were planted with raspberry 6 and 12 weeks after the start of the experiment. After 18 weeks the numbers of *P. penetrans* in fallow soil had decreased by 80% and final numbers did not differ between the untreated and treated soil. In untreated soil growing raspberries the total numbers of *P. penetrans* increased markedly but where aldicarb was applied almost no *P. penetrans* were recovered. However, when fallow, treated pots were planted with raspberries 6 or 12 weeks after treatment the surviving nematodes reproduced rapidly within the raspberry roots, indicating that aldicarb had been much more effective when applied in the presence of a host.

(T. J. W. Alpey)

### *Control of P. penetrans and damage to raspberries*

At a site heavily infested with *P. penetrans* (300/200 g soil) replicated plots were treated prior to planting raspberries in spring, 1979. Dazomet

(Basamid 400 kg/ha) applied as a prill and dichloropropene (Telone II 226 l/ha) and metham-sodium (Campbells metham-sodium, 40% liquid, 512 l/ha) applied with the Combiject decreased the number of *P. penetrans* in the top 20 cm of soil by 93, 82 and 88% respectively. However, between 20 and 40 cm deep dichloropropene and metham-sodium almost eliminated *P. penetrans* but in the dazomet treated plots the numbers were decreased 87% compared with the untreated. Three months after application in the spring, aldicarb (Temik, 6.6 kg a.i./ha) had decreased numbers of *P. penetrans* in the top 30 cm by 83%.

At the end of the first year cane growth had been increased, compared with that in the untreated, by 77, 102, 90 and 116% respectively by the dazomet, dichloropropene, metham-sodium and aldicarb. At the end of the second year (1980) the length of cane/10 stools was increased 196, 217, 198 and 212% respectively.

In a pot (15 cm) test in 1979 with untreated soil from this site, treating the soil with aldicarb (10 mg a.i./pot), benomyl (60 mg a.i./pot) or a combination of the two chemicals prior to planting raspberries (cv. Glen Clova) increased the weight of the raspberry plants by 225, 123 and 291% respectively compared with the untreated.

(D. L. Trudgill)

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

##### *Pratylenchus penetrans* damage to raspberries

The relationship between the numbers of *P. penetrans* in the soil and the growth of raspberry plants was examined in a pot (15 cm) experiment. Two soils, identical except that one had been infested with *P. penetrans* were prepared and mixed to give a range of populations of *P. penetrans* from 0-960/200 g soil. Some replicates were left untreated whilst others were treated with aldicarb (10 mg a.i./pot) to control the *P. penetrans*. All pots were planted with small raspberry plants cv. Glen Clova and the plants were harvested 3 months later. The fresh weight of plants in the most heavily infested soil was only 23% of that in the uninfested soil and treatment with aldicarb gave a sixfold increase in the mean fresh weight. The most heavily infested plants contained, at the end of the experiment, a mean of 9,000 *P. penetrans* per g of roots. Treatment with aldicarb had decreased this to 1,400/g of roots. In the most heavily infested soil there had been a twofold increase in numbers of *P. penetrans*, but in soils with initially few *P. penetrans* a much greater increase (14-38 fold) had occurred.

##### *Role of additional pathogens*

In previous pot tests with soil from a raspberry plantation heavily infested with *P. penetrans*, raspberry plant growth had been increased by treating the soil with the fungicide benomyl (Benlate, 60 mg a.i./pot). The effect

of different amounts of benomyl (Benlate, 0-120 mg a.i./pot) on the growth of raspberry plants (cv. Glen Clova) was now examined using soil from the same plantation. Four months after planting the mean fresh weight of plants treated with 30 and 120 mg benomyl had been increased by 123 and 222% respectively. Combining aldicarb (Temik, 10 mg a.i./pot) with the benomyl treatment increased the mean fresh weight by 196 and 351% respectively compared with the untreated. Aldicarb gave good control of the *P. penetrans* but, compared with the untreated, there were more than three times the numbers of *P. penetrans* in pots treated with 120 mg a.i. benomyl

Soil from a field trial, where aldicarb and dazomet had been applied prior to planting to control *P. penetrans*, was tested in a similar manner. In soil from the untreated plots there was a small increase in plant growth in response to aldicarb and a large response (a threefold increase in fresh weight) to treatment of the soil with a combination of aldicarb and benomyl. In soil from plots which had been treated 2 years earlier with dazomet or aldicarb there were few *P. penetrans* present and no increase in plant growth was obtained following treatment with aldicarb. However, a combination of aldicarb and benomyl applied to the pots almost doubled mean plant weight.

In contrast, there was no increase in growth after treatment with benomyl of raspberry in soil from a site at SHRI planted for 4 years with raspberries grown from root cuttings but which previously had not grown raspberries for many years.

(D. L. Trudgill)

05002 Biology and ecology of trichodorid spp. and their role as virus vectors

As part of the long-term ecological study on two species of trichodorid nematodes and *Rotylenchus robustus* at a forest nursery site in Perthshire plots were treated with dichloropropene (Telone II, 225 l/ha). Sampling at different depths showed that between 0 and 40 cm more than 90% of the nematodes were killed but between 40 and 50 cm more than 50% survived. Proportionally more trichodorid nematodes survived treatment with dichloropropene than *R. robustus* which predominantly infested the upper soil layers.

(T. J. W. Alpey)

05011 Migratory plant parasitic nematodes associated with vegetable crops in Scotland

Previous studies at the above site showed that under Sitka Spruce there were no clearly defined seasonal fluctuations in the numbers of the different species of nematodes. However, there were significant differences in the

vertical distribution of *R. robustus* and the trichodorid nematodes, the former being most abundant in the top 30 cm of the soil whilst the latter were most abundant at greater depths.

The species of trichodorid nematodes present also had different distributions and there were differences in the distribution of sex ratios. In *Trichodorus primitivus* and *T. velatus* the sex ratio was one male to 1.6 females, but in *Paratrichodorus pachydermus* there were equal numbers of males and females.

Further experiments showed that the life cycle of *R. robustus* took between 14 and 18 months and that the basal temperature for development was ca. 6.5°C. However, it was noted that different biological activities probably had different threshold temperatures below which they do not function, e.g. in laboratory experiments eggs of *R. robustus* did not develop or hatch below 10°C but that feeding was observed to continue at less than 1°C. The effects of soil moisture were also examined and movement of the majority of nematodes was not affected until there was less than 8.7% (Pf 3.8) of water in the soil. It was concluded that under Scottish conditions soil temperature was the dominant factor controlling the rate of development of *R. robustus* and only occasionally did low soil moisture levels exert an influence.

(B. Boag)

*Rotylenchus* n. sp. from Jersey, Channel Islands

During a survey of hoplolaimids of the British Isles a new species of *Rotylenchus* was found. This species differs from the other members of the genus in having 7-10 annules in the lip region, the basal two of which had a regular longitudinal striations which continue along the complete body length, oesophageal glands which do not overlap the intestines and a small plasmid. Males were abundant.

(B. Boag, D. J. Hooper<sup>1</sup>)

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

*Effect of Longidorus elongatus on the growth of grass*

Two trials examined the effect of dichloropropene (Telone II, 225 l/ha) on the growth of a grass/clover mixture at sites heavily infested with *L. elongatus* (ca. 250/200 g soil). In the year following treatment there were large significant increases in yield (ca. 1.6 t dry matter/ha). However, in one experiment which had continued for 2 years the yields from the un-

---

<sup>1</sup> Rothamsted Experimental Station, Harpenden, Herts.

treated plots between August and September in the second year exceeded those from the treated. This result may be due to the untreated plots containing a greater proportion of clover in the sward than the treated plots.

At another site, divided into 96 sub-plots and sown with a grass/clover mixture, a significant, inverse relationship was demonstrated between the yield of grass and numbers of *L. elongatus*.

(B. Boag)

#### *Effect of cropping on numbers of L. elongatus and other plant parasitic nematodes*

The effect of different cropping patterns on the plant parasitic nematode fauna was examined over 4 years at a site heavily infested with *L. elongatus* (400/200 g soil). For the first 2 years numbers of *L. elongatus* changed little in most plots but thereafter decreased in plots which had grown pea, swede, potato, carrot or barley in each year. At the end of the fourth year numbers of *L. elongatus* in these plots were not significantly different from those which had been fallowed. The proportion of the population that were adult had also increased. In plots which were sown each year with grass the numbers of *L. elongatus* did not decrease and the ratio of adult to larvae remained constant at ca. 1:3.

In plots where grass was alternated with the other crops final populations of *L. elongatus* were only ca. 50% of those at the beginning of the experiment. In plots where crops other than grass were alternated, final populations of *L. elongatus* were less than 25% of the initial population.

Numbers of *Paratylenchus* and *Pratylenchus* increased in plots growing barley. Swede increased the numbers of *Paratylenchus*, *Tylenchorhynchus* and *Pratylenchus* and carrot and potato increased the numbers of *Pratylenchus*. Numbers of *Tylenchorhynchus* and of *Helicotylenchus* were increased by pea and grass increased the numbers of *Helicotylenchus*.

(B. Boag, I. E. Raschke)

#### *Hermaphrodite Longidorus elongatus*

Hermaphrodite longidorids have been recorded on three previous occasions but never from the British Isles or within the species *L. elongatus*. Because of their infrequent occurrence little is known about their morphological variation or frequency distribution. During the experiment on the effect of cropping on numbers of *L. elongatus*, ten specimens of hermaphrodite *L. elongatus* were found amongst 66000 females. Large differences in morphology were observed between hermaphrodites, especially in the size of their spicules which ranged from 23 to 61  $\mu$ .

(I. E. Raschké, B. Boag)

### *Reproduction of L. elongatus and Xiphinema diversicaudatum*

The reproductive potential of single females was measured in small pots (25 ml) at 18°C. No reproduction occurred on raspberry (cv. Malling Jewel) but each female produced a mean of 25 larvae on strawberry and 12 on perennial ryegrass over a period of 12 weeks. Single females of *X. diversicaudatum* produced a mean of ca. 50 larvae on strawberry over a similar period.

(B. S. Griffiths, D. J. F. Brown)

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

#### *Histological changes*

Changes in the roots of good and poor hosts which occur as a result of feeding by *L. elongatus* and *X. diversicaudatum* are being studied in good and poor hosts. The initial studies have concentrated on ryegrass (*Lolium perenne*) growing in agar. In root tips fed upon by *L. elongatus* some cells became enlarged, with enlarged nuclei (up to 10,000  $\mu\text{m}^2$  after 8 days feeding). The DNA content of the nuclei increased after 2 days feeding from 2.4C to 5C and after 8 days up to 5.5C. No multinucleate cells were found.

In root tips fed upon by *X. diversicaudatum* multi-nucleate cells occurred frequently, the areas of the nuclei being as great as 20,000  $\mu\text{m}^2$  with a DNA content of 24C after 4 days feeding. In root tips of strawberry (*Fragaria vesca*), a better host for *X. diversicaudatum* than *L. perenne*, a greater number of multi-nucleate cells were found. The nuclei in the cells had an area of up to 9,000  $\mu\text{m}^2$  and a DNA content of up to 14C. Control nuclei had areas ranging in area from 300 to 2,000  $\mu\text{m}^2$  with DNA contents of 2 and 4C.

(W. M. Robertson, B. S. Griffiths)

#### *Transmission of viruses by populations of X. diversicaudatum*

The ability of a French population of *X. diversicaudatum* to transmit arabis mosaic virus (AMV) and two strains of strawberry latent ringspot virus (SLRV-T39, type strain from Britain; SLRV-Ip, from peach in Italy) was examined using pairs of nematodes. AMV was transmitted to 10 of 40 and SLRV-T39 to four of 40 bait plants. SLRV-Ip was not transmitted. When single nematodes were tested by immunosorbent electron microscopy (ISEM) virus was detected in all nematode virus combinations. However, when thin sections, prepared from the heads of these nematodes, were examined with an electron microscope, virus particles were observed in only one nematode exposed to SLRV-T39.

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

### *Morphology of populations of X. diversicaudatum*

The morphometrics of several populations of *X. diversicaudatum* from Europe, the USA and New Zealand were compared and considerable variations found. Populations with the largest females came from Dundee, Scotland, Wrekin, Wales, and Holziken, Switzerland. In comparison, females from San Diego, USA, and Kostinbrod, Bulgaria, were significantly smaller ( $P=0.01$ ) in all respects than the Scottish nematodes.

However, when adults from the Scottish population of *X. diversicaudatum* maintained for 4 years on rose in a heated glasshouse were re-measured, they were found to be significantly smaller ( $P=0.01$ ) than specimens from the original woodland population.

(D. J. F. Brown)

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

Secretions from the oesophageal gland cell in *Longidorus* and *Xiphinema* spp. are injected into plant roots during feeding and induce cell changes which result in the formation of a gall. The oesophageal bulb, which contains the gland cell, is a complicated structure and a stereological analysis has been made to identify the proportion of the bulb occupied by different tissues. Gravid, well fed specimens of *X. index* were prepared by standard and carefully controlled methods before examining thin sections through the oesophageal bulb using an electron microscope. Sections were examined at random, point counts being made of the different types of tissues using a square lattice. Measurements were also made using a digitising platten to confirm the area of each section.

Results showed that in nematodes starved for 1 or 2 days prior to fixing, 34% of the volume was occupied by dorsal gland cell material, 30% by radial muscles, 25% by the ventral glands and the remainder by peripheral muscle (3.9%), nerve (3.4%) and basement membrane (3.2%). In specimens which had been starved for 2 days prior to fixing there was a small (8%) but significant decrease in the volume of the dorsal gland cell in the anterior part of the oesophageal bulb compared to those starved for 1 day.

### *Histology*

Recent research in Germany has shown that macerated oesophageal bulbs from well-fed *X. index* contain a component which stains using the periodic acid Schiff reaction (PAS). However, this reaction was much reduced in bulbs from nematodes starved for 14 days. An attempt has been made to locate the sites of PAS staining in thin sections from whole bulbs. Using sections embedded in epoxy resin it has been possible to stain the gland duct membranes using the periodic acid-thiosemicarbazide-silver proteininate reaction. Granular material, probably glycogen, in the radial and peripheral muscles has also been stained.

(W. M. Robertson)



### *Root-knot nematode in Scotland*

Only four species of root-knot nematode (*Meloidogyne* spp.) are known from Britain, and only one *M. ardenensis*, is found in Scotland. Little is known about this nematode, but its biology on a hedge of *Lonicera nitida* is being studied at a site in Cupar, Fife. Regular, monthly, sampling has shown that mature females were present in October, but that few eggs had been laid. During November to February the number of eggs/g root increased from 22 to 112 and the number of larvae in the soil from 6 to 16/200 g. During this period the soil temperature was mostly 4°C or less indicating that *M. ardenensis* is well adapted to cold conditions.

(Z. A. Stephan)

### *Techniques*

A method has been devised for measuring the thickness of sections used in light microscopy. An interference technique normally used in metallurgy for measuring the thickness of highly reflective metallic coatings has been tested on sections and found to give results which are accurate to about 30 nm using sodium light. Sections cut from epoxy resin or glycol methacrylate were found to give adequate reflectance as were sections of specimens embedded in gum sucrose and cut on a cryostat. Interference fringes are recorded photographically and subsequently projected onto a digitising platten to measure their separation and hence the section thickness. The method gives a fast visual assessment of variations in the thickness of a section across its surface and these minor variations can also be measured if necessary.

Accurate measurement of section thickness is important to the stereological studies and certain of the quantitative histochemical measurements presently being undertaken.

(W. M. Robertson, B. S. Griffiths, B. Storey<sup>1</sup>)

## ENTOMOLOGY

### 05013 *Control of aphids and virus diseases of potato, raspberry and bulbous ornamentals*

#### *Potato*

The effectiveness of granular insecticides and early haulm destruction in preventing spread of potato leaf roll virus (PLRV) was tested in 1979 at five sites in Scotland and one site in Suffolk. In 1980 tubers harvested from these sites were grown at SHRI to assess PLRV infection.

Generally, the levels of spread of PLRV at all the Scottish sites were small, except in the untreated plots from three sites where there was a

---

<sup>1</sup> Department of Physics, University of Dundee.

moderate amount of spread in the plots where the haulm was not destroyed until early September. Disulfoton granules (10% a.i., 83 g/100 m row) and thiofanox (5% a.i., 112 g/100 m row) almost completely prevented virus spread even though the plots had been planted with PLRV infector plants for the duration of the experiment. The small amount of PLRV spread in the Scottish sites was probably the result of there being few *Myzus persicae* in 1979. On untreated crops *M. persicae* numbers started to increase in about mid-July. Disulfoton delayed this increase by about 2 weeks and thiofanox by about 1 month.

At the Suffolk site a larger and earlier population of *M. persicae* than that recorded at any site in Scotland—developed on the untreated plots, reaching a maximum at the end of July. An enormous population of *Aphis nasturtii* developed in July but populations of *M. euphorbiae* were earlier and smaller than those in Scotland. The control of *M. persicae* by disulfoton was relatively poor from the end of July. High levels of PLRV spread (30-40% in plants adjacent to the infectors) occurred in treated and untreated plots at this site. *M. euphorbiae* was controlled by both insecticides until mid-August.

(J. A. T. Woodford, S. C. Gordon, C. S. Aveyard with M. W. Shaw<sup>1</sup>,  
R. G. McKinlay<sup>2</sup>, P. Osborne<sup>2</sup>, G. N. Foster<sup>3</sup> and J. Whiteway<sup>4</sup>)

---

05001 *Ecology and control of horticultural and agricultural pests*

---

*Toxicity of potato plants treated with granular insecticides*

Potato cv. Maris Piper was treated with thiofanox (Decamox) granules (112 g, 5% a.i./100 m row) at planting in early April and the toxicity of leaves from different parts of the plant were assayed at 2-week intervals beginning in late May. When *M. persicae* were placed on excised leaves in the laboratory the lower leaves proved to be more toxic than leaves from the upper and middle zones of the plant. The prolonged dry spell during April and May, 1979, did not appear to adversely affect the uptake of thiofanox. A similar trial on non-excised leaves confirmed these trends but the persistent wet weather throughout June and July hindered the gathering of results from this trial.

(S. C. Gordon, R. Haggart<sup>5</sup>)

---

<sup>1</sup> North of Scotland College of Agriculture.

<sup>2</sup> East of Scotland College of Agriculture.

<sup>3</sup> West of Scotland Agricultural College.

<sup>4</sup> ADAS, Cambridge.

<sup>5</sup> Dundee College of Technology.

### *Effectiveness of control of aphids on potatoes*

A large population of *M. euphorbiae* developed in a potato trial at SHRI. Severe top roll symptoms, due to aphids feeding on the upper leaves were observed in all plots not treated with thiofanox granules. Using a commercial tractor-mounted sprayer the plots showing top roll symptoms were sprayed in late July with pirimicarb (280 g/400 l/ha), to which was added a fluorescent tracer dye so that the effectiveness of the spray cover could be assessed. Leaf samples were taken from the upper, middle and lower zones of the treated plants and, generally, only the upper surfaces of leaves from the upper zone of the plants received an adequate cover. The under surface of the upper leaves and both surfaces of leaves in the middle and lower zones of the plant were inadequately covered by the insecticidal spray. Pesticide entering the middle and lower zones did so mainly as a result of run off. In spite of the poor cover a commercially acceptable kill of *M. euphorbiae* was obtained because pirimicarb has a strong vapour and systemic action.

(S. C. Gordon)

### *Control of raspberry aphids*

Fluorescent tracer studies show that it is possible to obtain good spray cover of raspberry leaves when applying medium volumes with a hydraulic sprayer by using a high velocity air blast (Ann. Rept 1979, p. 84). However, the air blast caused some injury to the crop and considerable pesticide drift.

In 1980 a low velocity, medium volume, air-assisted sprayer (Directair black currant mistblower; Drake & Fletcher) designed for use in black currants was tested in a raspberry plantation using an air velocity of 49 km/h (as for black currants) and calibrated to deliver 330 l/ha. The spray cover and degree of pest and disease control obtained were compared with those for a hydraulic sprayer delivering 2000 l/ha — the recommended volume for raspberries using five treatments and an untreated control applied to plots of cv. Malling Jewel. The treatments included a contact insecticide (fenitrothion) applied on 15 July; three dose rates (0.3, 0.7, 1.1 l product/ha) were applied with the cross-flow sprayer, the greatest amount being equivalent to the standard commercial rate used in the hydraulic sprayer treatments.

The increasing rates of fenitrothion applied by the cross-flow sprayer killed 66, 82 and 79% respectively of the large raspberry aphid (*Amphorophora idaei*) compared with the untreated controls. Significantly fewer aphids were present in plots treated with the hydraulic sprayer (95% kill). These results with the cross-flow sprayer are encouraging but the air speed probably needs adjusting to obtain maximum control of *A. idaei* which lives mainly on the under surfaces of leaves.

(S. C. Gordon, B. Williamson<sup>1</sup>)

---

<sup>1</sup> Mycology Section.

## ESTATE

W. I. A. JACK

---

Continuing rising costs, adverse weather conditions and depressed markets for produce made the year under review one of the most difficult and disappointing. Weather conditions were never ideal for most farming operations as the meteorological records show. The early spring was wet, cold and late, but drought in April and May caused problems in germination, crop establishment and weed control; harvesting operations were frequently interrupted by rain, reducing yield and quality. Fortunately, however, the weather conditions in the autumn and early winter allowed field work to proceed uninterrupted.

### *Farm and experimental crops*

Farm crops included 34.6 ha barley, 8.1 ha winter wheat, 8.5 ha hay, 2 ha grass, 1.6 ha field beans and 4.5 ha fallow; this is an increase of 2.8 ha from the previous year as more land was released from field experiments and their access roadways, and used for rotational crops of cereals, field beans and grass.

Barley sowing started on 4 April, which was 22 days later than the previous year. Drought during April and May caused germination and growth of the crop to be erratic; weed control was poor, resulting in quality and yield lower than previous years. Combining started on 22 August and was completed under reasonable conditions on 1 September. The yield of 5.7 t/ha was down 0.8 t/ha on the previous year. The difficulties encountered during the growing season resulted in grain samples in general being of poor quality, with a high moisture content averaging 18.5%, low bushel weight, and nitrogen above 2%; 28% of the tonnage was sold for malting.

Winter wheat cv. Mardler overwintered well and received a top dressing of nitro-chalk at a rate of 300 kg/ha on 3 March; there was little disease and few pests present on the crop. To avoid shedding, the crop was combined on 23 August giving a yield of 7.4 t/ha, and was of feeding quality grain.

Grass grew rapidly in the early spring and was not affected by the drought of April and May. Hay was cut on 9 June; drying was delayed by frequent rain and good quality hay could not be made. Baling was completed on 23 June in rather unsatisfactory conditions; the yield was down 3.8 t/ha compared with the 1979 crop. A second cut was taken on 13 August and was baled and carted in excellent conditions.

Field beans, cv. Maris Bead, promised well, with little evidence of pests and diseases present. A desiccant was applied on 17 September and the crop ripened quickly. During the first week of October the crop was combined, but yielded less than expected.

Seed for the Institute's 1981 potato experiments grew well and protective spraying against pests and diseases was applied throughout the growing season; haulm was flailed off early in September. Lifting started under difficult conditions on 28 September. However, conditions improved considerably, enabling the work to be completed on 19 October and giving a good clean sample. The yield of 45.7 t/ha was an increase of 3.7 t/ha on 1979.

Field experiments included 11.7 ha raspberries, 6.3 ha black currants, 1.9 ha black and hybridberries, 1.6 ha strawberries, 5.7 ha potatoes, 2.9 ha vegetables, 0.4 ha field beans and 2.3 ha other crops.

The picking of soft fruit commenced with strawberries on 13 June, 27 days earlier than 1979, followed by raspberries on 6 July, black currants and blackberries on 8 July, hybrid berries on 31 July and blueberries on 8 August. The early start to the season with fewer pickers and frequent showers, coupled with the depressed state of the processing market, made it an extremely difficult year with the result that part of the soft fruit crop had to be abandoned. The quality of strawberries in general was high, but the quality of raspberries and black currants have been better; there was a higher incidence of botrytis this year, despite the routine spraying programme.

The fruit crop sold included 30.1 t raspberries, 18.3 t strawberries, 1.0 t black currants, 0.6 t blueberries, 0.2 t blackberries and some hybridberries and cranberries. This totalled 2.7t less than 1979. Marketable produce from brassica and vegetable trials totalled 43.5 tonnes, showing an increase of 34 t over 1979, due mainly to some Pentlandfield trials being grown at the Institute.

Following harvest, the routine programme of plot clearance, stubble cleaning, sub-soiling and spraying was practised. Ploughing was done when conditions were suitable and was almost completed by 11 December. Winter wheat was sown on 3 November and establishment was satisfactory. During periods when land work was at a standstill, much was done to put the estate in good trim by repairing dykes, fences and gates; roads were repaired where required, windbreaks trimmed, and farm machinery renovated and painted.

New farm equipment acquired during the year included a combine seed drill, fertiliser spreader, electronically operated bout marker, and a piston-diaphragm pump to improve field spraying applications.

### *Glasshouses*

The production and maintenance of plant material for use by the scientific sections reduced again this year. Plant production at 127,264 units was

down 15,391 on 1979; included were *ca.* 72,000 indicator test plants raised from seed, from 40 species, for the Virology and Zoology Sections, 8,000 raspberry pot plants from 44 cultivars and advanced seedlings for other Institute work, and 2,000 black currant plants from single bud cuttings were grown as single stem plants for a plant breeding project in 1981. Two thousand Tayberry pot plants were raised from leaf bud cuttings for NSDO and SNSA, and several large sowings produced plants for field trials of brassicas, raspberries and black currants.

Pest and disease control gave few problems following prompt and regular control measures. However, vine weevil appeared in host plants for nematode stocks where few control measures can be initiated, and its spread has proved difficult to control even where chemicals may be used; DDT had to be resorted to to get any measure of control. Timely application of bupirimate (Nimrod) is giving good control of powdery mildew on a wide range of plants, with triadimefon (Bayleton) and metalaxyl (Ridomil 25 WP) giving control of the disease under glass.

The campaign was continued to eradicate sources of contamination of clean stock within the glasshouse area by the excavation of the floors of three Dutch light houses; two houses were then provided with concrete floors and one floored with clean stone chips.

A further insect-proofed structure was erected to provide additional space for the production of virus-tested clones of Narcissus.

## INFORMATION SERVICES

R. J. A. EXLEY

---

The objective of the ARS is to increase the productivity of the agricultural industry. While research workers communicate with each other through the well established channels of the learned journals and scientific meetings those concerned with applied research should welcome access to any medium which exposes their work directly to producers, but more particularly to any which exposes it to the advisory and development services, the importance of whose role is self-evident.

Contact is commonly made between Institute staff and the specialist and horticultural advisers of the Scottish Colleges of Agriculture, and encouraged by the activities of the SHRI Association which Information Services organise. However, because much of the Institute's work has relevance throughout the UK, it is particularly satisfactory that both this year and last the Institute provided by invitation a speaker at three ADAS conferences. Also in 1980, despite the financial constraints, the horticultural advisers from the Yorkshire/Lancashire Region visited the Institute, as well as two parties of selected soft fruit growers each accompanied by their advisers, one from Cheshire/Staffordshire and one from Worcestershire.

### LIBRARY

The library loan figures for 1980 were similar to 1979. There were 290 book loans and 517 serial loans making a total of 807 internal loans, and 838 inter-library loans giving a total of 1645 for the whole year or an average of 137 loans per month. As many books as could be afforded were purchased during the year with 100 books, as well as other literature, being acquired. The serials subscription list was reviewed in order to delete titles that had become irrelevant or peripheral to the research programme, and to add appropriate new titles. As a consequence twenty titles were deleted and nine were added.

The most important event in 1980 was the Institute gaining access to the Lockheed/DIALOG information system. This gives the Library the capability to run on-line searches and current awareness services. Thirteen searches had been effected by the end of the year, and the success rate, in terms of relevance and comprehensiveness, appears to be good.

During the year the library mailing lists were computerised, easing the work of distributing Institute publications. An inspection and evaluation of the pamphlet and report collections was begun, with a view to improving access to them by readers. A comprehensive catalogue listing publications by Institute staff was also started.

Both members of the library staff attended the Inter-Library Loans Seminar in Edinburgh, held in October and organised by the National Library of Scotland, and the Librarian attended a 2 day residential meeting of the Agricultural Research Service Librarians at the National Institute for Research in Dairying in December. The Librarian also attended both meetings of the Scottish Agricultural Librarians' Group held during 1980; the April meeting was at the West of Scotland College of Agriculture, and the Institute hosted the September meeting.

(Ursula M. McKean)

#### VISUAL AIDS

Substantial increases were recorded in each photography category and the jobs total exceeded 1600 for the first time; the graphics jobs total was equal to the previous year.

	<i>Photography</i>					<i>Graphics</i>
	Jobs	Colour	Monochrome	Diazo	E.M./Prints	Jobs
1979	1499	4216	4658	394	1412	92
1980	1608	4533	4722	579	2902	92

Costs of photographic sensitised materials soared during the early part of the year due to an astronomical increase in silver prices. Stocks purchased before the rises enabled the Institute to avoid buying paper and film at the highly inflated prices and thankfully silver prices have returned to their former level.

Aerial colour photography of the Institute's land at Mylnefield, East Pilmore and Gourdie in May and August was used to assess land uniformity in cereal and grass crops early in the growing season and just prior to harvest. The annual aerial photographic survey of raspberry plantations in Perthshire and Angus brought the total flying time in 1980 to just over 5 hours.

Specialised photography, e.g. time-lapse cinemicrography, growth analysis and ultra-violet photography, as mentioned in earlier annual reports, continued during the year.

In April, the Macaulay Institute for Soil Research borrowed the Visutek titling unit to produce captions of a suitable standard for their 50th anniversary displays. It was gratifying to see that these captions contributed to a fine display when viewed at their Open Day.

T. G. Geoghegan, S. F. Malecki and M. I. McMaster attended the 4th ARC Photographers and Graphic Officers' Conference at Welsh Plant Breeding Station, 16-17 September.

(T. G. Geoghegan)



SCOTTISH HORTICULTURAL RESEARCH INSTITUTE  
ASSOCIATION

---

*Committee*

<i>Chairman</i>	D. Morrison	A. D. Kay
	W. S. Courts	P. G. Mitchell
	J. Duffus	D. C. Pate
	A. G. M. Forbes	D. W. Purdie
	G. M. Hodge	R. J. Smith
	J. A. Inverarity	J. S. Whitehead

The 1980 AGM was held on 28 February when, following the business of the meeting, Institute staff gave lectures on topics concerning *Rubus* fruits, including new and prospective varieties, training options, a review of developments in plantation sprayers, and a progress report on the Combiject for the sub-surface application of soil sterilants.

Successful field demonstrations of research concerning soft fruits were held in the summer with a 'Strawberry Walk' on the evening of 8 July and with a 'Raspberry Walk' on the afternoon of 19 July.

A winter meeting on a wide range of topics relating to the growing and harvesting of *Rubus* fruits was held on 12 November.

*Publications*

During the year the Association financed the following:

*Bulletin No. 17 (May, 1980)*

*Some aspects of strawberry production*

Strawberry cultivars—past, present and future *by* H. J. Gooding, SHRI, p. 1-7.

Some aspects of plant health-limiting the spread of red core *by* I. G. Montgomerie, SHRI, p. 8-12.

Production of certified strawberry runners in Scotland *by* D. H. Turner, ESCA, p. 13-20.

Variations in yield components of strawberry plantations in eastern Scotland *by* D. T. Mason, SHRI, p. 14-25.

The effect of shelter on strawberry *by* D. K. L. MacKerron, SHRI, p. 26-29.

Recent advances in weed and runner control in strawberries *by* H. M. Lawson and J. S. Wiseman, SHRI, p. 30-35.

*Occasional Publication No. 8*

Raspberry Cultivar Trial, 1975-79, *by* M. R. Cormack and J. McD. Brown.

01046 *Agrometeorological Recording*

## MYLNEFIELD

The weather during 1980 was particularly variable and had several unusual patterns, the most noticeable of which was the prolonged dry spell during April and May. At that time of year potential evaporation rates were low and in most crops there was rather sparse cover so that soil moisture deficits were not large. However, by the third week of May they had reached their maximum for the year. There were reports, however, of difficulties in germination and establishment of spring sown crops because of the dry surface soil.

*Wind*

Over the period January to May the mean windspeed was only 81% of the long term average, and January was the least windy January since our records began. Monthly mean windspeeds were below the 20-year average in all months except November and December when windspeeds were 112 and 148% of the average respectively.

*Temperature*

Temperatures for the year were generally near the average and although March, July and October were colder than usual, February, April and December were warmer. Air maxima were low in July, exceeding 20°C on only 2 days. The warmest weather of the year was during the first week in June when the highest daily maximum was 26.2°C and the mean of the daily maxima for the week was 20.3°C.

*Rainfall*

Rainfall during the year was particularly erratic and overall totalled 122% of the 25-year mean. February and March were the wettest two consecutive months since December, 1963. Then April and May were the driest two consecutive months since our records began in 1954. There then followed the wettest June since 1966 with twice the average rainfall for that month.

*Sunshine and solar radiation*

The total of hours of sunshine for the year was 87% of the long term mean making this the dullest year since 1954. Only April, May and October had above average sunshine. Differences of solar radiation from average reflected the differences in bright sunshine.

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

Month	Temperature														Mean daily Solar Radiation mWh/cm <sup>2</sup>	Bright Sunshine hours		Windspeed Mean km/h	DFA †		
	Daily Air Maxima		Daily Air Minima		0.1 m Soil		0.3 m Soil		Earth		Accumulated Day Degrees		Days Ground Frost	Potential Evaporation mm		Rainfall				Total	DFA *
	Mean °C	DFA *	Mean °C	DFA *	Mean °C	DFA *	Mean °C	DFA *	Mean °C	DFA *	Above 6°C	Below 6°C				Total mm	DFA *				
January	3.8	-1.8	0.0	0	0.4	-1.1	2.2	-0.3	1	128	27	1.2	69.5	+ 6.3	37.2	-16.0	43	8.2	-2.9		
February	6.4	+0.7	2.0	+1.9	2.5	+0.9	3.6	+1.0	14	65	12	7.6	117.7	+69.2	31.3	-42.7	80	9.6	-2.5		
March	6.4	-1.6	1.0	-0.7	2.6	-0.7	4.3	+0.1	12	83	20	22.5	108.1	+63.9	71.2	-34.3	166	12.0	-2.7		
April	12.4	+1.3	4.4	+1.2	7.8	+1.6	7.6	+0.7	85	14	16	66.9	5.0	-36.3	186.0	+27.0	410	12.1	-2.5		
May	14.4	+0.7	5.2	-0.6	12.0	+1.9	10.7	+0.6	131	13	14	96.7	15.5	-40.6	236.1	+52.3	520	10.7	-1.9		
June	17.2	+0.2	9.5	+0.9	14.4	+0.5	13.8	+0.3	225	2	1	84.1	97.9	+49.0	151.8	-31.6	494	11.0	-0.9		
July	16.9	-1.5	10.3	+0.2	14.2	-1.0	14.3	-0.8	264	1	1	75.5	68.9	+ 4.2	115.3	-60.5	402	10.1	-0.6		
August	18.0	-0.1	10.8	+0.8	14.5	+0.2	14.8	0	262	1	3	62.0	69.9	+ 0.3	112.0	-42.7	331	8.8	-1.0		
September	16.3	+0.4	10.0	+1.5	12.2	+0.7	13.5	+0.9	216	1	1	35.3	66.6	+ 7.9	75.8	-43.5	201 <sup>Δ</sup>	10.1	-0.7		
October	10.3	-2.4	4.3	-2.0	6.6	-1.7	9.0	-0.8	89	24	14	22.4	71.3	+13.8	114.3	+23.3	156	11.2	-0.1		
November	8.4	+0.1	3.1	+1.0	4.7	+0.7	6.6	+0.9	38	45	14	10.7	67.2	+11.0	51.8	-15.5	61	13.6	+1.5		
December	7.7	+1.4	2.3	+1.4	3.1	+0.8	4.5	+1.0	31	62	22	11.7	70.0	+ 1.7	40.6	- 4.4	36	17.8	+5.8		
									1368	439	145		827.6	+150.4	1223.4	-188.9	242	11.3	-0.5		

\* DFA = Deviation from average 1954-78

† DFA = Deviation from average 1959-78

Δ = Includes estimated values

Month	Temperature										Days Ground Frost	Rainfall		Bright Sunshine Hours		Mean daily Solar Radiation mWh/cm <sup>2</sup>	Windspeed Mean km/h
	Daily Air maxima		Daily Air minima		0.1m Soil		0.3m Earth		Accumulated Day Degrees			Total mm	DFA *	Total	DFA *		
	Mean °C	DFA *	Mean °C	DFA *	Mean °C	DFA *	Mean °C	DFA *	Above 6°C	Below 6°C							
January	4.9	-1.8	-0.2	-1.7	1.5	2.9	2.9	-2.0	4	102	29	63.8	-26.5	47.9	+5.2	51.3	9.0
February	7.3	-1.0	2.8	+1.9	3.7	4.4	+0.8	27	43	20	54.9	-12.6	42.2	-31.7	88.7	10.1	
March	6.8	-0.8	1.5	-0.3	3.4	5.0	-0.2	16	68	19	57.8	+18.0	97.5	-7.5	214.1	13.7	
April	12.3	+1.2	4.6	+1.4	7.5	7.9	+0.6	94	14	12	4.4	-33.8	199.1	+31.1	418.3	12.7	
May	16.6	+2.5	5.9	-0.6	11.6	11.1	+0.9	180	9	7	22.8	-33.9	284.6	+110.7	573.8	10.8	
June	15.9	-1.2	9.1	+0.6	12.9	13.0	0.0	202	0	0	85.7	+33.9	116.5	-89.8	410.8	11.2	
July	17.2	-0.4	10.2	-0.4	14.0	14.2	-0.3	253	0	0	164.3	+94.4	133.1	-38.5	405.8	10.0	
August	17.5	-0.3	10.9	+0.1	14.2	15.2	+0.6	267	1	1	157.9	+90.3	123.2	-29.8	318.1	10.8	
September	16.0	+0.3	11.1	+2.3	12.7	14.0	+0.9	235	0	0	121.4	+52.0	81.1	-44.6	204.9	14.8	
October	11.1	+1.9	5.8	-0.7	7.5	10.0	-0.5	97	15	7	189.7	+118.9	69.4	-30.3	120.4	14.8	
November	9.0	+0.5	3.4	+0.5	5.4	7.4	-0.2	56	43	13	101.1	+2.2	60.9	+5.3	65.7	14.4	
December	8.4	+0.6	3.1	+0.1	4.5	5.4	-0.7	42	41	15	135.0	+51.1	26.6	-11.7	39.0	19.2	
TOTALS	—	—	—	—	—	—	—	1473	336	123	1158.8	+354.0	1282.1	-131.6	—	—	—

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

## PUBLICATIONS

---

- ALBERSHEIM, P., DARVILL, A. G., McNEIL, M., VALENT, B. S., HAHN, M. G., LYON, G. D., SHARP, J. K., DESJARDINS, A. E., SPELLMAN, M. W., ROSS, L. M., ROBERTSON, B. K., AMAN, P. and FRANOEN, L. (1981). Structure and function of complex carbohydrates active in regulating plant-microbe interactions. *Pure and Applied Chemistry* **53**, 79-88.
- ALPHEY, T. J. W. (1980). The efficacy of fumigation of nematode-infested soil following different methods of soil sealing. *Plant Pathology* **29**, 131-135.
- BARKER, H. (1980). Studies on the behaviour of raspberry ringspot virus in plant leaves and protoplasts. *Ph.D. Thesis, University of Dundee*.
- BARKER, H. (1980). Superinfection of mesophyll protoplasts with virus, p. 103-107. In Ingram, D. S. and Helgeson, J. P., eds. 'Tissue culture methods for plant pathologists.' Blackwell Scientific Publications Ltd., Oxford: pp. 272.
- BEM, F. and MURANT, A. F. (1980). Heracleum latent virus. *Commonwealth Mycological Institute/Association of Applied Biologists Descriptions of Plant Viruses* No. 228.
- BOAG, B. (1981). Nematode problems in Scottish forest nurseries. *Proceedings: Conference on Crop Protection in Northern Britain, Dundee, 1981*, Scottish Crop Research Institute: 237-241.
- BOAG, B. (1981). Effect of pesticides on *Rotylenchus robustus* and the yield of swede and grass. *Annals of Applied Biology Supplement: Tests of Agrochemicals and Agrochemicals* **2**, 8-9.
- BOAG, B. (1981). Observations on the population dynamics and vertical distribution of trichodorid nematodes in a Scottish forest nursery. *Annals of Applied Biology* **98**, 463-469.
- BOAG, B. (1982). Observation on the population dynamics, life cycle and ecology of the plant parasitic nematode *Rotylenchus robustus*. *Annals of Applied Biology* **100**. (In press.)
- BOAG, B. and HOOPER, D. J. (1981). *Rotylenchus onensis* n. sp. (Nematoda: Hoplolaimidae) from the British Isles. *Systematic Parasitology* **3**, 119-125.
- BROOK, R. M. (1980). The carbon economy of the field bean, *Vicia faba* L. *Ph.D. Thesis, University of Dundee*.
- BROWN, D. J. F. (1981). The effect of operator and measuring system error on the morphometrical variability of one nematode specimen. *Revue de Nematologie* **4**, 169-191.
- BROWN, D. J. F. and TAYLOR, C. E. (1981). Variazioni nella trasmissione di virus tra popolazioni di nematodi vettori Longidoridae. *Atti Della Societa Italiana Nematologi. Giornate Nematologiche, Firenze, 1979*, 191-204.
- COTES, L., TRUDGILL, D. L. and STEWART, R. M. (1981). Tolerance of early potato cultivars to potato cyst nematode and its relevance to chemical control. *Proceedings: Conference on Crop Protection in Northern Britain, Dundee, 1981*, Scottish Crop Research Institute: 97-100.
- DALE, A. (1980). The use of mark-sense computer cards in horticultural research. *Horticultural Research* **20**, 91-92.
- DUNCAN, J. M. (1980). Persistence of mycelium of *Phytophthora fragariae* in soils. *Transactions of the British Mycological Society* **75**, 383-387.
- DUNCAN, J. M. (1980). A technique for detecting red stele (*Phytophthora fragariae*) infection of strawberry stocks before planting. *Plant Disease* **64**, 1023-1025.
- DUNCAN, J. M. and COWAN, J. B. (1980). Effect of temperature and soil moisture content on persistence of infectivity of *Phytophthora fragariae* in naturally infested field soil. *Transactions of the British Mycological Society* **75**, 133-139.
- DUNCAN, G. H. and ROBERTS, I. M. (1981). Extraction of virus particles from small amounts of material for electron microscope serology. *Micron* **12**, 171-173.

- FORSTER, R. L. S. (1980). Production and properties of mutants of tomato black ring virus. *Ph.D. Thesis, University of Dundee.*
- FORSTER, R. L. S. and JONES, A. T. (1980). Lucerne transient streak virus. *Commonwealth Mycological Institute / Association of Applied Biologists Descriptions of Plant Viruses No. 224.*
- FOSTER, G. N., MCKINLAY, R., SHAW, M. W., AVEYARD, C. S., GORDON, S. C. and WOODFORD, J. A. T. (1981). The control of the aphids and leaf roll virus disease of potatoes by granular insecticides. *Proceedings: Conference on Crop Protection in Northern Britain, Dundee, 1981, Scottish Crop Research Institute: 91-96.*
- FOX, R. A. and DASHWOOD, E. PATRICIA (1981). Interactions between tuber age, depth of inoculation and gangrene development. *Potato Research 23*, 470 (Abstract).
- GORDON, S. C. (1981). Synthetic pyrethroid insecticides—possible uses in raspberry. *Proceedings: Conference on Crop Protection in Northern Britain, Dundee, 1981, Scottish Crop Research Institute: 293-296.*
- GORDON, S. C. and WILLIAMSON, B. (1981). Raspberry pests and diseases are difficult targets for commercial sprayers. *Proceedings: Conference on Crop Protection in Northern Britain, Dundee, 1981, Scottish Crop Research Institute: 183-187.*
- HARRISON, B. D. (1980). Foreword in Fauquet, C. and Thouvenel, J. C., *Maladies virales des plantes cultivées en Côte d'Ivoire.* ORSTOM, Paris: pp. 128.
- HARRISON, B. D. and ROBINSON, D. J. (1981). Tobravirus, pp. 515-540. In Kurstak, E., ed. *'Handbook of plant virus infections: comparative diagnosis.'* Elsevier/North Holland Biomedical Press, Amsterdam: pp. 943.
- HARRISON, J. G. (1981). *Fusarium acuminatum* on field bean. *Plant Pathology 30*, 121.
- HARRISON, J. G. (1981). Chocolate spot in field beans in Scotland. *Plant Pathology 30*, 111-115.
- HARRISON, J. G. (1981). A laboratory technique for estimating chocolate spot susceptibility of bean cultivars and its relation to disease in the field. *Annals of Applied Biology Supplement: Tests of Agrochemicals and Cultivars 2*, 72-73.
- HEGARTY, T. W. and ROSS, HEATHER A. (1981). Investigations of control mechanisms of germination under water stress. *Israel Journal of Botany 29*, 83-92.
- HODGKIN, T. (1980). The inheritance of partial self-compatibility in *Brassica oleracea* L.: Results from a half diallel homozygous for a moderately recessive S-allele. *Euphytica 29*, 65-71.
- HODGKIN T. (1980). The inheritance of partial self-compatibility in *Brassica oleracea* inbreds homozygous for different S-alleles. *Theoretical and Applied Genetics 58*, 101-106.
- HODGKIN, T. (1981). Some aspects of sib production in F1 cultivars of *Brassica oleracea*. *Acta Horticulturae No. 111*, 17-24.
- HODGKIN, T. (1980). Boron increases pollen tube numbers in self-pollinated *Brassica oleracea* stigmas. *Cruciferae Newsletter No. 5*, 18-19.
- HODGKIN, T. (1981). The inheritance of node number and rate of node production in Brussels sprouts. *Theoretical and Applied Genetics 59*, 79-82.
- JENNINGS, D. L. (1980). Recent progress in breeding raspberries and other *Rubus* fruits at the Scottish Horticultural Research Institute. *Acta Horticulturae No. 112*, 109-116.
- JENNINGS, D. L. (1980). Planning 20 years on. *The Grower 94*, 14-15.
- JENNINGS, D. L. (1981). A hundred years of Loganberries. *Fruit Varieties Journal 35*, 34-37.
- JONES, A. T. (1980). A screening method to detect seed-borne virus infection in *Vicia faba*. *Fabis 2*, 46-47.
- JONES, A. T. and DUNCAN, G. H. (1980). The distribution of some genetic determinants in the two nucleoprotein particles of cherry leaf roll virus. *Journal of General Virology 50*, 269-277.

- JONES, A. T. and FORSTER, R. L. S. (1980). Lucerne Australian latent virus. *Commonwealth Mycological Institute/Association of Applied Biologists Descriptions of Plant Viruses* No. 225.
- JONES, A. T. and JENNINGS, D. L. (1980). Genetic control of the reactions of raspberry to black raspberry necrosis, raspberry leaf mottle and raspberry leaf spot viruses. *Annals of Applied Biology* **96**, 59-65.
- KURPPA, A., JONES, A. T., HARRISON, B. D. and BAILISS, K. W. (1981). Properties of spinach yellow mottle, a distinctive strain of tobacco rattle virus. *Annals of Applied Biology* **98**, 243-254.
- LAWSON, H. M. (1980). Biology and control of raspberry suckers. *Scientific Horticulture* **31**, 101-105.
- LAWSON, H. M. (1980). Recent research on cane vigour control in Scotland. *Acta Horticulturae* No. 112, 151-156.
- LAWSON, H. M. and WISEMAN, J. S. (1980). Recent advances in weed and runner control in strawberries. *SHRI Association Bulletin* No. 17, 30-35.
- LAWSON, H. M. and WISEMAN, J. S. (1980). Herbicide programme for spring-planted strawberries. *Proceedings: British Crop Protection Conference—Weeds*, Brighton, 1980, British Crop Protection Council: 1, 353-360.
- LAWSON, H. M. and WISEMAN, J. S. (1980). Strawberry runner control with dinoseb-in-oil. *Proceedings: British Crop Protection Conference—Weeds*, Brighton, 1980, British Crop Protection Council: 1, 361-368.
- LAWSON, H. M. (1981). Potato seedlings as weeds: a new slant on the ground-keeper problem. *Proceedings: Crop Protection in Northern Britain*, Dundee, 1981. Scottish Crop Research Institute: 137-142.
- LYON, G. D. and ALBERSHEIM, P. (1980). The nature of the phytoalexin elicitor of *Erwinia carotovora*. *Plant Physiology* **65**, 137. (Abstract.)
- MASON, D. T. (1981). Effects of benomyl on yield components of red raspberry (*Rubus idaeus* L.) in relation to the incidence of spur blight (*Didymella appianata*) and cane botrytis (*Botrytis cinerea*). *Journal of Horticultural Science* **56**, 193-198.
- MASON, D. T. (1981). A comparison of the hedgerow and stool systems of growing the red raspberry (*Rubus idaeus* L.) in relation to cane disease incidence and yield component compensation. *Horticultural Research* **21**. (In press.)
- MASON, D. T. and TOPHAM, P. B. (1981). Measurement and evaluation of the crop components of a raspberry harvest model. *Horticultural Research* **21**, 19-28.
- MASON, D. T., WOODFORD, J. A. T. and TRUDGILL, D. L. (1981). The effect of benomyl on some invertebrate inhabitants of a red raspberry, *Rubus idaeus*, plantation in relation to fruit yield. *Annals of Applied Biology* **98**, 43-51.
- MONTGOMERIE, I. G. and KENNEDY, D. M. (1980). The pathogenicity of *Phytophthora* species to red raspberry. *Acta Horticulturae* No. 112, 167-176.
- MOWAT, W. P. (1980). Epidemiological studies on viruses infecting narcissus. *Acta Horticulturae* No. 109, 461-467.
- MOWAT, W. P. (1980). The production of virus-free narcissus stocks in Scotland. *Acta Horticulturae* No. 109, 513-521.
- MURANT, A. F. (1981). Nepoviruses, p. 198-238. In Kurstak, E., ed. *Handbook of plant virus infections: comparative diagnosis*. Elsevier/North-Holland Biomedical Press, Amsterdam: pp. 943.
- MURANT, A. F. (1981). The role of wild plants in the ecology of nematode-borne viruses, pp. 237-248. In Thresh, J. M., ed. *Pests, pathogens and vegetation*. Pitman, London: pp. 517.
- MURANT, A. F., TAYLOR, M., DUNCAN, G. H. and RASCHKE, J. H. (1981). Improved estimates of molecular weight of plant virus RNA by agarose gel electrophoresis and electron microscopy after denaturation with glyoxal. *Journal of General Virology* **53**, 321-332.
- MURANT, A. F. and ROBERTS, I. M. (1980). Particles of raspberry vein chlorosis virus in the aphid vector, *Aphis idaei*. *Acta Phytopathologica Academiae Scientiarum Hungaricae* **15**, 103-106.

- PEROMBELON, M. C. M. (1981). The ecology of erwinias on aerial plant surfaces, pp. 411-431. In Blakeman, J. P., ed. *Microbial ecology of the phylloplane*, Academic Press: pp. 502.
- PEROMBELON, M. C. M. and KELMAN, A. (1980). Ecology of the soft rot erwinias. *Annual Review of Phytopathology* **18**, 361-387.
- PEROMBELON, M. C. M., LOW, R., QUINN, C. and SELLS, A. (1980). Contamination of pathogen freed seed potato stocks by *Erwinia carotovora* during multiplication: Results of a six year monitoring survey. *Potato Research* **23**, 413-425.
- PERRY, D. A. (1981). Ed. *Handbook of Vigour Test Methods*. International Seed Testing Association, Zurich: pp. 72.
- PERRY, D. A. (1981). Report of the Vigour Test Committee, 1977-1980. *Seed Science and Technology* **9**. (In press.)
- RASCHKE, IRENE E. and BOAG, B. (1981). Morphological variation and distribution frequency of hermaphrodite *Longidorus elongatus*. *Revue de Nematologie* **4**, 283-285.
- ROBERTS, I. M. and BROWN, D. J. F. (1980). Detection of six nepoviruses in their nematode vectors by immunosorbent electron microscopy. *Annals of Applied Biology* **96**, 187-192.
- ROBINSON, D. J., BARKER, H., HARRISON, B. D. and MAYO, M. A. (1980). Replication of RNA-1 of tomato black ring virus independently of RNA-2. *Journal of General Virology* **51**, 317-326.
- TAMADA, T. and HARRISON, B. D. (1980). Factors affecting the detection of potato leafroll virus in potato foliage by enzyme-linked immunosorbent assay. *Annals of Applied Biology* **95**, 209-219.
- TAMADA, T. and HARRISON, B. D. (1980). Application of enzyme-linked immunosorbent assay to the detection of potato leafroll virus in potato tubers. *Annals of Applied Biology* **96**, 67-78.
- TAMADA, T. and HARRISON, B. D. (1981). Quantitative studies on the uptake and retention of potato leafroll virus by aphids in laboratory and field conditions. *Annals of Applied Biology* **98**, 261-276.
- THOMPSON, R. (1980). Ed. *Proceedings: EEC Seminar, Vicia faba: physiology and breeding*, Wageningen, 1980, Commission of European Communities: 358.
- THOMPSON, R. and TAYLOR, H. (1980). Factors limiting growth and yield of *Vicia faba*. *Proceedings: EEC Seminar, Vicia faba: physiology and breeding*, 1980, Wageningen, Commission of European Communities: 34-46.
- TOPHAM, P. B. and MASON, D. T. (1981). Modelling a raspberry harvest: effects of changing the starting date of, and the interval between, machine harvests. *Horticultural Research* **21**, 29-39.
- TORRANCE, L. and HARRISON, B. D. (1981). Properties of Scottish isolates of cocksfoot mild mosaic virus and their comparison with others. *Annals of Applied Biology* **97**, 287-297.
- TRUDGILL, D. L. (1980). Effects of *Globodera rostochiensis* and fertilisers on the mineral nutrient content and yield of potato plants. *Nematologica* **26**, 243-254.
- TRUDGILL, D. L. and RASCHKE, I. E. (1980). The effect of aldicarb on the growth and yield of six crops in soil infected with *Longidorus elongatus* (Nematoda, Dorylaimida). *Horticultural Research* **20**, 67-72.
- TULLOCH, BARBARA (1980). Observations on the pollen of some psycies and hybrids of *Narcissus*. *The Daffodil Journal* **17**, 116-119.
- WAISTER, P. D. (1980). Biennial cropping of raspberries. *The Garden—Journal of the Royal Horticultural Society* **105**, 332-334.
- WAISTER, P. D. (1980). Scots look West—Raspberry harvest. *Grower* **94**, 20, 23.
- WAISTER, P. D., WRIGHT, C. J. and CORMACK, M. R. (1980). Potential yield in red raspberry as influenced by interaction between genotype and cultural methods. *Acta Horticulturae* No. 112, 273-282.
- WAISTER, P. D. and CORMACK, M. R. (1981). Cropping on and off—Biennial raspberries. *Grower* **95**, 33, 35.



- WATERHOUSE, P. M. and MURANT, A. F. (1981). Purification of carrot red leaf virus and evidence from four serological tests for its relationship to luteoviruses. *Annals of Applied Biology* **97**, 191-204.
- WILLIAMSON, B. (1980). *Sydowiella depressula* on red raspberry. *Transactions of British Mycological Society* **74**, 647-649.
- WILLIAMSON, B. (1980). Does spur blight (*Didymella applanata*) reduce the yield of red raspberries? *Acta Horticulturae* No. 112, 285-294.
- WILLIAMSON, B. (1981). The effects of raspberry cane diseases on yield. *Scottish Crop Research Institute Association Bulletin* No. 19, 8-14.
- WILLIAMSON, B. and HARGREAVES, A. J. (1981). Effects of *Didymella applanata* and *Botrytis cinerea* on axillary buds, lateral shoots and yield of red raspberry. *Annals of Applied Biology* **97**, 55-64.
- WILLIAMSON, B. and HARGREAVES, A. J. (1981). The effect of sprays of thiophanate-methyl on cane diseases and yield in red raspberry, with particular reference to cane blight (*Leptosphaeria coniothyrium*). *Annals of Applied Biology* **97**, 165-174.
- WILLIAMSON, B. and RAMSAY, A. M. (1981). Prospects for control of cane blight in machine-harvested raspberries. *Proceedings: Crop Protection in Northern Britain*, 1981, Dundee, Scottish Crop Research Institute: 281-285.
- WILLS, A. B. and WISEMAN, EVELINE M. (1980). Testing for sibs by acid phosphatase isoenzyme analysis: new genetic evidence. *Eucarpia Cruciferae Newsletter* No. 5, 20.
- WILLS, A. B., WHITEHOUSE, R. N. H. and McNAUGHTON, I. H. (1980). Eds. *Eucarpia Cruciferae Newsletter* No. 5, pp. 66.
- WOODFORD, J. A. T. (1980). The relevance of early haulm destruction to the problem of leaf roll in seed potatoes. *Arable Farming* **7**, 55, 58, 61.
- WOODFORD, J. A. T. and AVEYARD, C. (1980). Controlling the spread of potato leaf roll in Scottish seed potatoes. *Potato Progress* **1**, 6-12.
- WRIGHT, C. J. and WAISTER, P. D. (1980). Seasonal changes in the mineral nutrient content of the raspberry. *Acta Horticulture* No. 112, 295-304.

## INSTITUTES FOR AGRICULTURAL RESEARCH IN GREAT BRITAIN

---

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

### *ARC Institutes*

Animal Breeding Research Organisation	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	Letcombe Regis, Wantage, Berks., OX12 9JT
Meat Research Institute	Langford, Bristol, BS18 7DY
Poultry Research Centre	King's Buildings, West Mains Road, Edinburgh, EH9 3JS
Weed Research Organisation	Begbroke Hill, Sandy Lane, 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	Worthing Road, Rustington, Little- hampton, 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
Nation 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, Hert., AL5 2JQ
Welsh Plant Breeding Station	Plas Gogerddan, Aberystwyth, Cardiganshire, SY23 3EB
Wye College, Department of Hop Research	Ashford, Kent, TN25 5AH

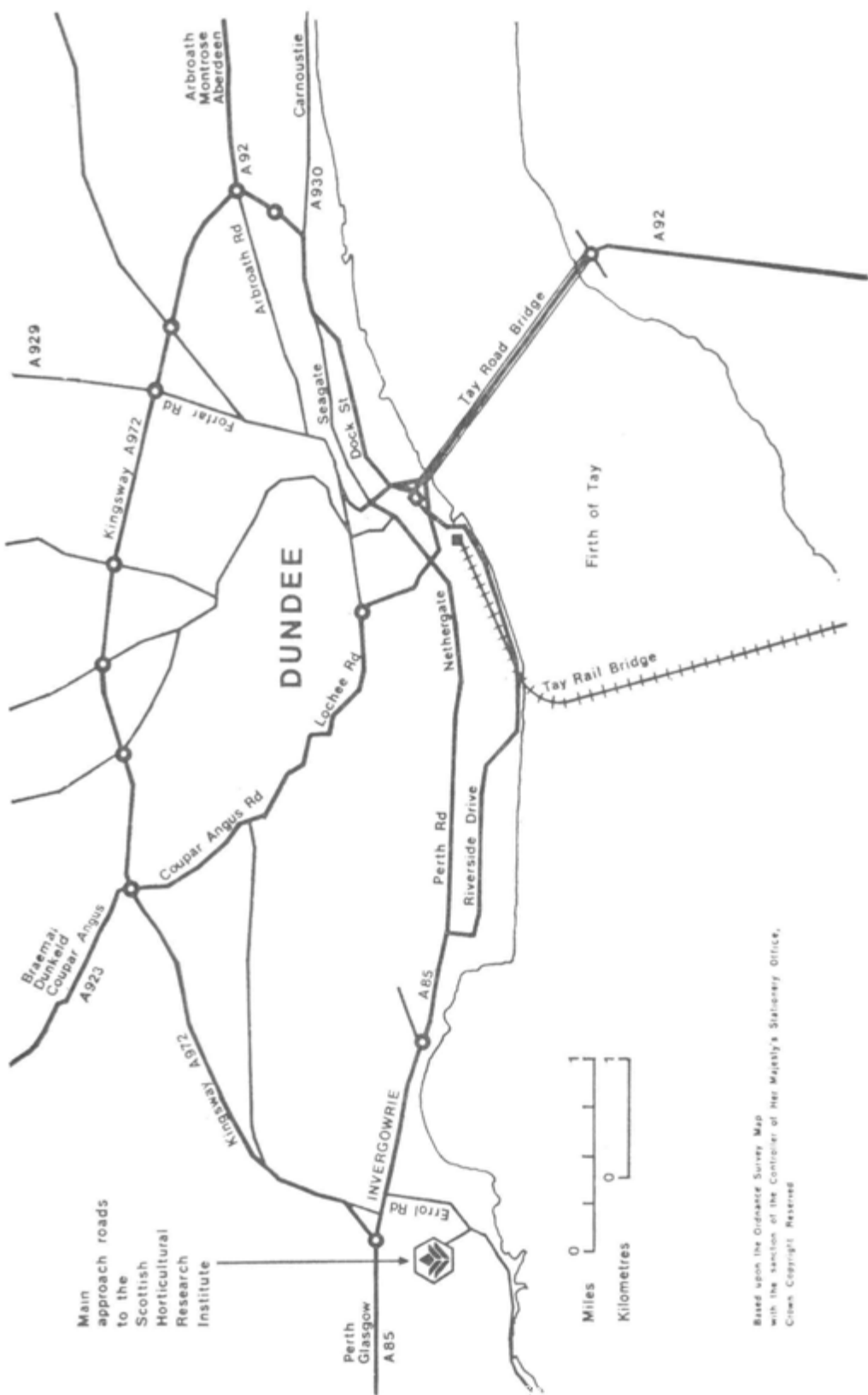
### *State-aided Institutes in Scotland*

Animal Diseases Research Association	Moredun Institute, 408 Gilmerton Road, Edinburgh, EH17 7JH
Hannah Research Institute	Ayr, Scotland, KA6 5HL
Hill Farming Research Organisation	Bush Estate, Penicuik, Midlothian, EH26 0PH
Macaulay Institute for Soil Research	Craigiebuckler, Aberdeen, AB9 2QJ
Rowett Research Institute	Bucksburn, Aberdeen, AB2 9SB
Scottish Horticultural Research Institute	Invergowrie, Dundee, DD2 5DA
Scottish Institute of Agricultural Engineering	Bush Estate, Penicuik, Midlothian, EH26 0PH
Scottish Plant Breeding Station	Pentlandsfield, Roslin, Midlothian, EH25 9RF

## ABBREVIATIONS

---

AAB	Association of Applied Biologists
ABRO	Animal Breeding Research Organisation
ADAS	Agricultural Development and Advisory Service
ADRA	Animal Diseases Research Association
ARC	Agricultural Research Council
BA	British Association
BBC	British Broadcasting Corporation
DAFS	Department of Agriculture and Fisheries for Scotland
EAPR	European Association for Potato Research
EEC	European Economic Community
EHS	Experimental Horticultural Station
EM	Electron microscope
EMRS	East Malling Research Station
ERCC	Edinburgh Regional Computing Centre
ESCA	East of Scotland College of Agriculture
FBPP	Federation of British Plant Pathologists
GCRI	Glasshouse Crops Research Institute
HEA	Horticultural Education Association
ISHS	International Society for Horticultural Science
NCAE	National College of Agricultural Engineering
NFT	National Fruit Trials
NIAB	National Institute of Agricultural Botany
NIAE	National Institute of Agricultural Engineering
NSCA	North of Scotland College of Agriculture
NSDO	National Seed development Organisation
PBI	Plant Breeding Institute
PYO	Pick your own
SIPP	Society of Irish Plant Pathologists
SNFU	Scottish National Farmers' Union
SNSA	Scottish Nuclear Stock Association
UK	United Kingdom
USA	United States of America
USSR	Union of Soviet Socialist Republics
VTSC	Virus tested stem cutting
WPBS	Welsh Plant Breeding Station
WSAC	West of Scotland Agricultural College



Based upon the Ordnance Survey Map with the sanction of the Controller of Her Majesty's Stationery Office. Crown Copyright Reserved

