SCOTTISH PLANT BREEDING STATION

REPORT

April 1980 to January 1981

And the Report to the sixtieth
Annual General Meeting of the

SCOTTISH SOCIETY FOR RESEARCH IN PLANT BREEDING

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Report of the Scottish Society for Research in Plant Breeding

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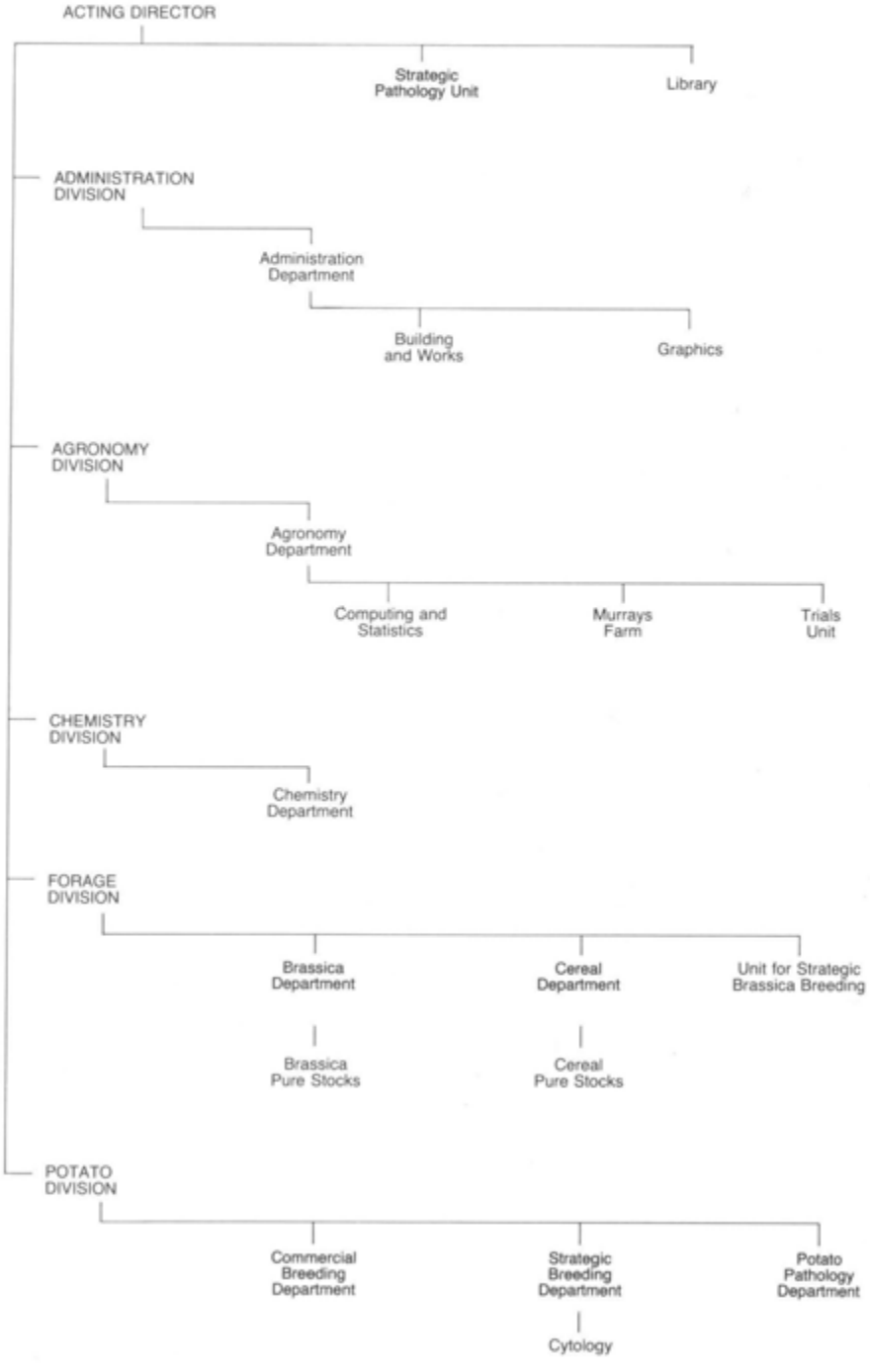
OUTLINE MANAGEMENT STRUCTURE ON 31st JANUARY 1981



REPORTS BY DIRECTOR AND ACTING DIRECTOR

Last year (*Ann. Rep. 1979-80*, 8) I gave a full account of the statement made by Her Majesty's Secretary of State for Scotland about the future requirements of state-funded plant breeding and crop research in Scotland and I outlined the effects that the far-reaching instructions issued by the Secretary of State would have upon the future of the Scottish Plant Breeding Station and on the Scottish Society for Research in Plant Breeding. Some of these effects are discussed in more detail in my account given to the Annual General Meeting in 1979 (*Ann. Rep. 1979-80*, 124).

In the period covered by this report further developments have taken place. A few days before the beginning of the year the Programme Review Group, appointed by the Agricultural Research Council, carried out a thorough examination of the proposals put forward by the Station (and by the Scottish Horticultural Research Institute) for future work. Its composition was given in my report last year. During the summer it was announced that the new Institute resulting from the amalgamation of the Scottish Plant Breeding Station and the Scottish Horticultural Research Institute would be named the Scottish Crop Research Institute. The amalgamation became effective on 1st February 1981 when the Society ceased to be responsible for the management of the Station.

As a consequence of these changes this Annual Report covers the ten months from 1st April 1980 to 31st January 1981 and is, therefore, the last by a Director of the Scottish Plant Breeding Station. This is an historic and inevitably sad event marking, as it does, the end of more than sixty years during which the Society has managed active plant breeding programmes in Scotland. Although the Society's responsibility for management of the research programme will cease, the association with plant breeding will continue through representation on the Governing Body of SCRI. The record of success, particularly in potato breeding, stands for future generations to see; it is an enviable one. When, at a later date, the history of the period comes to be written the full value of the synergistic relationship between scientists and the members of the Society will be acknowledged. It is an association which has done much to influence crop production both in the United Kingdom and in many other parts of the world. However, the arrangements for the future of crop research in Scotland should allow a new relationship to develop and should also provide more effective facilities.

It was inevitable that with such fundamental changes taking place much of the time of the staff was occupied with planning. Detailed documentation was prepared for the Programme Review Group. Because of its importance to the future of the breeding work presently forming the larger part of the SPBS research programme the report of the Group is included here:—

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 recommendations 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 Mylnefield, 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. Effects 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 £2·6 m per annum. They cover the entire programmes of SHRI and SPBS and about one-fifth of the MISR programme.

Conclusions and Recommendations

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-oriented 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 blackcurrants. 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 blackcurrants 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, Mylnefield, 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 situation. 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.

It was particularly satisfying to note that the Report, with a few minor but very important exceptions, proposed the continuation of the programme of the Station. However, the recommendations on oats and winter barley were disappointing to staff and to the Board of the Society, as was the lack of clear

advice on proposals to breed potatoes for overseas markets, despite the support it might give to Scottish seed potato production.

The Secretary of State for Scotland gave his approval to the recommendations on 15th October 1980:—

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 advantages 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 blackcurrants.

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 re-deployment 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 of 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 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 fruit) and blackcurrants (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.

Related to Specific Crops

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 spring 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 blackcurrants 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.

It will be seen that SCRI is expected to develop closer links with the breeding of oats and winter barley elsewhere and that further consideration will be given to the proposed breeding of potato varieties for ware production overseas.

Discussions commenced immediately to put the recommendations into effect as far as they related to the SPBS programme. The Programme Review Group's recommendations, of course, covered the whole programme for SCRI, and crop research should in the future be strengthened by the fusion of the plant breeding and crop research packages of the two former stations. The date of the amalgamation marks only the beginning of a long and intricate period of integration of staff, facilities and programmes. It will not be an easy process and will need the goodwill and forebearance of all concerned.

The remainder of my report will deal with a range of aspects of the Station's organisation and work during the period under review. Many restrictions on staff recruitment, imposed during the planning for SCRI, were removed and it was possible to make a number of appointments of staff of high calibre which were consistent with the Secretary of State's plan for the future.

The management changes outlined in my remarks following the Annual General Meeting (this report page 131) have worked satisfactorily to the

benefit of the administrative and the scientific work of the Station.

In view of the proposals to evacuate the Pentlandfield site, no major capital building works were started.

During the year a comprehensive re-appraisal of the Station's present and future computer requirements and data capture capacity was completed. A start was made to supplement our present and ageing computer equipment with a series of micro-computers; four have been installed at the time of writing.

The near infra red (NIR) analysis work of the Chemistry Division using the Neotec 6350 (scanning infra red analyser) has progressed on two fronts, namely, improvements made in NIR methodology and new applications of NIR analysis to aid plant breeding.

Examples of the former include new programmes for improving the detection of spectral differences between samples and a new means of deriving very high multiple correlations between NIR prediction and manual estimations of the quality component of interest. Applications of NIR under investigation include the prediction of the content of SMCO (the haemolytic factor in kale), in leaves or whole plants of Maris Kestrel and NIR prediction of factors important in malting quality assessment of barley varieties (hot water extract, beta glucan content, etc.). The NIR technique has also been applied to problems in pathology work, including the prediction of numbers of mildew spores washed from barley leaves.

During the course of the year brassica breeding and related activities were reorganised with the effort being concentrated on the breeding of the three main UK crops, swede, forage rape and kale. Assistance for the breeders in dealing with purity and multiplication of seed was provided by the creation of a Stocks Unit, within the Brassica Department, under Miss I. K. Munro. The Department, led by Dr Macfarlane Smith, works closely with the new Strategic Unit under Dr McNaughton, which is investigating long-term developments in brassica breeding and is creating new genetic variation by means of interspecific and intergeneric crosses for use by the breeders. A necessary part of this work is the development and utilisation of techniques for embryo, anther and tissue culture.

The forage rape and kale programmes are now organised on a routine basis which should give rise to a steady flow of new cultivars in the future. Swede breeding has already reached this stage with two cultivars, Angus and Melfort, completing the second year of National List trials. The former has a bronze skin and the latter a green skin, but both have yellow flesh with a high dry matter content. They are late-maturing types with exceptional freedom from bolting, cracking and rotting. Disease resistance is similar to many existing cultivars, though there are indications of better than average resistance to turnip root fly, a cause of severe root damage and losses to the processor.

In my previous reports I have made little mention of the work of the Strategic Pathology Unit. This Unit is under the control of Dr J. F.

Malcolmson and in the past two years completely new facets of research have emerged. Studies with the Scanning Electron Microscope have proved to be a promising innovation in the programme on potato blight in the Strategic Pathology Unit. Having established methods of preparing specimens for examination, it is now evident that the SEM can provide useful information on both the mycology of *Phytophthora infestans* and its interaction with the host. Details of the spores and hyphae both on and within the host are clearly described and the three dimensional quality of the image obtained allows interpretation in terms of the actual microspace. This, together with the SEM's facility for specimen manipulation, introduces the possibility of studying the various facets of field resistance in a more effective manner than has hitherto been available by light microscopy.

A DAFS/ARS Package Review of Brassicas was held in November 1980 (Package 4 in the SPBS Research Programme). The review indicated that although the main effort be concentrated on breeding finished varieties of the three principal crops this need not exclude work with some of the minor crops. The final content of the programme, however, has still to be decided.

No new SPBS varieties were placed on the UK Recommended Lists in 1980 (for 1981). The oat variety, Fyne, which was recommended by the NIAB in 1979, was not recommended by the Scottish Colleges for Scotland in 1980.

Further new submissions were made for National List Testing in 1981. If varieties still under consideration after completing trials in 1980 are included, the Station has six barleys, five potatoes, one fodder radish, one rape and four swedes under examination for National List entry and possible commercialisation.

Mr J. Arbuckle retired as Chairman of the Society in July 1980 after serving for nine years in this post. The staff and I wish him well in his new role as Chairman of the Governing Body of SCRI. We welcomed Colonel J. Gray as the new Chairman who undertook to guide the Station and the Society through the final stages of amalgamation. Our thanks are due to both of them.

I should refer in my report to the death during the year of Sir David Lowe. An obituary appears on page 130. Without Sir David's knowledge and wisdom Scotland and Scottish agriculture will be the poorer. The Society and the staff will miss a wise counsellor and friend.

I regret also having to record the death of Dr J. W. Gregor who was Director of the Station for fifteen years from 1950–1965, which included the move from Craigs House to Pentlandfield. There is an obituary on page 35.

Finally, I must record that my appointment as Director is being terminated as a result of the amalgamation. I have been Director since 1976 and then became only the fifth Director in the Society's sixty-year history—my predecessors being Mr Montague Drummond (1921–25), Mr William Robb (1925–50), Dr J. W. Gregor (1950–65) and Professor N. W. Simmonds (1965–76). Dr J. H. W. Holden was Acting Director for several months prior

to my arrival and Mr R. N. H. Whitehouse, the Deputy Director for the past four years, was appointed Acting Director for the last few days of January 1981. I should like to acknowledge the help and support of the staff during this period and also the friendly counsel and advice given to me by members of the Board, both past and present.

I should like to thank Dr R. J. Killick and his colleagues on the Editorial Board who have edited this final Report and who have seen it successfully through the press.

R. C. F. Macer, Director.

Dr Macer relinquished his executive authority in the Station at the end of November 1980 although his employment by the Society continued until the middle of January 1981. For the sake of the historical record I am including a timetable of the events leading to the amalgamation on 1st February 1981 in so far as they involved the Scottish Plant Breeding Station.

1978

July	Working Party on the future of state-funded plant breeding and crop research in Scotland set up by the Department of Agriculture and Fisheries for Scotland.
October	Working Party visited Pentlandfield.
December	Report of the Working Party received.

1979

December	Recommendations of Working Party accepted by Secretary of State for Scotland.

1980

January	Members of SHRI/SPBS Programme Review Group appointed by the Agricultural Research Council.
March	Programme Review Group met in Edinburgh to hear opinions from staff.
May	Report of Programme Review Group received.
October	Response by Secretary of State for Scotland to Programme Review Group's Report received.

1981

January	Date of amalgamation and name of new Director announced.

Although the Scottish Plant Breeding Station has ceased to exist as a separate entity most of its programmes will continue within the Scottish Crop Research Institute and staff are now identifying the need for new buildings and facilities. Opportunities for the development of research work are also under discussion both within the new institute and in collaboration with colleagues elsewhere. It seems likely that the future of state-funded plant breeding will depend increasingly for its success on co-operation between institutes and to this end recent meetings at WPBS and PBI have examined ways in which this could occur.

R. N. H. Whitehouse, Acting Director.

INFORMATION CONCERNING STAFF AND VISITORS

Director

Dr R. C. F. Macer continued to serve on the Selection Panel of the Scientific Awards Advisory Committee of the Royal Agricultural Society of England and as a member of the NSDO Advisory Committee and various committees of the Edinburgh Centre of Rural Economy. With the ending of the second phase of the Joint Consultative Organisation his period of service on the Arable Crops and Forage Board and as Chairman of its Cereal Committee ceased.

On 25th November 1980, Dr Macer gave a lecture to the Medical and Physical Society of St Thomas's Hospital, London, entitled "Feeding the World—the Plant Breeder's Contribution". He also gave lectures to the Botany and Science Studies Departments of the University of Edinburgh and completed his term as External Examiner, Department of Genetics, University of Birmingham.

Staff

The following members of staff were appointed during the year: W. Powell (Higher Scientific Officer); Miss M. C. Mackay (Scientific Officer); Miss H. E. Playfair (Clerical Officer); Miss K. A. Stewart (Shorthand Typist) and B. Dixon and K. Petrie (Agricultural Workers).

Resignations included: Mrs J. A. Fantes and Mrs C. L. Ross (Higher Scientific Officers); Miss I. B. Majewicz and R. H. McHale (Scientific Officers); Miss D. J. Fullerton, Miss G. Horne, Miss S. Milligan, Miss M. E. Pearce and Miss D. Watt (Assistant Scientific Officers); Mrs A. Fulcher (Clerical Officer) and J. M. Fairley (Agricultural Worker).

J. W. Russell (Agricultural Worker) retired after fourteen years service at Pentlandfield. Mr Russell (Joe to everyone) was for many years responsible for the maintenance of the increasingly large area of netted crops of cereals and brassicas. We extend our best wishes for a long and happy retirement.

The following members of staff were promoted during the year: J. Brown, J. S. Swanston and A. Young to Higher Scientific Officer; Mrs V. Goodall (née Purves) to Assistant Scientific Officer; Miss G. E. Lightbody to Clerical Officer; Miss L. S. MacPherson and M. P. L. Campbell to Process and General Supervisory grade.

It is with regret that we record the death of Miss S. McFarlane, who died as a result of injuries caused by a road accident. Although Shona had just joined the staff as an ASO in the Strategic Breeding Department, she had worked at

SPBS for several years, initially as a sandwich student, then as a vacation student. Her appointment to a permanent post reflected the esteem in which she was held by all who knew her. We extend our sympathy to her family on their bereavement.

New Qualifications

M. F. B. Dale was awarded a Ph.D. by the Faculty of Science and Engineering, University of Birmingham, for his Thesis, "Breeding Patterns in the Genus *Beta*, Section *Beta*".

Miss S. Milligan obtained an H.N.C. in Biology. D. J. Hall, J. G. McCluskey, T. Nelson and K. Taylor gained O.N.C. Biology.

Visitors

There were a number of visitors to the Station during the year from ARC Headquarters, including Dr R. Riley, Secretary of the ARC, Dr J. Ingle, ARC Scientific Adviser on plant biochemistry, and Dr S. Huyshe, ARC Consultant in data processing. In addition two parties representing the ARC Computer Committee visited SPBS to gather information on future computing needs. Professor J. H. Burnett, Principal and Vice-Chancellor of Edinburgh University, visited the Murrays, and Professor J. K. A. Bleasdale, Director of NVRS delivered the Tenth SSRPB Lecture (*Ann. Rep. 1979-80*, 130-138). The Station also welcomed a number of visitors from DAFS.

The Potato Division attracted a number of visitors. These included: Dr K. U. Ahmad, the Potato Project Director of the Bangladesh Agricultural Research Institute, Dacca, and Dr V. Yogaratnam, co-leader of the Sri Lanka Potato Breeding Program, who visited the Breeding Department; Dr S. Man, Chief of the Seed Potato Production Laboratory, Institute of Potato Research and Production, Basow, Rumania, who visited the Breeding and Pathology Departments; Dr K. M. Swiezynski, Potato Research Institute, Młochów, Poland, who visited the Commonwealth Potato Collection; Dr L. J. Turkensteen, Research Institute for Plant Protection, Wageningen, who visited the Pathology Department; Dr P. E. Thomas, USDA Irrigated Agriculture Research and Extension Centre, Prosser, Washington, who discussed potato virus work with the Pathology Department; Dr A. Rizvi, from the International Potato Centre, Peru who visited the Breeding Department; Mr J. D. Currie of the Ministry of Agriculture and Fisheries, New Zealand, who discussed potato cyst nematode policy with the pathologists; Dr D. H. Lapwood from Rothamsted, who visited the pathologists to discuss problems involving potato softrot. In addition, the work of the Potato Division was demonstrated to a number of interested groups who visited Pentlandfield or the Murrays.

Visitors to the Chemistry Division included Dr C. J. Badenhorst, from the

Crop Breeding Institute, Causeway, Zimbabwe; Dr B. Axell and Mr J. Murray from the South African Breweries Ltd., Isando, Transvaal, who were shown the small scale tests used in malting evaluation. Professor J. R. Todd, Department of Agriculture, Belfast; Mr A. Davies, FRI, Norwich, and Dr I. Murray, NSCA, Aberdeen, visited the Chemistry Department at various times to discuss recent developments in NIR.

The Forage Division entertained a number of visitors including Dr J. Jakubiec from the Agricultural University of Warsaw, Poland; Professor D. R. Knott, University of Saskatchewan, Canada; Dr D. Bond, PBI, Dr D. Mason, Dr P. Gymer and Mr N. Chamberlain, from Nickersons (RPB) Ltd., Dr S. R. Sanderson and Dr R. Gaunt from DSIR/CRD New Zealand and Mr A. Pattullo, Convenor of the SSRPB Cereal Research Committee, who all visited the Cereal Department. Dr Hanne Ostergard, from the Danish Atomic Energy Authority, visited the Cereal Department, and Dr H. D. Patterson, and several members of staff from the ARC Unit of Statistics, Edinburgh University, discussed the analysis of breeding trials with the cereal breeders. Professor R. A. Nilan, Washington State University, Pullman, Washington, visited R. N. H. Whitehouse and the Cereal Department, to discuss the organisation of the forthcoming IV IBGS to be held in Edinburgh. The Brassica Department was visited by Professor M. A. Schweppenhauser, University of Salisbury, Zimbabwe, who was shown the breeding programme, and Dr P. Rouselle, Station D'Amelioration des Plantes, Le Rheu, France, who discussed rape breeding and embryo culture. Dr J. Bowman, Nickersons (RPB) Ltd., Mr M. Joordens, Zaadhandel BV, Venlow Bleric, Holland, Mr S. Linington, Charles Sharp Ltd., Sleaford, Mr K. Day and Mr S. Christopher, Sinclair McGill Ltd., Ayr, Mr R. Osborne, Asmer Seeds Ltd., Lancashire, and Dr J. Heriott, ESCA, visited SPBS at various periods to discuss aspects of the breeding work. Dr R. P. Patchett, Dalgety Agronomy Centre, Timaru, New Zealand visited SPBS to discuss joint work involving the multiplication of SPBS breeding lines in New Zealand.

Visits abroad

M. S. Phillips attended the XV International Nematology Symposium in Bari, Italy, where he read a paper on "New Techniques for Screening Potato Clones for Resistance to *Globodera pallida*". He also presented a paper written by J. M. S. Forrest and Mrs L. A. Farrer entitled "The Effect of Brief Exposures to Potato Root Diffusate on the Hatching of *Globodera pallida*".

G. R. Mackay, R. L. Wastie and Miss I. Majewicz visited Dublin, Eire, for a joint AAB/FBPP/SIPP meeting. G. R. Mackay gave a paper on "Breeding for Potato Cyst Nematode Resistance", and Miss I. Majewicz read a paper, "The use of New Serological Techniques for the Detection of Certain Potato Viruses", written with Miss J. C. M. Rose of the Botany Department, University of Glasgow.

In July, Miss R. Solomon attended an EAPR meeting at Rennes, France, where she read a paper, with Miss I. B. Majewicz on the "Introduction of the New Serological Techniques for use in a Potato Breeding Programme". Miss Solomon then visited potato breeding programmes at research institutes in Brittany.

The European Association for Potato Research held two meetings in Wageningen, The Netherlands; J. H. W. Holden attended the business meeting, and R. L. Wastie the Pathology Section meeting. Later in the year, W. T. B. Thomas also visited Wageningen to attend an IAMFE Conference on "The Mechanisation of Field Experiments".

M. F. B. Dale joined an FAO expedition to Greece where samples of *Beta nana* were collected as part of a Genetic Conservation Programme.

G. R. Mackay visited Valencia, Spain, and La Pueblo, Majorca, to inspect SPBS potato trials and to discuss collaboration with L. Matutano, S.A.

In January R. J. Giles left for Gore, New Zealand, where he will spend three months selecting and harvesting SPBS barley breeding material.

Conferences, Visits and Lectures within the UK

The European Association for Potato Research (Section Breeding and Varietal Assessment) and Eucarpia (Section Potatoes) held a joint meeting in Edinburgh from the 24th to the 26th June, 1980. J. H. W. Holden, as Chairman of the EAPR Section, organised the meeting with the help of colleagues in the Potato Division. The following papers were presented by members of staff: "Uniformity Trials and the Determination of Optimum Plot Size and Shape", by R. J. Killick; "Preliminary Data on Disease Resistance of Tetraploid Hybrids from Tetraploid × Resistant Dihaploids". by M. J. De Maine; "Problems in Breeding for Tuber Quality", by J. H. W Holden. One afternoon was spent at SPBS where participants were able to view the work of the Potato Division. The conference dinner was given by the Potato Marketing Board and co-ordinated by Mr J. McFarlane of the SSRPB Board of Directors.

In September, a party of four from the Brassica Department visited NVRS, Wellesbourne, for the second ARC Brassica Breeders meeting, where they contributed to discussions on different aspects of brassica breeding and tissue culture.

The sixth meeting of ARS Cereal Breeders, was held at the WPBS, Aberystwyth, on the 1st-3rd July 1980. Six members of staff from the Cereal and Chemistry Departments attended.

J. H. W. Holden and R. J. Killick attended the Potato Breeders meeting held at NIAB on the 14th July 1980.

In April, Miss J. F. Malcolmson visited the Glasshouse Crops Research Institute, Littlehampton, for the Sixth ARS Conference on Electron Microscopy.

I. A. Cowe presented a paper entitled "The use of NIR in the Rapid

Assessment of Malting Barley", at a symposium on Near Infra Red Reflectance Spectroscopy, held at the Flour Milling and Baking Research Association, Chorleywood.

A party of three brassica breeders attended a meeting of ARS and commercial brassica breeders held at the NIAB trial site at Headley Hall, Yorkshire, where I. H. McNaughton led the discussion assisted by J. E. Bradshaw, with a talk on the problems of SMCO in brassica forage crops.

In August J. M. S. Forrest attended a meeting of the Potato Nematode Working Party, held at ADAS, Leeds.

Miss G. Cruickshank attended a meeting of ARC Photographers held at WPBS.

Mrs B. E. Asher attended a meeting for Scottish Agricultural Librarians held at WSAC on the 24th April 1980.

Several members of staff gave lectures to outside bodies during the year. These included: I. H. McNaughton on "Classification of Races in *Plasmodiophora brassicae*", and Miss I. B. Majewicz on "Using ELISA to detect virus Y and leafroll in Potatoes", to the Edinburgh Plant Pathology and Mycology Club; J. H. W. Holden, "The Contribution of Potato Breeding to improved Potato Production", given to the South Staffordshire Farmers Club; M. F. B. Dale "Evolutionary Directions in Wild, Primitive, and Cultivated Sugar Beets", given to the Liverpool Polytechnic Biological Society.

Two FBPP meetings, held in December, were attended by members of staff from SPBS. I. H. McNaughton attended the session "Methods in Plant Pathology", held at Leeds University, and M. J. C. Asher and J. M. S. Forrest the session "Plant Disease Etiology", held at The London School of Economics.

A variety of visits to other ARC Institutes, trial sites and research bodies were made by various members of staff during the year to discuss joint trials and other collaborative work.

Miss C. J. Williamson, R. P. Ellis and G. R. Mackay gave lectures on aspects of plant breeding to students at the ESCA, Kings Buildings, Edinburgh. R. J. Giles also lectured on "Cereal Multiplication and Stocks Work", to M.Sc. students at the same location.

Membership of Committees

R. N. H. Whitehouse continued as a member of the International Organising Committee and as Chairman of the Executive Committee of The Fourth International Barley Genetics Symposium 1981. Several other members of staff served on the Executive Committee. Mr Whitehouse continued, with I. H. McNaughton, on the Editorial Staff of *Eucarpia, Cruciferae Newsletter.*

J. H. W. Holden continued as Chairman of the Breeding and Varietal Assessment Section of the European Association for Potato Research. Dr

Holden also acted as external examiner for an M.Sc. course in plant breeding at the University College of Wales, Aberystwyth.

Miss J. F. Malcolmson continued to serve on the Scottish Joint Committee for National Certificates and Diplomas in Biology and on Sub-Committee E (infraspecific) of the International Mycological Association.

A. M. Hayter served on the BAPB Cereals Group Committee and F. J. W. England continued as Co-ordinator of the BAPB Spring Barley Trials.

M. J. C. Asher continued to serve on the Committee of the Federation of British Plant Pathologists, and acted as assistant Editor of the *FBPP News*.

Two members of staff served on AAB Committees during the year. R. J. Killick served as a member of the Plant Breeding Group, J. M. S. Forrest as a member of the Nematology Group. Dr Forrest also served as a member of the ADAS Potato Nematode Working Party.

J. W. McNicol served on the ERCC Research Councils Users' Committee.

Courses attended

Several members of staff attended ARC/SRC Management Training courses. ERCC courses on Fortran and Pascal programming, and on the use of microcomputers, were well attended, as were courses on laboratory and industrial safety. Occasional courses in various aspects of plant breeding and related sciences, were attended throughout the year. Day release classes leading to City and Guilds, O.N.C., H.N.C., and Institute of Biology qualifications continued.

Visiting research workers and students

Dr M. M. Uddin, a Principal Scientific Officer from the Jute Research Institute, Dacca, Bangladesh, visited SPBS for two months. During his stay he spent a week with each department and before leaving gave a seminar entitled "Jute Breeding in Bangladesh".

Dr Yusuf Kirtok, from the Faculty of Agriculture, University of Cukurova, Adana, Turkey, visited the Cereal Department for three months to study cereal breeding methods and to complete a research project on barley single seed descent using nutrient film techniques.

Mr D. McCalmont of the Lanchester Polytechnic spent nine months in the Potato Pathology Department working on potato tuber diseases, as part of a sandwich course.

Mr Herman Tah, a sandwich student from Sheffield City Polytechnic, spent six months in the Data Preparation and Statistics Unit writing programs for the Apple computers. In January he was replaced by Mr S. Ng, from the same organisation, who continued the development of Apple programs.

Mr C. Tapsell, a CASE award student from the Department of Genetics, University of Birmingham, continued his work on cross prediction in barley in the Cereals Department. Mr D. Stevenson, a CASE award student from

the Botany Department, University of Edinburgh, and Miss F. Bloch, a sandwich student from Napier College of Commerce and Technology, both spent several months with the Cereal Department, the former working on the control of tillering in barley, the latter on the physiology of barley development.

Dr M. Wás, from the Institute for Potato Research, Młochów, Poland, spent three months with the Potato Pathology Department working on aspects of Potato Virology.

Mr A. Rennie arrived in January to spend six months with the Chemistry Department as part of a Department of Employment Job Experience Scheme.

Miss M. Allen worked for six months in the Brassica Department on powdery mildew on swedes and rape, as part of a sandwich course from the Paisley College of Technology.

The SPBS also offered facilities to students studying for further degrees or to visiting workers: Miss A. Cunningham, a CASE award student from the Botany Department, University of Edinburgh, studied interspecies crosses between *Brassica* and *Raphanus* in the Unit for Strategic Brassica Breeding, as part of a Ph.D. course; R. C. McDonald, from the Invermay Agricultural Research Centre, Mosgiel, New Zealand, studied factors affecting SMCO in kale as part of a Ph.D. course; A. Ould Ramoul, from Algeria, studying at the University of Edinburgh, spent some time in the Potato Breeding and Pathology Departments; R. Bain, from the East of Scotland College of Agriculture, worked on potato storage diseases with the Potato Pathology Department; W. Fielding from the Department of Statistics, Edinburgh University, studied design of potato trials with the Commercial Breeding Department, as part of a Ph.D. course; Miss J. C. M. Rose, a CASE award student from the Botany Department, University of Glasgow, continued work on resistance to blight in tubers and foliage and potato cyst nematode resistance in the Potato Pathology Department.

Subsequent Appointments and Promotions

P. D. S. Caligari was appointed as a Senior Scientific Officer in the Potato Division as from 1st February 1981 and R. Kidger as a Scientific Officer in the Data Preparation/Statistics Unit as from 6th April 1981. Miss J. E. Middlefell and Mrs J. Spence were promoted to Scientific Officer, R. Borzucki to Higher Scientific Officer and Miss C. J. Williamson, I. A. Cowe and J. W. McNicol to Senior Scientific Officer all with effect from 1st April 1981.

J. W. Gregor, C.B.E., Ph.D., D.Sc., F.R.S.E.

Dr J. W. Gregor died on the 30th September 1980. Dr Gregor was a member of the staff of the Scottish Plant Breeding Station for forty-one years and its Director for the period 1950–1965.

James Wylie Gregor was born on the 14th January 1900, the son of an Edinburgh physician turned farmer, at Innerwick, near Dunbar. He was educated in Melrose and at Edinburgh Academy. He joined the Royal Flying Corps towards the end of the 1914–18 war and was demobilised in 1919.

He was awarded a Diploma from the Edinburgh and East of Scotland College of Agriculture (there was, at that time, no degree course in agriculture at Edinburgh) before joining the staff of the Scottish Plant Breeding Station in 1924. He became Chief Assistant a year later.

Soon after this appointment he began a series of studies, which were to occupy most of his working life, on the genetics of plant populations in relation to their environment. He produced a classic series of papers on the genecology of *Plantago maritima* L. and this work, together with that of his contemporaries, Turesson, Clausen, Sinskaia and Stapledon, established genecology on a firm scientific base and exerted a profound influence on the methods of plant breeders and the effectiveness of their work. His scientific contributions led to the award of a D.Sc. in 1939. He was elected a Fellow of the Royal Society of Edinburgh in 1959 and was awarded the C.B.E. in 1961.

Dr Gregor became Director of the Station in 1950. The early years of his Directorship were much occupied with arrangements for the transference of the Station's work from Craigs House, Corstorphine, to the new site at Seafield (now Pentlandfield) on the estate of the Edinburgh Centre of Rural Economy. Dr Gregor retired in 1965 but for many years thereafter he continued to take an interest in the affairs of the Station.

Dr Gregor was a shrewd man with a very warm and kindly nature. He was on close and friendly terms with everyone who served with him. He had a great interest in good food and good wine and a generous delight in sharing them with others. He will be remembered with great affection by all who knew him.

Patricia J. Watson, M.A., Ph.D.

Dr Patricia J. Watson died on the 4th January 1981. She was brought up in Glasgow, where she attended the Glasgow Girls' High School and Glasgow University. She graduated in 1933 with an M.A. in Classics, but went on to take the College Diploma in Horticulture in 1943 at the West of Scotland Agricultural College where she was the best student of her year.

In 1947 Miss Watson was appointed as a temporary assistant in the Forage Department of the Scottish Plant Breeding Station which was then located at Corstorphine. She gained a Ph.D. in Genetics from Glasgow University in 1949; she was in charge of the Herbage Plant Section (which later became the Grass Breeding Section) from 1953 until her retirement in September 1971. Her work, with Dr J. W. Gregor, on complementary grazing and the genecology of hill grasses foreshadowed much of the recent work on upland pastures.

A world cruise in 1972 and, on return to Edinburgh, a heavy commitment to voluntary work seemed to be the prelude to a very busy retirement. Sadly, this was not to be as Pat suffered a heart attack soon afterwards which limited her subsequent activities. However, she was still able to indulge her life long love of gardening and her continuing interest in the arts.

As Training Officer she helped many of the more junior members of staff with advice and encouragement early in their careers. She contributed to the social life of the Station by running the lunch-time coffee club. Pat Watson will be remembered as a lively and always interesting person, a respected colleague with whom it was a real pleasure to work, and a good friend.

COLLABORATORS

This list of collaborators in the work of the Station includes farmers, landowners, colleges and official organisations who have provided field facilities, and workers in universities and official and industrial laboratories who have provided valuable scientific help. We hope that the list is complete, and to all collaborators, named or (perchance) unnamed, we offer our thanks.

(a) Agricultural Research Council Institutes

There has been direct collaboration during the year with the ARC and State-aided Institutes marked with asterisks in the list on pp 123–24.

(b) Other Official Bodies

Agricultural Development and Advisory Service at Bangor, Cambridge, Wolverhampton, Leeds, Newcastle and March, Cambs.; and at Gleadthorpe, Terrington and Arthur Rickwood Experimental Husbandry Farms.

Department of Agriculture and Fisheries for Scotland, Agricultural Scientific Services, Edinburgh.

Department of Scientific and Industrial Research, Crop Research Division, New Zealand.

Edinburgh Centre of Rural Economy.

Forestry Commission, Northern Research Branch, Edinburgh.

MRC Clinical and Population Cytogenetics Unit, Western General Hospital, Edinburgh.

National Institute of Agricultural Botany, Cambridge, Cockle Park and Headley Hall.

National Seed Development Organisation, Cambridge.

Potato Marketing Board, London.

Royal Botanic Garden, Edinburgh.

Swedish Seed Association, Svalöf.

(c) Universities and Colleges

Agricultural Research Council Unit of Statistics, Edinburgh University.

Birmingham University, Department of Genetics.

East of Scotland College of Agriculture, Edinburgh.

Edinburgh Regional Computing Centre.

Edinburgh University, School of Agriculture, Department of Botany.

Heriot-Watt University, Department of Brewing and Chemistry.
Imperial College of Science and Technology, London, Department of Zoology and Applied Entomology.
Newcastle upon Tyne University, School of Agriculture.
North of Scotland College of Agriculture, Aberdeen.
University College of Wales, Aberystwyth.
West of Scotland Agricultural College, Ayr.

(d) Industrial Collaborators

American Calan Inc., Route 4, Northwood, New Hampshire, USA.
Brewing Research Foundation, Redhill, Surrey.
Dalgety Agricultural Research, Timaru, New Zealand.
East Coast Viners Grain, Ltd., Drumlithie, Stonehaven, Aberdeenshire.
J. E. England and Sons (Wellington) Ltd., Perthshire.
Fisons Ltd., Levington Research Station, Ipswich, Suffolk.
Flour Milling and Baking Research Station, Chorleywood, Herts.
Fridlington Farms Ltd., Plantation Farms, Sheriff Hutton, Yorks.
Golden Wonder Ltd., Broxburn, W. Lothian.
H. J. Heinz Co. Ltd., Hayes Park, Hayes, Middlesex.
Maxwell Davidson Ltd., 31 Moray Place, Edinburgh.
Miln Marsters Group, Chester.
Moray Firth Maltings, Inverness.
Nickerson RPB Ltd., Lincs.
Pauls and Sanders Ltd., Key Street, Ipswich, Suffolk.
Potato Processors Association, Food Manufacturers Federation, London.
Saphir Foods Ltd., Lime Walk, Long Sutton, Lincs.
Scottish Agricultural Industries Ltd., Edinburgh.
Sinclair McGill (Scotland) Ltd., Ayr.
A. H. Worth Co. Ltd., Manor Farm, Holbeach Hurn, Nr. Spalding, Lincs.

(e) Individuals

W. Aitken, Carlophills Farm, Peeblesshire.
J. Black, Drochil Castle, Peeblesshire.
J. Craigs, Tritlington Hall, Tritlington, Northumberland.
Professor S. Desborough, University of Minnesota, USA.
V. Evans, Bubbleton, Penally, Dyfed.
G. Finlay, Shanwell Farm, Tayport, Fife.
J. Barclay Forrest, Whitemire, Duns, Berwickshire.
G. Gammie, Westerton of Pitarrow, Laurencekirk.
A. Gordon, Balmuchy, Fearn, Ross and Cromarty.

J. S. Graham, Queenstonbank, East Lothian.
E. Jones, Lunnon Farm, Lunnon, Swansea.
R. E. T. Kay, Ayton Castle Estates, Ayton, Berwickshire.
D. Killen, Kittles Home Farm, Penrice, Glamorgan.
Dr Y. Kirtok, Faculty of Agriculture, University of Cukurova, Adana, Turkey.
J. F. MacBrayne, West Byres, Ormiston, E. Lothian.
W. McCrone, Cairnside, Kirkcolm, Stranraer, Wigtown.
J. MacFarlane, Flichity Farm, Farr, Inverness.
I. K. MacKenzie, Inverarnie, Farr, Inverness.
Dr P. Mattusch, Institut fur Pflanzenschutz in Gemusebau, Marktweg 60, 5030 Hurth-Fischenich, Fed. Rep. Germany.
Professor G. Milbourn, ESCA.
R. Miller, Tullochgorum, Inverness-shire.
A. G. Porter, East Scryne, Carnoustie, Angus.
W. H. Porter, West Scryne, Carnoustie, Angus.
J. Riddell, West Peaston Farm, Ormiston, E. Lothian.
T. Rowe and Sons, Over Ardoch, Braco, Perthshire.
Dr G. Russell, ESCA.
C. D. Scott, Waterside, Newburgh, Aberdeen.
G. A. Storrar, Rossie, Auchtermuchty, Fife.
B. Thomas, Carswell Farm, Penally, Dyfed.
W. R. E. Thomson, 33 St Mary's Street, Edinburgh.
R. Trotter, Ormiston Mains, Ormiston, E. Lothian.
A. B. Turnbull, Home Farm, Penrice, Glamorgan.

LIST OF ABBREVIATIONS

Organisations:

AAB	Association of Applied Biologists.
ADAS	Agricultural Development and Advisory Service.
ARC	Agricultural Research Council.
ARCUS	Agricultural Research Council, Unit of Statistics.
ARS	Agricultural Research Service.
BAPB	British Association of Plant Breeders.
CIP	International Potato Centre, Lima, Peru.
DAFS	Department of Agriculture and Fisheries for Scotland.
DANI	Department of Agriculture for Northern Ireland.
DSIR	Department of Scientific and Industrial Research (New Zealand).
EAPR	European Association for Potato Research.
EHF	Experimental Husbandry Farm.
EMRS	East Malling Research Station.
ERCC	Edinburgh Regional Computing Centre.
ESA	Edinburgh School of Agriculture.
ESCA	East of Scotland College of Agriculture.
FAO	Food and Agricultural Organisation (of the United Nations).
FBPP	Federation of British Plant Pathologists.
FMBRA	Flour Milling and Baking Research Association.
FRI	Food Research Institute.
GCRI	Glasshouse Crops Research Institute.
GRI	Grassland Research Institute.
HFRO	Hill Farming Research Organisation.
HRI	Hannah Research Institute.
IAMFE	International Association for the Mechanisation of Field Experiments.
IBGS	International Barley Genetics Symposium.
IBPGR	International Board for Plant Genetic Resources.
IPO	Institute for Plant Protection Research (The Netherlands).
JCO	Joint Consultative Organisation.
MRC	Medical Research Council.
NIAB	National Institute of Agricultural Botany.
NIAE	National Institute of Agricultural Engineering.
NFU	National Farmers' Union.
NSCA	North of Scotland College of Agriculture.
NSDO	National Seed Development Organisation.
NVRS	National Vegetable Research Station.
ODA	Overseas Development Agency.
PBI	Plant Breeding Institute (Cambridge).
PMB	Potato Marketing Board.
PPA	Potato Processors Association.
RES	Rothamsted Experimental Station.
RRI	Rowett Research Institute.

SARI	Scottish Agricultural Research Institutes.
SCRI	Scottish Crop Research Institute.
SHRI	Scottish Horticultural Research Institute.
SIAE	Scottish Institute of Agricultural Engineering.
SIPP	Society of Irish Plant Pathologists.
SPBS	Scottish Plant Breeding Station.
SRC	Science Research Council.
SSRPB	Scottish Society for Research in Plant Breeding.
UCW	University College of Wales.
USDA	United States Department of Agriculture.
WPBS	Welsh Plant Breeding Station (Aberystwyth).
WSAC	West of Scotland Agricultural College.

Others:

CASE	Co-operative Awards in Science and Engineering.
CNS^-	Thiocyanate.
CVT	Co-ordinated Variety Trials (also a computer program for their design and analysis).
DM %	Dry Matter Percentage.
DMY	Dry Matter Yield.
DOMD	Digestible Organic Matter in the Dry Weight.
DUS	Distinctness, Uniformity and Stability.
ECD	European Club-root Differential.
ELISA	Enzyme-linked Immunosorbent Assay.
EMAS	Edinburgh Multiple Access (Computer) System.
EMS	Ethyl Methane Sulphonate.
Hb	Haemoglobin.
JET	Joint European Trials.
JMT	Joint Main Trials.
NIR	Near Infra Red.
NLT	National List Trials.
PAR	Photosynthetically Active Radiation.
PCN	Potato Cyst Nematode.
PCV	Packed Cell Volume.
PLRV	Potato Leafroll Virus.
PMR	Partial Mildew Resistance.
PMTV	Potato Mop-top Virus.
PSTV	Potato Spindle Tuber Virus.
PVA	Potato Virus A.
PVX	Potato Virus X.
PVY	Potato Virus Y.
SAN	Semi-artificial Napus.
SEM	Scanning Electron Microscope.
SMCO	S-Methyl Cysteine Sulphoxide.
SSEM	Serum-specific Electron Microscopy.
TRV	Tobacco Rattle Virus.
UV	Ultra-violet.
VDU	Visual Display Unit.

INDEX OF DEPARTMENTAL REPORTS

AGRONOMY DIVISION

The Agronomy Division provides farm and greenhouse services for the station both at Pentlandfield and the Murrays. Nearly all field trial work is carried out at the Murrays where approximately 40 hectares (out of a total of 133) are in experimental use in any one year. In addition the Division includes the Field Trials Unit and the Statistics and Computing Unit.

The Field Trials Unit carries out, on a "contract" basis, trials of Breeders' advanced material of cereals and brassicas and also conducts "invitation" trials for sister institutes and other bodies. It is particularly well equipped for carrying out off-site trials since it has its own transport and small plot machinery.

The detailed reports of the Murrays Farm Unit and the Field Trials Unit appear below, that of the Statistics and Computing Service appears with those of other service units on page 114.

F. J. W. England

Field Trials Unit

Trials of advanced breeders' material from the cereal and brassica programmes continued following the pattern of previous years. Trials were grown at the Murrays and at four regional centres for each crop group. In addition to the material grown for SPBS colleagues there was an increased amount for sister ARS institutes and other bodies. In all 35 cereal and fifteen brassica trials were grown.

Cereal sowing took place in early April, a little later than usual and the plots were combined in the first half of September. Winter cereal trials for harvest in 1981 were drilled in early October and Fonofos granules were incorporated in the seed-bed following the severe wheat bulb infestation of the previous season.

Rapid and efficient harvesting of forage brassicas has always presented difficulties, by contrast with the relative ease of combining cereal trials. These difficulties have been largely overcome with the purchase this year of a Hege 211B self-propelled forage harvester. This machine cuts the green material which is then transferred by pick-up reel onto an elevator canvas and thence into a rear mounted weighing box. Plot yields can be read off directly by the driver who then dumps the material from the box. The machine has harvested all our rape trials most successfully and is capable of cutting about

45 plots, each of three drills of ten metres length, in an hour. It has also proved capable, rather to our surprise, of harvesting cabbage trials.

I. M. Chapman
A. Young

Murrays Farm Unit

The year started with a fairly mild, wet winter followed by a very dry spring. June and August were very wet as were October, November and December. Because of the dry spring, emergence and early growth were slow; in spite of this crops yielded well. Harvesting of cereals and potatoes went ahead with not much interruption despite the wet autumn. The 18·0 hectares of winter wheat *cv.* Mardler, sown in Potato Shed and Longriggs fields, overwintered well. The crop was top dressed with 500 kg ha^{-1} grain fertiliser (22-11-11) at the beginning of April. The seed had been treated against wheat bulb fly and no damage was seen. A further 9·0 hectares of Mardler was sown in Cottage and Reserve C fields at the beginning of March. Grain fertiliser (22-11-11) at the rate of 375 kg ha^{-1} was applied in the seed bed. The wheat was harvested at the end of September. The yield for the autumn sown crop was 7·47 t ha^{-1}, the March sown crop yielded 4·83 t ha^{-1}.

The winter barley *cv.* Sonja in Hollow field overwintered well. It was top-dressed at the beginning of April with 375 kg ha^{-1} grain fertiliser (22-11-11). The crop was harvested in mid August and only yielded 3·38 t ha^{-1}.

There was a total of 36 hectares spring barley *cv.* Golden Promise sown in Loan, Crow and Wee Murrays at the beginning of April. The seed was treated with a mildewicide. In spite of a slow start, due to the dry weather, growth was good and little disease was seen. Harvesting started on 3rd September and was completed on 30th September. The yield for Loan was 4·76 t ha^{-1}, for Crow 5·53 t ha^{-1} and Wee Murrays 5·77 t ha^{-1}. The quality of the grain was poor with low bushel weight. The straw in Crow and Loan was chopped and ploughed in but that in Wee Murrays was baled and carted off before ploughing.

Another six hectares of Golden Promise was sown in spare ground in Wall and Folly fields. This was harvested on 24th and 25th September, yielded 4·93 t ha^{-1} and was of malting quality.

About one hectare of spring oats *cv.* Fyne were sown in Loan field on 5th March. 375 kg ha^{-1} grain fertiliser (22-11-11) was broadcast in the seed bed. The crop grew very well and, though tall, there was little lodging. The oats were harvested on 8th October, when some grain had shed, and yielded 3·75 t ha^{-1}.

The area used for cereal trials, selection plots, multiplication and surrounds

amounted to another 19·0 hectares under cereals.

Potato trials were grown in Folly field and occupied about 8·5 hectares, the remainder of the field being sown with barley. Potato fertiliser (15-15-21) was broadcast at the rate of 1255 kg ha^{-1} before the final cultivations. An early potato trial was planted at the beginning of April and the main planting was done between 24th April and 11th May. Thiofanox (Dacamox) aphicide granules were applied in the drills before covering. The crop was sprayed with Metribuzin (Sencorex) a week after planting. Emergence was slow and irregular due to the drought conditions but the rain in June saved the crop and growth thereafter was good. There was little aphid activity and apart from precautionary sprays of demephion and pirimicarb in alternate weeks in August, no other spraying was done. A fungicide spray was incorporated with these sprays to control blight.

The early potato trial was harvested at the beginning of August and the main harvest started on 6th October and finished on 4th November. Yields were good.

Early in the year 190 kg ha^{-1} muriate of potash (50%) and 5000 kg ha^{-1} ground magnesian limestone were applied on Wall field. About 8·0 hectares were used for brassica trials and selection plots, the spare ground was sown with barley.

For the swedes and turnips 815 kg ha^{-1} potato fertiliser (15-15-21) was applied to the seed bed before the final cultivations, for kale, rape and cabbage 815 kg ha^{-1} grain fertiliser (22-11-11) was applied. Trifluralin (Treflan) was used as a herbicide in the seed bed. Sowing started at the beginning of May and continued at intervals until August. The crop was sprayed with chlorpyrifos (Dursban 48E) three times, immediately after sowing, at emergence and three weeks after emergence, to control cabbage root fly. The drought resulted in erratic germination, but, in general, growth was good particularly in the later sown material. Harvesting started at the beginning of November.

The grass in Sunnyside and Reserve B was top dressed with grain fertiliser (22-11-11) at the rate of 375 kg ha^{-1} at the beginning of April. The crop was cut for hay at the end of June and was sold to the East of Scotland College of Agriculture. The yield was poor, 3·11 t ha^{-1} in Sunnyside and 1·30 t ha^{-1} in Reserve B. The aftermath was top dressed with 140 kg ha^{-1} Nitram and grazed by lambs from ESCA until the middle of September.

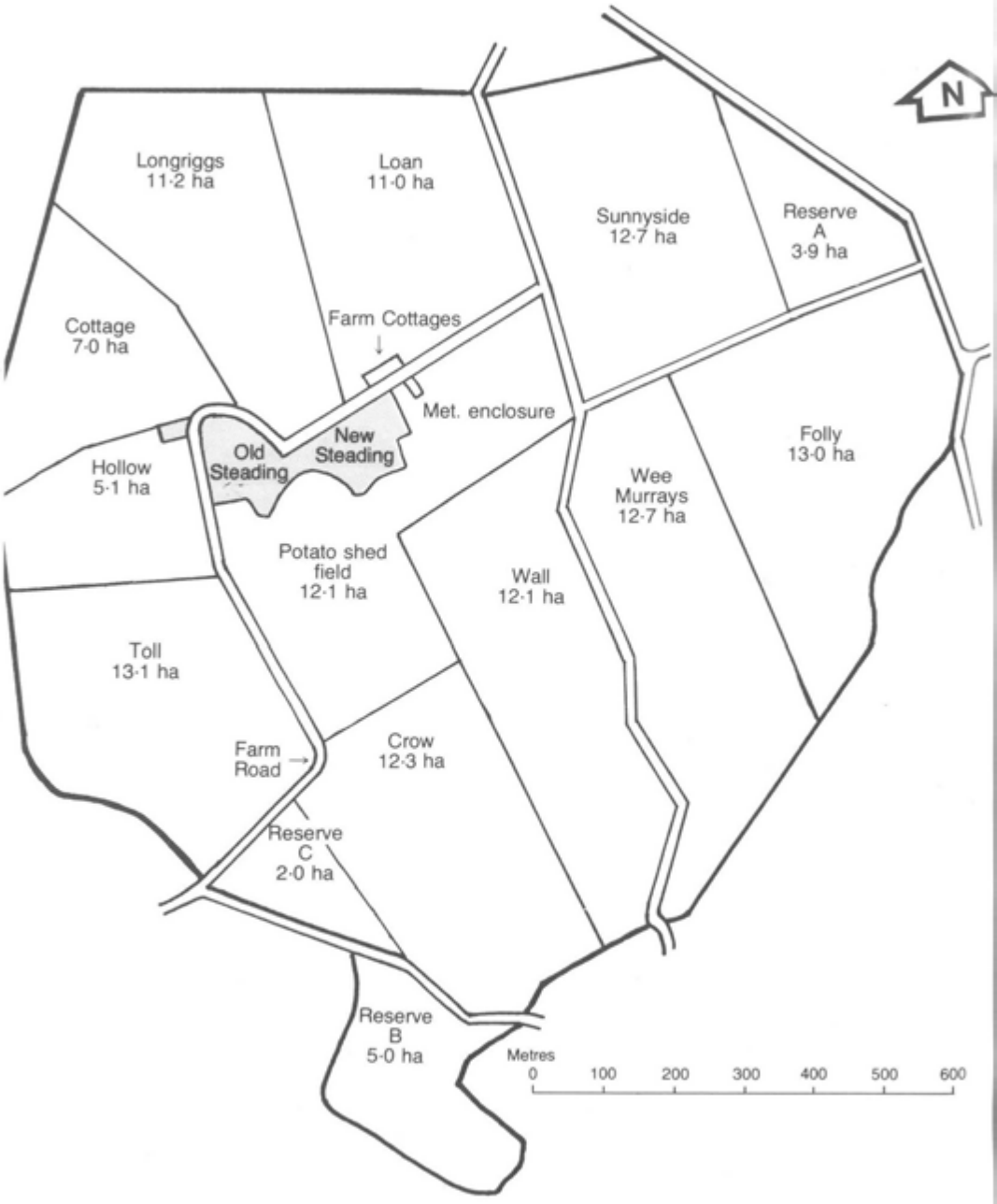
The grass in Sunnyside was sprayed with glyphosate (Round-up) in mid October and ploughed at the end of November in preparation for cereal trials in 1981.

About two hectares in Reserve A were ploughed in late August and 125 kg ha^{-1} muriate of potash (50%) and 125 kg ha^{-1} grain fertiliser (22-11-11) were applied before the sowing of winter wheat and winter barley trials in mid October. Fonofos granules were applied prior to sowing and chlorpyrifos sprayed after sowing as a precaution against wheat bulb fly attack. The crop has grown well apart from occasional signs of slug damage.

Twenty five hectares of winter wheat *cv.* Mardler were drilled in Hollow, Toll and Cottage fields. The wheat sown in Hollow field in mid October is growing well; the remaining area was sown early in December and brairding is slow. Potato fertiliser (15-15-19) at the rate of 250 kg ha^{-1} was broadcast on the seed bed.

G. R. White

Map of the Murrays showing field areas



Meteorological Summary. The Murrays 1980

Table 1

Month	Mean air temperature °C Max.	Min.	Mean soil temperature °C 5 cm.	10 cm.	Number of days air temperature ≤ 0°C Air	Grass	Total rainfall mm.	Number of wet days > 1·0 mm.
January	3·6	−0·4	0·7	1·0	13	22	40·4	11
February	6·3	2·0	2·9	3·0	6	9	26·9	9
March	5·7	1·0	2·3	2·6	12	18	72·0	12
April	11·9	3·8	7·9	6·9	1	8	6·9	2
May	14·9	4·4	12·1	10·5	1	13	13·9	5
June	16·2	8·7	14·5	13·3	0	0	95·8	11
July	16·8	9·4	14·6	13·7	0	0	51·8	10
August	17·7	10·1	14·6	13·8	0	0	102·9	12
September	16·1	9·7	12·2	11·9	0	0	31·2	9
October	10·5	4·3	6·7	6·8	3	8	83·6	11
November	8·0	2·9	4·4	6·1	9	11	73·6	18
December	7·6	2·4	3·3	3·6	9	14	59·8	15
Annual total (366 days)	—	—	—	—	54	103	658·8	125
Annual mean (366 days)	11·3	4·8	8·0	7·7	—	—	—	—

CHEMISTRY DIVISION

Over the past few years the Chemistry Division analytical services have changed steadily from mainly "wet chemistry" manual methods to an increasing number of physical, usually automated, tests which offer several advantages over more traditional methods. In near infra red analysis (NIR), for example, sample preparation and analysis time is relatively fast (a few minutes per sample). Furthermore, several constituents in one sample can be predicted simultaneously by NIR so an infra red analyser can be used as a multiple screening tool enabling breeders to increase sample through-put considerably.

In 1980 the infra red system was upgraded further by exchanging the Technicon 2·5 InfraAlyzer for a rental hire of a Technicon 300 InfraAlyzer. One of the main advantages of the Technicon 300 over the 2·5 is that the filter wheel is readily interchangeable. This means that the scanning infra red analyser, the Neotec 6350, can remain as a research tool, and when important wavelengths are identified by the Neotec 6350, these can be transferred, when appropriate filters have been made, to the Technicon 300 which will employ the filters in the relevant analysis.

Some promising progress was made during the year when NIR was used to predict the haemolytic factor, S-methyl cysteine sulphoxide (SMCO), in Maris Kestrel kale. This may allow SMCO to be routinely predicted on the Technicon 300 in the near future. Manual estimations will, however, continue in parallel with NIR predictions for a further year for further calibrations and checking predicted estimates. Preliminary experiments in which NIR has been used to predict counts of mildew spores washed from barley leaves have also shown considerable promise.

Our "Comparamill" unit for the estimation of milling energy of barley (*Ann. Rep. 1979-80*, 32) was completed last year, and after some initial difficulties, passed a rigorous testing period. Later in the year the Comparamill was included in our rapid screening tests for malting quality and a high sample throughput was achieved (sample loading, mill cleaning and the calculation of results are all automated).

Development work in our autoanalyser laboratory included the successful building of a manifold for the estimation of vitamin C content of potatoes, and a manifold for the estimation of glucose in barley extracts. Progress was also made in measurements of potato glycoalkaloids using the FRI dye binding test, with values for Pentland Crown falling within the expected range. It only remains to develop a check system involving gas chromatography before alkaloid measurements will become a routine service.

An Apple microcomputer and an electronic balance were acquired as part of the new station data processing scheme developed by the Computing and

Statistics Unit. Our data processing should henceforth be more versatile as the Apple can be used as both a logging system and a computer.

These above developments were in addition to an increased work-load as a result of S-methyl cysteine sulphoxide and thiocyanate ion (a goitrogen) estimations on brassica breeding material becoming part of the routine workload. Work on potato glycoalkaloids also carried on throughout the year.

It is hoped, however, that some further marrying of infra red and routine analysis plus current improvements in data processing will streamline the work of the Chemistry Division.

M. J. Allison

Chemistry Department

The work of the Chemistry Department is mainly concerned with the routine analysis of quality factors important in plant breeding. In 1980 the 2·5 InfraAlyzer was exchanged for a Technicon 300 infra red analyser for the following reasons: there are nine filters in the 300 compared to six in the 2·5; a doubling in the speed of measurement (in the 300 the reference disc and the sample are scanned simultaneously); the filter wheel in the 300 can be removed in minutes and thus the filters can be changed readily (removal of the filter wheel in the 2·5 is a lengthy procedure requiring a service visit). The latter advantage allows use of wavelengths identified by the scanning infra red analyser, the Neotec 6350, for the production of specific filters which are simply inserted into a 300 filter wheel. Thus results of research on the 6350, if successful, can be relatively quickly transferred to the 300 and applied to routine work. It is not too fanciful to think in terms of separate filter wheels for malting quality of barley and forage quality of brassicas.

During the year research work on the Neotec 6350 has progressed on two fronts, namely, improvements made in our NIR methodology and new applications of NIR to plant breeding problems. New additions to the Neotec 6350's suite of programs have been made continually in the last year. One example is a program for the detection of spectral differences between samples.

A second improvement in methodology has been the discovery of a method for rapidly identifying combinations of wavelengths that give the highest multiple correlations between NIR predictions and the manual estimations. In this new technique increased use is made of the graphical displays used in the 6350 regression program. A full description of this type of wavelength selection together with several successful applications has been submitted for publication.

Progress has also been made in applying infra red analysis to plant breeding problems. For example, milled samples of Maris Kestrel kale leaves, stems,

and whole plants were scanned in the 6350, and high correlations were observed for NIR predictions versus manual estimations of S-methyl cysteine sulphoxide (SMCO), a haemolytic factor in kale. After calibration high correlations were also observed between the NIR predictions and manual estimates of SMCO in Maris Kestrel leaf and stem samples which were from the same trials, but were not included in the calibration population. Calibration equations for whole plant SMCO were less successful in predicting the "check" populations ($r < 0{\cdot}6$) than the leaf and stem predictions ($r = 0{\cdot}90$ and $r = 0{\cdot}93$, respectively). Further work is in progress to derive robust predictive equations for SMCO content in a wide range of kales, and possibly other brassicas.

As part of some collaborative work with the PBI chemistry department, the possibility of identifying specific wavelengths that relate to hot water extract values of malted barley was investigated using the Neotec 6350. A report on the NIR prediction of hot water extracts of spring and winter barley samples has been published by Dr A. Morgan (PBI), but specific wavelengths concerned could not be identified as he used a fixed filter machine. Rothwell Plant Breeders have also collaborated with us in these experiments. Both Rothwells and the PBI sent us barley samples and a full malt analysis. The 6350 work on these samples is still in progress but one problem already apparent after the initial scans is that the NIR prediction curve seems to be a complex one with the data points best fitted by a sinusoidal curve. The shape of the curve is evident for the PBI samples and is much more pronounced in the Rothwell samples.

Other collaborative work with PBI included NIR prediction of the sedimentation values of wheat flour in sodium dodecyl sulphate solutions. This test is widely accepted as a measure of breadmaking quality. In calibration experiments high correlations ($r = 0{\cdot}93$) were observed between NIR predictions and the manual estimates. Furthermore, the wavelengths selected correspond well with selections made in some parallel work on the same test by FMBRA, Chorley Wood. We are also engaged in some collaborative work with NIAB chemistry department on the NIR predictions of digestibility of forage brassicas.

Other NIR work during the year included very promising results from the NIR prediction of counts of mildew spores washed from barley leaves. High correlations were observed ($r = 0{\cdot}95$) using only two or three wavelengths. Preliminary experiments indicated that races of wheat yellow rust (kindly supplied by Dr R. Johnson of PBI) and races of potato blight may be identified by their infra red "finger-prints" (absorption spectra of the fungi over the range 1100 to 2500 nanometres). The importance of having dry specimens was emphasised in these experiments by the fact that infra red absorption by water in blight fungal material obscured many absorption details in two main areas in the NIR. Attempts were also made during the year to predict the beta amylase activity in barley flour by NIR but the results obtained indicated that calibration populations ranging widely in genetic

background cannot be used to derive successful prediction equations.

Improvements were made in the data processing aspect of chemistry work in 1980. An increase in software included a complete suite of programs on the Wang 2200 for the calculation of results for the wide range of tests used in a full malting quality analysis. In addition, hardware in the form of an Apple microcomputer with VDU and disc drives was purchased as part of the overall Station plan to upgrade data capture and processing facilities.

It is intended to interface the Apple with a Mettler PK300 electronic balance so that data can be logged and processed when the programs are written. It is envisaged, therefore that the Apple will have dual functions, as a logger and as a computer.

It was reported last year (*Ann. Rep. 1979-80*, 32) that Calan Electronics Ltd., who had collaborated with SPBS on the development of the "Comparamill", had ceased production. Nevertheless one completed Comparamill unit was delivered to the department just before the closure of Calan Ltd. The Comparamill passed some rigorous testing, after a few teething problems and, later in the year, was included in our routine assessment systems for malting quality. Because many of the operations involved in the estimation of milling energy have been automated in the Comparamill, an impressive throughput rate is possible with 60 samples per hour typical of a comfortable working rate. In addition to our routine workload of milling energy measurements, we also collaborated with Dr P. Shewry of Rothamsted Experimental Station on an experiment to explore possible relationships between milling energy and hordein band patterns in barley. The electrophoretic analysis is currently in progress. Amcal Ltd. of Northwood, New Hampshire, USA, have taken over the Comparamill project and it is hoped that Comparamills will be available commercially in the not too distant future.

In addition to a number of milling energy determinations routine chemical analyses over the last year included digestibility estimations (2,170 brassica samples); Kjeldahl nitrogen (1,800 brassica and barley samples); malt analyses including α-amylase and diastase estimations (400 samples); manual predictive method for diastatic activity (2,300 samples); S-methyl cysteine sulphoxide and thiocyanate (1,300 and 1,200 brassica samples, respectively); Vitamin C in potatoes (60 estimations); protein in potatoes (37 estimations). Some of the above analyses were part of experiments designed to calibrate the Neotec 6350.

The toxic factors in kale, SMCO and thiocyanate ion, were estimated both in breeding material and as part of a time course experiment on changes in level of the toxic factors during growth. For all of the kale cultivars in the experiment SMCO content increased between mid-September and mid-January. In a separate study on fodder cabbage the increase in SMCO in December was even steeper than in the kales. Results from the time course study on toxic factors in kales have been written up and submitted for publication.

Development work in the autoanalyser laboratory consisted of the construction of a new manifold for the automated measurement of Vitamin C content in potatoes. Extracts from tubers of some Neotuberosum lines showed considerable variation in Vitamin C content. The manifold was also successfully used to estimate the Vitamin C content of blackcurrant juice. A second manifold for the estimation of glucose was also built this year, and in tests, the analysis system proved to be very sensitive and highly repeatable. Protein contents of Neotuberosum lines were estimated by a Coomassie blue dye binding method. Again there was a wide range of protein content among Neotuberosum selections.

Work on potato glycoalkaloids continued again this year, using the dye binding method developed at the FRI, Norwich. Previous anomalous results were shown to be due to one of the reagents used in the estimations. When this was corrected, levels of approximately 7 mg glycoalkaloid per 100 g fresh weight were observed for samples of Pentland Crown, and these results were in the range expected for this variety. This dye binding test plus a gas chromatography system (to identify dye binding material) may soon be employed for the routine testing of potato breeding material.

Although the majority of chemistry routine work is analysed manually, it is expected that at least some of the routine work will be analysed in the future by infra red plus a manual check on a percentage of the samples.

DAFS Package 4
ARC Project 03002
DAFS Package 1
ARC Projects 04009–04012

M. J. Allison
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FORAGE DIVISION

Work with Brassicas

During the year, breeding and research work with forage brassicas has been re-organised in order to offer a more logical and better integrated approach to the problems. Effort is now being concentrated on kale, swede and rape with the minor crops, namely, turnip, radicole, fodder cabbage and catch crops including radish, reduced in scale, returned to the drawing board for some basic studies or used as components of other programmes, for example as sources of disease resistance or parents of wide crosses.

The genus *Brassica*, together with some other cruciferous genera, provide, perhaps, the greatest opportunity for imaginative breeding work because there is a range of partially or completely inter-fertile species and because stable polyploids can be generated, some of which have a high degree of fitness. In order to exploit this situation a small Unit, without direct breeding responsibilities, has been established. It seeks to expand the work, previously undertaken, of synthesising radicole and *B. napus*; the latter by means of embryo culture. The transfer of genetic material from the mustards into the currently cultivated forage species offers possibilities but little has yet been done.

Considerable effort has been devoted to developing tissue culture techniques, other than embryo culture. Fine differences in the culture media, especially in the auxin : cytokinin balance, can be critical. Techniques are now in use for excised apices, whereas for leaf segments further work is required for plantlet formation although they root readily. Anther culture, or more strictly pollen culture, is more difficult. Work will be restricted, at least initially, to *B. napus*.

When these techniques are routinely available, there will be many applications including the propagation of sterile or precious plants, the induction of mutations in culture, the isolation of disease resistance genes in haploids and the subsequent production of homozygous diploids.

Breeding programmes with the three main crops have been allocated to individual breeders who now have the whole of the United Kingdom to consider when determining breeding objectives or designing trials systems. The latter should include sites representative of the areas in which the crops are grown. Sites for southern trials have not yet been chosen but discussions concerning them have started.

There is a need to examine the place of forage brassicas in agriculture, to determine what would make brassicas more competitive with cereal grains or conserved grass and to ascertain whether there are other uses or markets

for them. The brassicas are diverse not only in their phylogenetic relationships but in the ways they are grown, harvested and utilised. For these reasons much thought is being given to the type of plant most likely to meet agricultural needs for the remainder of the century.

The swede programme has been in existence longest and is already producing entries for National List Trials; Angus and Melfort are receiving favourable comments; two more selections will enter trials in 1981 as will one forage rape derived from an artificially synthesised form of *B. napus*. The kale programme is the most recent and has not submitted material for national testing but advantage was taken of the cold conditions early in 1979 to select for increased winter hardiness.

Various breeding procedures with these crops are being explored. In addition to inter-varietal crossing with swedes, self-incompatible lines, each homozygous for an S-allele, have been developed in order to test the practicability and performance of F_1 hybrid crops. Most of the technical difficulties have been solved and it should now be possible to assess the merits of single and double cross hybrids.

Induced mutations in rape and methods of cultivar production in kale are also being studied.

These breeding projects are supported by routine work and research programmes including measurements of digestibilities and toxic factors (Chemistry Division), field performance and yield (Agronomy Division), disease reaction and seed purity (Brassica Department). Some of these involve co-operative research programmes between breeders and specialists and all are geared to the needs of the breeding programmes. Advances in breeding for reduced SMCO content must be preceded by the development of accurate and rapid assessments of SMCO, probably using infra-red analysis. This is of particular relevance to work with kale and cabbage since they contain the highest contents.

Most field trials are harvested mechanically and dry-matter yields determined after oven drying. This method of assessment disregards a number of important interactions between animal and crop. The size of the experiment described last year using lambs to compare only two genotypes precludes its use as a routine procedure to test the products of the breeding programme. Methods of obtaining data on animal performance need further consideration.

Resistance to the organisms producing clubroot and powdery mildew would benefit most, if not all, the crops. Improvements have been made in methods of testing and in the field assessment of losses due to disease. Resistance to most of the known UK populations of the clubroot organism are now available to breeders in the major brassica crops. There are reasons to hope that these sources will be more durable than has been the case with cereal foliar pathogens but prudence demands that alternative sources are also isolated and held in readiness.

Radicole is the most disease resistant of the crops studied, but although

great advances have been made, existing genotypes are not suitable for cultivation because of low seed yield and reduced intake by lambs compared with rape. To what extent these are attributes of the lines examined or of the crop as a whole must now be determined by returning to more fundamental work rather than cultivar production.

In order to ensure that seed of advanced lines of all the crops is available in sufficient quantity and with adequate purity for National List submissions and future commercialisation, multiplication is now being handled by a small Unit. The work is demanding because of the range of crops, the requirements for cross pollination in isolation from other stocks and the official standards for distinctness, uniformity and stability which are only just becoming known.

R. N. H. Whitehouse

Unit for Strategic Brassica Breeding

The Unit for Strategic Brassica Breeding was initiated in May 1980, its main function being to create new variation through inter-specific hybridization, introgression, tissue culture, etc., for incorporation, at a suitable stage, into the appropriate breeding programmes for selection and evaluation. Disease resistance is an important consideration in this work. Time has been spent setting up facilities and establishing tissue culture techniques.

The remit of the Unit includes developing anther culture techniques in order to fix new or existing variation through the production of haploids and thence, by chromosome duplication, homozygous lines. It is possible that haploids could be useful *per se*, e.g., in studies of the effects of mutagens and in the isolation of disease resistance genes.

Anther culture of *Brassica* species is known to be difficult, especially with *B. campestris* and *B. oleracea* species which give very low frequencies of haploid plants per anther cultured. Canadian workers, Dr W. A. Keller and colleagues, have recently achieved a higher success rate with *B. napus* (oil-seed rape) and have started to use the technique routinely. Haploid production in forage rape and swedes should, therefore, be a feasible proposition.

In an initial experiment a few hundred anthers were taken and cultured from the swede cultivar, Marian. This first attempt was not successful and there were problems with contamination of some of the plates. It is proposed to carry out this work more comprehensively in spring 1981 using both cultivars and breeding material of *B. napus*, a major objective being the fixation of genes influencing disease resistance.

Culture experiments were conducted using meristematic tissue of both *B. napus* (forage rape cultivar Lair) and *B. oleracea* (Brussels sprouts). Small buds

were taken from the axils of young leaves of rape and axillary buds removed from within sprouts of Brussels sprouts. Comparisons were made between explants cultured on filter paper bridges in liquid media and on agar media. Murashige and Skoog (1962) Plant Salts formed the basic ingredients of the media used. It proved relatively easy to induce shoot growth, to proliferate shoots and to induce root formation.

Experiments were also carried out on non-meristematic tissues in attempts to induce complete plants. Small leaf lamina and petiole segments were taken from swede and rape plants and placed on an agar based medium. Callus was induced and, in some cases, abundant roots were formed. So far, however, shoots have not been induced on such explants.

A critical factor would seem to be the auxin : cytokinin ratio, as well as the concentration of these hormones. A wider range of auxin : cytokinin ratios requires to be tested in order to discover a formula capable of inducing complete plant formation. The optimal formula is likely to vary with the type and age of explant as well as with the species, if not the actual genotype.

One complete plantlet was obtained following culture of *Raphanobrassica* flower buds. Shoots were formed on one medium and roots induced after transfer to a second medium with a higher auxin content.

Work to improve the *B. napus* crops, swedes and forage rape, by introgression of new characters from the parent species, *B. campestris* (turnips, oriental salad vegetables, etc.) and *B. oleracea* (the kale group), continued. Embryo culture is necessary to raise hybrids from this difficult cross. Artificial *B. napus* forms, produced in this way, now figure prominently in the forage rape breeding programme and to a lesser extent in the swede breeding programme. In the latter the main contribution has been club-root resistance obtained from *B. campestris*.

A wide range of colchicine induced autotetraploid forms of *B. campestris* and *B. oleracea* has been grown in the field and plants selected for crossing in spring 1981.

It is important not only to engender new variation for use in breeding programmes but to acquire and evaluate existing variation which may be of direct use or of indirect value following, for example, inter-specific hybridization and gene transfer.

Seed was obtained of an artificial "heading" form of *B. napus*, named Hakuran, derived in Japan from *B. oleracea* var. *capitata* (cabbage) × *B. campestris* ssp. *pekinensis* (Chinese cabbage). Four lines of Hakuran were visually compared, in a small June sown transplant experiment, with the fodder rape cultivar Lair. The Hakuran lines were not as vigorous as rape, formed no heads, flowered prematurely and were obviously not adapted to UK conditions. Since no disease resistance is claimed for Hakuran it would seem to have no attribute to offer to a *B. napus* breeding programme.

F_4 *B. oleracea* hybrids, derived from crosses between cabbage and var. *alboglabra* by The University of Wisconsin—Madison, were also examined as transplants for possible use in *B. napus* synthesis or in the kale breeding

programme. These hybrids also flowered prematurely from a June sowing and did not appear to have any desirable characteristics for use in forage breeding.

As a start to the production of addition lines of *B. oleracea* with extra chromosomes derived from *B. campestris*, several putative allotriploid hybrids were obtained from 4x *B. oleracea* × 2x *B. campestris* crosses using embryo culture. The *B. campestris* parent was ECD 04, one of the differential host set with a wide spectrum of club-root resistance.

Selections were made in the field in autumn 1979 from *Raphanobrassica* families with marrow-stem kale in their parentage and in 1980 seed was obtained from two distinct forms(*a*) a medium stemmed, leafy type and (*b*) a taller "marrow-stem" type. There has been insufficient seed, so far, to carry out any yield assessment but plants were visually more vigorous than those developed from earlier crosses in which thousand-head kale was a *Brassica* parent.

Lines of radicole, apparently true breeding for resistance to virulent populations of club-root (*Plasmodiophora brassicae*), were mass multiplied, and individual plants were also self pollinated and used in crosses with less resistant, but otherwise desirable lines. Lines which had given low disease indices in controlled tests were also mass multiplied.

Seed production in Tygan insect-proof cages and in polythene tunnels was hindered by cold, wet and humid weather which favours continuous flowering and thus delays capsule ripening. This seems to be a characteristic of radicole.

A number of F_2 *Raphanobrassica* plants, with *R. maritimus* (sea radish) × *R. sativus* (fodder radish) hybrids as parents, were raised under glass for seed production in 1981.

Data from the rape versus radicole lamb grazing trials at the Murrays and Hartwood sites (see *Ann. Rep. 1979-80*, 48) have been statistically analysed. Live weight of lambs from the two crops were compared from seven regular weekly sampling dates at each site. The differences in lamb performance, as assessed by live weight, were highly significant at the three latest sampling dates, thus indicating the progressive disparity between lambs grazing the two crops over the period of the experiments. Lambs from the rape plots were the heavier. The results, therefore, clearly showed the superiority of rape as a fattening crop.

Apart from the third sampling date at the Murrays there were no significant differences between weights of lambs at high and low stocking rates. There were significant stocking rate by crop interactions at the third, fourth, fifth and sixth sampling dates at the Murrays, but no significant differences for this factor at Hartwood.

Statistical analysis of Haemoglobin (Hb) and Packed Cell Volume (PCV) levels in blood samples, taken at the seven sampling dates, showed virtually no differences between lambs from the two crops or differences between stocking rates.

Lowering of Hb and PCV levels is symptomatic of haemolytic anaemia, attributed to high plant contents of SMCO. Hb and PCV levels did not show any marked changes throughout the grazing period.

Because of the relatively poorer performance of radicole as a grazing crop and difficulties of seed production it now seems unlikely that a cultivar can be produced until the causes of these deficiencies are better understood and the difficulties overcome.

Seed production has been a major stumbling block in attempting to obtain a crop plant from *Raphanobrassica* at SPBS. Attempts to develop *Raphanobrassica* elsewhere, for example in Sweden, Japan and at WPBS, have met with very similar problems and, so far, there has been no satisfactory resolution.

At SPBS fertility has been markedly increased, from a very low level in early generations, to a level high enough to provide seed for numerous small plot experiments and several lamb grazing trials. For seed production on a field scale, thanks are due mainly to NSDO. The most successful field scale multiplication, however, has only produced about twenty per cent of the seed crop normally obtained from an equivalent area of rape.

Poor seed production of *Raphanobrassica* is undoubtedly due mainly to genetic imbalance, cytological anomalies being of lesser significance. Bad weather also can have an adverse effect. In wet or humid conditions plants are liable to flower continuously. Ripening of capsules from the first flowers is then impeded by late flowering. In field scale multiplications this can lead to problems in combining, seed drying and seed cleaning.

High levels of resistance to club-root (*Plasmodiophora brassicae*) have been found in some lines of radicole in controlled tests carried out at SPBS, but other lines were susceptible to the virulent inoculum used, thus showing that screening and selection is necessary to fix the highest levels of resistance.

DAFS Package 4
ARC Project 03001
03014

I. H. McNaughton

Brassica Department

Studies of Swede Hybrids

Estimates of the degree of outcrossing produced in the field by a modified double-cross multiplication have been obtained from three lines of swede. The modified double-cross method involves crossing lines which are heterozygous for self-compatible and self-incompatible alleles. The lines used were produced from backcrosses of Ruta Øtofte and Bangholm Sahna

to two S-genes from H52 (*Ann. Rep. 1973-74*, 12). Plants of these lines, which have yellow flesh, were isolated with plants from a line of Criffel, which has the dominant white flesh character. Seed from the plants was sown in trial and the progenies were scored for flesh colour. The variation in outcrossing was quite considerable, both within and between lines. The degree of outcrossing in the lines from Bangholm Sahna varied from 48 to 92 per cent in one line and from 33 to 93 per cent in the other, with means of 77 and 56 per cent respectively. The line from Ruta Øtofte gave from 46 to 95 per cent outcrossing, with a mean of 71 per cent. The variation in outcrossing appeared to correspond with variation in self-compatibility as scored by pollen-tube counts. Only plants which had pollen-tube scores of zero appeared to be capable of enforcing high levels of outcrossing. This result could, however, be expected from these outcrossing tests, as the crosses involved differed in flower colour (pleiotropic with flesh colour), and had a pollen donor : recipient ratio of one to three. The conditions used were an extreme test of the strength of the incompatibility reaction, and under less extreme conditions the modified double-cross may perform satisfactorily.

Although higher degrees of outcrossing are aimed for, the hybrids from the two lines with over 70 per cent outcrossing performed well in a small trial of six replicates in which they were compared with six control cultivars. The hybrids from the high and low outcrossing lines of Bangholm Sahna gave dry weight yields of 117 and 99 per cent, respectively, of the mean of the control cultivars, and the Ruta Øtofte hybrid gave 119 per cent. Ruta Øtofte was the highest yielding control cultivar, with 110 per cent of the mean of the controls and the Ruta Øtofte hybrid was just higher yielding than it at the five per cent level of significance.

Two more homozygous S-allele lines were obtained from screening the advanced lines of the backcrossing programme. Five such lines are now available, involving four swede cultivars and four different S-genes. These will be used in further work to examine the possible use of the modified double-cross. Further outcrossing tests have been set up to study other conditions and ways of using self-incompatibility for producing hybrid swedes. The use of the three-way and double-cross multiplications are to be examined in both isolation sites and insect cages using either flower colour or skin colour as the genetic marker. The results of this work should show which methods could be used for commercial production. If it is found necessary to use a normal double-cross multiplication involving four self-incompatible lines, a knowledge of the interactions of the incompatibility factors will be needed. Plants from eight different S-gene lines have been intercrossed, and their incompatibility reactions are to be studied. Not all of the possible crosses were made in 1980, but it is hoped to complete the diallel set with further pollinations in 1981.

In order to identify high-yielding crosses for use in the hybrid swede programme, a half-diallel set of crosses was produced by hand-pollination from ten lines of swedes. Sufficient seed to sow in trial was produced from 41

out of the 45 possible crosses. The lines used had been selfed and selected for at least two generations. The results from the trial should, therefore, be much more reliable than previous F_1 hybrid trials, which have involved crosses between commercial cultivars which were rather variable. High and low dry matter content selections from two cultivars, Ruta Øtofte and Criffel, were included to examine differences in combining ability between lines selected from within a commercial cultivar. The other lines used were also selections from commercial cultivars, with the exception of SPBS 700 (DA700), the advanced line from the pedigree breeding programme which is to be submitted for National List trials.

In the future, it is expected that selections from the pedigree programme will provide most of the material for the hybrid swede programme. For the next few years, however, the programme will have to depend mainly on selections from commercial cultivars. For this purpose, further selections from the cultivars Criffel, Bangholm Dima, Ruta Øtofte, Bangholm Wilby and Bangholm Magres were sown in trial. Lines from the cultivars Ingleston and Ashgrove are also being examined, and plants of Acme have been selfed in order to provide further material for testing. Some of the lines selected are distinct from their parental cultivars and may be potential new cultivars. A line, SPBS D28, with dark, curly foliage selected from Bangholm Dima has performed well in trials conducted by the Field Trials Unit and has been submitted for National List trials.

Swede Breeding

INBRED LINES FROM INTER-CULTIVAR AND OTHER CROSSES

The procedure used previously at SPBS for the Pedigree Breeding Programme has been based on a two year cycle, with plants sown in trial one year and seed being produced from the selections in the next year. Such a procedure would take ten years to produce selections from F_5 lines which, with a further five years of trials and multiplication still needed, would mean taking fifteen years from crossing to the release of a new cultivar.

With the adoption of a new system, it is intended that F_5 trials should be held in the fifth year after crossing, and so shorten the time of release to ten years. By vernalising F_1 seedlings and producing seed overwinter in controlled conditions, F_2 seed should be sown in the field the following spring under normal cropping conditions. Single plant selections made from these plots should produce F_3 seed in the second year after crossing. Thereafter, plants of all selections which are to enter trials will be grown overwinter in a glasshouse to produce seed in the summer of the year that the selected lines are being grown in trial. F_5 lines should, therefore be in trial in the fifth year whilst seed from the lines, sufficient for entry into Field Trials Unit trials, is being produced simultaneously.

A start was made with the new procedure by vernalising F_1 plants from the hybrid swede programme. Experiments on the vernalisation of swedes have shown eight weeks at 5°C to be the minimum treatment for this type of work. It was also found that growing the plants on for periods longer than a week before starting cold treatment, progressively delayed the onset of flowering. Seedlings from the crosses were pricked out at the end of August, grown on for a week in the greenhouse, and then transferred to 5°C for ten weeks to ensure complete vernalisation. The plants started to flower in the first week of January and they were then self-pollinated to produce F_2 seed.

Work on the previous series of breeding lines continued with F_3 lines, F_4 lines and advanced selections being sown in trial at the Murrays. The F_3 trial contained lines derived from selections made from the results of the F_1 trial of 1976. F_2 populations were sown in 1978, and plants were selected and transplanted after a hard winter. Although 300 plants were selected, only 71 produced enough seed to sow in trial. The lines obtained, however, should have good winter hardiness. Selections will be made primarily on dry matter yield, but disease resistance and morphology will also be of importance. The F_4 lines in trial were reselections from the series of crosses from which Angus and Melfort were selected. Fifty lines were sown in trial, most of which have high dry matter content and winter hardiness. Some signs of internal browning were observed in this trial, and any lines showing symptoms of this condition will be discarded.

From the F_3 trial of 1979, 50 lines were originally selected, with five plants of each being transplanted for bag-selfing. Survival and seed set was good, with the result that reselection will be necessary to reduce the number of entries for trial. Five lines were selected from the F_4 trial of 1979, with the intention of multiplying them and entering them in Field Trials Unit trials. Plants were transplanted to insect cages, but they were severely affected by spray drift at the onset of flowering. Very little seed was obtained, and only two lines produced enough seed to sow at more than one site.

Several F_6 and F_7 lines were grown at three different sites in 1979 (*Ann. Rep. 1979-80*, 39) with varying results, but showing an overall pattern with lines yielding at the upper and lower ends of the scale, over three years and five trials. Several lines gave better dry matter yields than Ruta Øtofte and these were included in a further trial at the Murrays in 1980. The data from this trial have not yet been analysed.

In 1979 the Field Trials Unit carried out trials of F_7 lines at four sites. SPBS 700 was significantly higher in dry matter yield than Wilhelmsburger Sator at three of these sites (*Ann Rep. 1979-80*, 39). On the basis of these results SPBS 700 was sent to New Zealand to be multiplied, and will enter National List trials in 1981. In 1980 the Field Trials Unit again carried out trials at four sites: the Murrays; Tritlington Hall, near Cockle Park, Northumberland; Westerton of Pittarrow, Laurencekirk; and Yonderton Farm, Ayr. The trials included eleven advanced lines and five controls. Analyses of these trials have not been completed.

SPBS 9939 and SPBS 9943 have now been named Angus and Melfort, respectively. They entered first year National List Trials in 1979 and their dry matter yields, expressed as per cent of the mean of the controls, were 101 per cent for Angus and 105 per cent for Melfort. Both had higher dry matter contents than any of the other entries at 11·5 and 11·7 per cent, respectively. They have now completed their second year in National List Trials, and results are awaited.

Assessments of turnip root fly damage made by WSAC in 1979 showed that Angus and Melfort appeared to be highly resistant to attack. In order to make further observations, a small trial was grown in collaboration with WSAC at Crichton Royal Farm, Dumfries. Angus and Melfort, their parental cultivars and three F_1 hybrids of each were sown, along with five commercial cultivars. Because there was only a low incidence of attack, the results cannot be considered conclusive, but they did show that Angus and Melfort had lower scores than the controls. The F_1 hybrids also had low scores, while the parental cultivars gave slightly higher results. It has been suggested that high dry matter and low root fly attack are correlated, but this was not the case with the controls. The low dry matter cultivars Doon Major and Merrick gave lower scores than Bangholm Magres and Wilhelmsburger Sator, with the latter having over twice the scores of Doon Major and Merrick. It is intended to repeat this trial in 1981 to try to confirm these results.

INTROGRESSION OF CHARACTERS FROM RAPE INTO SWEDES

A number of swede × rape crosses have been made in recent years in an attempt to introgress quick establishment and early growth into swedes, and also to transfer disease resistance. Selections were made from F_2 populations from crosses with Canard rape, but the bulb characters in most cases were not very good. A multiplication of these plants was made in an isolation tunnel, in order to maintain some heterozygosity whilst selecting for good bulb morphology. A further series of F_2 populations has been produced, which include rape parents with clubroot resistance and also the low thiocyanate cultivar Samo.

INTROGRESSION OF CHARACTERS FROM TURNIP INTO SWEDES

Ten lines were selected from the 1978 trial of progenies from turnip × swede crosses, and five plants of each were transplanted for selfing. Due to the hard winter, only eighteen plants survived to produce enough seed to sow in trial in 1980. Several interesting morphological types have been produced, with considerable variations in leaf shape. The yields from these lines were also very variable. The highest yielding line produced the same dry weight yield as the highest control cultivar, with 113 per cent of the mean of the six controls. Some of the lines were very poor, however, with

the lowest producing only 50 per cent of the dry weight yield of the controls.

High dry matter content was one of the objectives in these crosses, with the high dry matter cultivar May turnip being used as a parent. Three lines from May turnip crosses gave dry matter contents of over thirteen per cent, the highest being 13·7 per cent. In comparison, Bangholm, which has the highest dry matter content of present commercial cultivars, had a dry matter content of 11·4 per cent. The yields of these lines were not very good, however, and this material will only be useful as a source of new variation for crossing with high dry matter swedes.

Swede Gene Bank

Plants from several cultivars were multiplied in 1980. Seed set, which looked promising, was badly affected by spray drift from an adjacent barley crop. This caused much distortion of fruits as well as flower and bud drop. However, sufficient seed is now available to sow 65 of the accessions as observation plots in the field. These will be scored for various characters and eventually each will be multiplied to give adequate seed for storage and use for future breeding work.

Further efforts are being made to germinate seed of the older accessions using a number of techniques.

Turnip Breeding

Based on the 1979 trial results, selections were made to set up a polycross of white and yellow-fleshed turnips in an attempt to combine high dry matter contents with high dry matter yields. Six plants from each of the five highest dry matter content, white-fleshed lines were sown with six plants from each of the five highest dry matter yield, yellow-fleshed lines. Fifty eight of the plants set seed, but only 40 have produced sufficient for trials in 1981 to assess dry matter content and dry weight yield. A multiplication was made from selections of the old Danish cultivar, May turnip (Mai Neep), from which selections for high dry matter content will be made. In order to transfer a high degree of resistance to clubroot from the European Clubroot Differential 04, into cultivars of traditional turnips, a series of backcrosses is being carried out. Plants of the first backcross selected from clubroot tests in 1980, were backcrossed again with traditional turnips as recurrent parents. Resistant seedlings selected after clubroot testing will be backcrossed again in the summer of 1981

Kale and Fodder Cabbage Breeding

KALE BREEDING

The main objective now is to improve the nutritional value of kale, for strip grazing by dairy cattle in the autumn, and into the winter in the milder

parts of the United Kingdom. (Adaptations are required for both early sowing into a conventional seed-bed, and later direct drilling into killed grass.) Consideration is also being given to the possibility of improving the clubroot resistance of kale.

Work continued on the small kale polycross improvement programme started in 1971. Fourth-generation polycross families were produced in 1980 for assessment in yield trials in 1981. The performance of third generation families with desirable characteristics was checked in a yield trial in 1980. The mean dry matter yield of these families was 103 per cent of the mean of the controls; Bittern, Canson, Condor, Kestrel, Merlin and Proteor. Thus their dry matter yield potential was confirmed. Their nutritional characteristics are at present being determined. The best families will be multiplied for assessment as potential new cultivars. One re-selected first generation family and two second generation families were assessed by the Field Trials Unit at Ayr, Cockle Park, and the Murrays in 1979. They did not yield well enough for use as autumn kales. However, one of the second generation families is very winter hardy. It is at present being re-selected in order to produce in 1981 a seed stock uniform enough for NLT submission in 1982 as a winter kale.

The exceptionally severe winter of January to March 1979 allowed very winter hardy plants to be selected for seed production later that year. These were mainly short, often bushy, plants from the reciprocal recurrent selection programme which was discontinued as such (*Ann. Rep. 1978-79*, 43), together with January King and Savoy Cabbages, Curly Kales, and a few plants from the polycross programme. The single plant progenies were assessed in a yield trial in 1980 as autumn kales. This was because it is not thought worthwhile breeding kales solely for late winter use. The mean dry matter yield of these families was only 88 per cent of the mean of the controls, Bittern, Canson, Condor, Kestrel, Merlin and Proteor. However, the mean dry matter content of the families was high at 17·0 per cent compared with 15·2 per cent for the mean of the controls. This suggests that high dry matter content may be associated with winter hardiness and may carry a yield penalty. The highest yielding families will be re-assessed in yield trials in 1981, and their nutritional characteristics determined before deciding how best to use them in future breeding work.

Three main areas of research work are in progress: firstly on factors affecting the nutritional value of kale, in particular the S-methyl cysteine sulphoxide (the haemolytic factor) and the thiocyanate (a goitrogen) contents of kale; secondly on breeding methods, type of cultivar (complex hybrid, synthetic, or open pollinated), and method of cultivar production; and thirdly on the best morphological type of kale for autumn use.

FODDER CABBAGE BREEDING

A small fodder cabbage breeding programme has been started. The aim is

to produce both autumn and winter maturing cabbages suitable both for grazing *in situ* by sheep, and for cutting for housed beef and dairy cattle.

In 1978 a mixture of autumn and winter culinary cabbages was planted in an isolation site. Seed was harvested in the autumn of 1979. The single plant progenies were assessed in 1980 for the fresh weight yield and dry matter contents of their hearts. Visual selection was then practised within families combining a high fresh weight yield and a high dry matter content. The selected plants have been transplanted into a polythene tunnel for seed production in 1981.

An assessment of cultivars of the main types which are at present used as fodder cabbages was made in 1979. Whilst cabbage hearts have a much higher digestibility than kale (making selection for higher levels unnecessary), they also have high S-methyl cysteine sulphoxide contents. Hence selection for lower levels will need to be introduced into the breeding programme. An assessment was also made of their clubroot susceptibility. All cultivars were particularly susceptible so that selection for improved resistance will also be required.

Forage Rape Breeding

PEDIGREE BREEDING

Progress continued to be made on the establishment of a broadly based rape breeding programme. Three different approaches, used alone, or in combination, are being followed. Formerly many of the crosses were between cultivars but much greater use is now being made of parental lines of artificial *Brassica napus* derived from inter-specific crosses between *Brassica oleracea* and *Brassica campestris* (*Ann. Rep. 1979-80*, 44). While the progeny of such an inter-specific cross may have a number of useful characteristics in its own right, it is usually necessary to make a further cross, or series of crosses, with existing cultivars to obtain the required characters. A third approach involves the use of the mutagenic chemical, ethyl methane sulphonate (EMS) to create new variation, and alter characters such as height.

The programme has a number of aims, among which are improved fresh weight and dry matter yields, better resistance to the two major diseases, powdery mildew (*Erysiphe cruciferarum*) and clubroot (*Plasmodiophora brassicae*), frost tolerance, non-flowering and a low content of toxic chemicals, such as S-methyl cysteine sulphoxide (SMCO) and thiocyanates.

In 1980, much of the material in the rape breeding programme was at the seed production stage, and, apart from the crossing programme, only F_2 plants and trials of advanced lines and cultivars were grown.

The 1980 crossing programme utilised a wide range of parents, including a number of existing cultivars of British and overseas origin, and complex hybrids of artificial *Brassica napus* crossed with one, and occasionally two,

rape cultivars. F_2 seed from the crossing programme will be produced in the glasshouse in 1981.

The F_2 generation consisted of 280 plots from the artificial *Brassica napus* programme, (*Ann. Rep. 1979-80*, 44), 150 plots from the mutation programme, and 126 plots from the inter-cultivar crossing programme. The control varieties Lair, Emerald, Samo and Nevin were included at regular intervals, and in the inter-cultivar crosses, the cultivar Nevin was sown as a powdery mildew spreader every third row. Glasshouse inoculated plants were transplanted into these spreader rows. All plots were assessed for mildew resistance, premature flowering, height and breaking, and 200 single plant selections were made for seed production in 1981, and subsequent trials.

Advanced lines from the artificial *Brassica napus* programme (*Ann. Rep. 1978-79*, 46-48), were included in Field Trials Unit trials. AR5/7/4/1, AR5/7/4/11 and AR5/7/10/1 were believed to have the best combinations of yield and disease resistance. The controls were the cultivars Lair, Canard, Emerald and Winfred. The trials were carried out at four centres, Ayr, Cockle Park, Dundee and East Lothian, with two sowing dates at the last site. The trials were assessed for height, breaking, flowering, and fresh weight and dry matter yields. Detailed analyses of the yield of these lines, together with chemical analyses of protein, digestible organic matter, SMCO and thiocyanates are awaited. However, on the basis of the raw data obtained in 1980, together with yield, disease and chemical assessments made previously, it was decided to enter the line AR5/7/10/1 into National List Trials as SPBS 5/7/10/1. Seed for this purpose was obtained from an out of season multiplication in New Zealand.

MUTATION BREEDING

The mutation breeding programme, commenced in 1978 (*Ann. Rep. 1979-80*, 45), was extended by the treatment of the rape cultivars Lair, Emerald, Canard, Samo, Bishop, Nevin, Winfred and Tantal with EMS. The same cultivars treated with water only, were included as controls, and observations are being made on germination, genetic abnormalities, rate of growth, flowering, disease resistance, etc. Seed will be obtained from treated plants in 1981, and F_2 selections made in 1982. While useful selections may be obtained directly from this programme, it is expected that its principal use will be to provide parents for the pedigree breeding programme.

Brassica Pathology

Sources of resistance to nearly all recognised UK populations of *Plasmodiophora brassicae* (Clubroot) in all of the crops (except fodder cabbage) handled by the Brassica Department are now available. Resistant lines of

stubble turnip, swede and rape are being incorporated into breeding programmes (see Breeders' Reports). Genotypes resistant to highly pathogenic populations of *P. brassicae* are being used by the Unit for Strategic Brassica Breeding as parents in introgression and hybridisation programmes.

Over 20,000 seedlings of swede, rape, turnip, kale, fodder cabbage, radish, radicole, catch crops and some novel genotypes were included in routine seedling tests for resistance to clubroot in 1980 and about 1,200 resistant plants were selected and retained for seed production.

Clubroot screening tests using rooted leaf cuttings from a range of forage brassica cultivars have confirmed the 1979 results and shown that a comparable reaction to *P. brassicae* is obtained from leaf cuttings and from seedlings. The highest incidence of infection occurred when leaf cuttings were inoculated just after the first roots appeared. The rate of root production varied from about six days in the fodder radish cultivar Slobolt to about twenty days in the kale cultivar Maris Kestrel. Apparently normal shoots developed on 96 per cent of leaf cuttings (inoculated and uninoculated) in which a fragment of axillary bud tissue was included.

Investigations have continued on four swede cultivars and two populations of *P. brassicae* under two temperature regimes and in the field. The results indicate that the differential reactions of these cultivars are characterised by differences in the rate of disease development which are accentuated in some temperature regimes. In a field trial, clubroot scores on three successive dates showed no increase in disease incidence or severity after the end of August. Information from this trial is being used to examine the relationship between glasshouse screening tests and field data.

The reduction in yield due to clubroot infection was also measured on two kale cultivars, Maris Kestrel and Rawara which differed in susceptibility to the *P. brassicae* population used. Inoculated and uninoculated seedlings from each cultivar were transplanted to the field. At harvest all inoculated Maris Kestrel and 83 per cent of Rawara plants were infected, although most infected Rawara plants showed only mild disease symptoms. Dry matter yields from inoculated plants were 54 per cent (Maris Kestrel) and twenty per cent (Rawara) lower than from uninoculated plants.

The results from the powdery mildew trial in 1979 on three swede cultivars showed a marked effect of different inoculation dates on yield. Infections developed more slowly on Marian than on Doon Major or Scotia but there were much greater differences in percentage of leaf area infected and in yield between inoculation dates (June, July, August, September and control) than between cultivars. Inoculation at the end of June led to approximately 50 per cent fresh weight and dry matter yield losses in Doon Major and Scotia and approximately 37 per cent losses in Marian.

The use of inoculated spreader rows to initiate powdery mildew infection, and Persulon spray applications to control infection where necessary was extended to include rape trials in 1980 (see Forage Rape Breeding). Eight of the most widely grown rape cultivars were sown in three drill plots in a

replicated trial and inoculated on 21st August. Control plots received one application of Persulon. The percentage of leaf area infected with powdery mildew was scored on three dates, and fresh weight and dry matter yields were measured. Seedling emergence, uniformity, height, stem breakage and flowering were also recorded and samples were taken for SMCO and thiocyanate analysis.

Miss Margaret Allen, a student at Paisley College of Technology spent six months working on glasshouse methods for assessment of powdery mildew. In a series of tests on swede and rape cultivars, a similar ranking of cultivars according to disease severity was obtained on inoculated seedlings, on leaf discs maintained on benzimidazole agar, on Hoagland's nutrient solution, and on mature plants.

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Cereals Department

The Cereals Department has a responsibility to breed varieties adapted to the environmental conditions of northern Britain and suited to the needs of manufacturers and processors. It also has a brief to conduct investigations, using appropriate scientific disciplines, in support of its breeding operations. In the course of the last decade spring oats have been replaced by spring barley as the crop given most attention and a programme with winter barley has recently been started. On spring beans there is a small selection experiment and a co-operative programme with PBI. While it is evident that the major effort must be devoted to spring barley there are cogent arguments for continuing breeding and other research with winter barley and spring oats for Scotland. Much time and effort has been expended in developing and presenting those arguments in various forums.

That spring barley breeding has now almost reached its first goal can be seen from the submissions to National List Trials, five in 1980 and three in 1981. There has been a steady increase over the decade in the size and complexity of the programme and in the technical standards achieved. The material beginning to flow into official trials has a distinctive and satisfactory appearance and some has performed well. It is hardly to be expected that the first selections from a new programme will be highly successful varieties but the overall impression is that the work is now well established. It is a matter of debate whether the agricultural industry wants varieties capable of giving very high yields but also subject to weaknesses which soon put them out of favour, or whether the industry would be better served by having varieties of consistent, if slightly more modest, performance, without serious weaknesses, which may continue in cultivation for longer. I incline towards the latter but whether our trials systems are capable of recognising them is another matter.

Data recording procedures have been adopted so that far larger amounts of information are available to breeders. Rapid screening tests for quality in early generations, disease observations at sites in Scotland, Wales, England and New Zealand, early or intermediate generation selection at several sites and yield data from integrated sets of trials run either by ARS breeders or BAPB, are some of the methods which are now standard. They have to be backed by an efficient method of data handling and data base management by computer. Field observations can now either be entered onto a hand held terminal, or written and punched later, for analysis on a micro or main computer so that results are quickly available.

The previous oat programme culminated in the recommendation by NIAB of the variety Fyne. Material grown in F_4 trial in 1980, and in earlier generations, resulted from a fresh start using pedigree rather than composite-cross methods and a greater emphasis on strong and usually short straw. Oat powdery mildew was allowed to spread from deliberately inoculated plants to aid selection. In the longer term it is intended that special

attention should be given to grain quality either for milling or feeding purposes.

The winter barley programme is of more recent origin; it recognises both the likely expansion of this crop in the north and the demand at harvest time for grain with good malting quality. It seems likely that the attributes of a northern variety will need to be defined rather precisely in terms of harvest date, morphology, disease resistance and grain quality if it is to be commercially successful.

At present it is not clear how the research and breeding effort necessary to support the oat and winter barley crops in Scotland will be monitored, nor how they will be managed in future.

Crop breeding raises a series of questions which can only be answered through a continuing research programme in various scientific disciplines. The Cereals Department has, over the last few years, increased its efforts in some of these fields and intends to maintain this trend.

Genetic studies on a large scale in conjunction with the Department of Genetics, University of Birmingham, are attempting to evaluate a method, using triple test crosses, for predicting which hybrid populations are likely to be the most profitable for selection. This investigation has necessitated extensive work, including the use of our New Zealand facility, and also much intensive collection and manipulation of data. Other genetic studies are investigating the location of genes controlling important characters such as straw height and the components of malting quality. It is a curious fact that plant breeders have so often proceeded successfully without stopping to map the genes which they seek to manipulate.

Physiological work was continued in collaboration with PBI on spring barley and with ESA on winter barley. In both instances the objectives are to examine the varietal and environmental factors influencing apical development and, subsequently, yield. The varietal interaction when better understood should lead to an improved ability to describe the kind of variety needed for Scotland and will thus help the breeders produce it. Selection was continued in spring barley for a physiological attribute of a different kind, namely the ability to grow satisfactorily on acid soils. Oats have had the advantage in this respect but some barley varieties, including an old Scottish one, are also tolerant of low soil pH.

Disease nurseries in each of which one disease, or more often one race of one disease, is propagated are a common component of breeding programmes. Although diseases are a feature of most crops it is not always easy to reproduce the environmental conditions which encourage epidemics. Nevertheless, this was achieved successfully for the main diseases of oats and barley with the result that it was possible to select resistant genotypes amongst breeding lines and potential parents. Many spring barley varieties over the last thirty years have provided some protection from powdery mildew but rarely has this lasted more than a few years. Attempts are now being made to isolate parental lines, which, by analogy with other crops, are

expected to offer a more durable, if less complete, form of resistance. Studies are in progress which seek to classify and document such resistances and then to recombine them to provide farmers with varieties of more consistent performance which may last longer in cultivation. These are long-term objectives.

R. N. H. Whitehouse

Barley Genetics

SPRING BARLEY

The investigations into cross prediction in spring barley were continued in collaboration with Professor J. L. Jinks of the University of Birmingham (*Ann. Rep. 1977-78*, 24; *Ann. Rep. 1978-79*, 26-27; *Ann. Rep. 1979-80*, 56-57). Mr C. R. Tapsell, a CASE award student, continued with the analysis of the data, for eventual submission as a Ph.D. thesis. Analysis concentrated on those characters, scored on a single plant basis, in which significant additive and dominance effects were generally present. (Tiller number was an exception.) Dominance was not consistently directional, nor ambi-directional, but was usually incomplete. Some evidence of epistasis was found in at least one cross for each character analysed, with (i) type interactions being found more frequently than (j) or (l) types. However, epistasis was a minor component of variation when compared to the additive and dominance effects.

Single plants recovered from plots of the five populations of random F_2 selections were scored in the laboratory for characters relating to morphology and yield. All the characters under study, again with the exception of tiller number, showed significant genetical variation between selections. The random selections from the cross Universe × Mazurka were regrown in a yield trial in 1980 and were harvested before they could be damaged by adverse weather conditions. The "deliberate" selections, derived by using normal plant breeding methods, were raised in a field trial in 1980 and were also scored in the field for the same characters scored on the triple test cross experiment. Single plants were recovered from each plot to enable the remaining characters to be scored in the laboratory. These selections had not been exposed to a heavy powdery mildew (*Erysiphe graminis*) epidemic prior to 1980 and relatively high levels of mildew susceptibility were found in the trial. However, the selections generally combined early or medium maturity with good straw characteristics, and some also showed high levels of mildew resistance combined with high yield. Single plant selections have been made

from these selections and these, together with the bulks remaining from the trial, will be further evaluated in the normal plant breeding programme.

The experiment has been extended so that a further 200 random F_2 selections from each of the crosses Golden Promise × Ark Royal and BH4/143/2 × Ark Royal have been advanced through two generations of single seed descent followed by multiplications in New Zealand during 1980–81. The resultant seed will be returned for yield trials in 1981 to further evaluate the genetic potential of these particular crosses.

As an alternative to carrying out the full triple test cross analysis to determine the potential of a cross, it has been suggested that an analysis of F_3 means and variances may give sufficiently accurate results to identify those crosses producing the best recombinant inbred lines. Accordingly, for each of the five crosses, single plants recovered from rows of F_3 plants, themselves derived from a random selection of F_2 plants, have been scored in the laboratory for height, neck length, and yield characters. Predictions made by this method and by the triple test cross method will be compared with the observed performance of the crosses.

A pilot glasshouse experiment to investigate the use of single seed descent coupled with selection is being carried out. The resulting selections will be grown in a field experiment in 1981 to estimate whether any significant advance has been made.

The investigations of linkage relationships between several dwarfing genes (*Ann. Rep. 1978-79*, 27; *Ann. Rep. 1979-80*, 57) continued. F_2 populations from a number of crosses were raised in the field in 1980 but were late sown and suffered severely from the drought in May. Consequently, germination was irregular and assessment of single plants was very difficult. However, all of the populations were scored for juvenile characters and will be scored for further characters in the laboratory during 1981.

The level of β-amylase activity amongst the F_3 progenies from crosses which included the high β-amylase experimental lines as parents (*Ann. Rep. 1979-80*, 57) was lower than expected, less than ten per cent of the lines having activities as high as that of the high β-amylase variety Akka. Low levels of grain nitrogen, reflecting adverse environmental conditions, could have contributed to this result. Five lines, showing the very highest levels of β-amylase activity, were used as parents in the 1980 crossing programme. Those lines which had exhibited the best morphology and disease resistance in F_3 continued on to F_4 yield trials. Of 107 lines trialled, 23 significantly out-yielded the mean of the control varieties.

Attempts to assign to a particular linkage group the gene determining the Sd type electrophoretic pattern (*Ann. Rep. 1979-80*, 57) continued. The two crosses examined included, as parents, marker stocks which enabled a total of nine morphological markers from five chromosomes to be observed. However, Sd type was shown to be inherited independently of all nine genes.

In 1980 an investigation into the location of genes controlling important malting characters was started. The varieties Ark Royal, Golden Promise,

Vada and Zephyr were crossed to stocks, obtained from the collection, which carried a number of morphological variants with known chromosome locations. The marker stocks were chosen to give as wide as possible coverage of the seven chromosomes which make up the barley genome. Further crossing will be necessary to ensure that both arms of the seven chromosomes are tested. The four varieties crossed to the marker stocks were chosen because they showed a contrast in characters which are important in determining malting quality and which can be assessed by small scale tests. For example, Ark Royal has good malting quality, and this is reflected in low values for the milling energy and beta-glucan content prediction. In contrast Vada has poor malting quality and correspondingly high scores for milling energy and beta-glucan content.

In 1980 the F_3 generations from eight crosses were grown in the field and the grain produced will be screened for characters which are known to determine malting quality. It would be possible to plan crosses in the breeding programme with greater precision if the genes controlling such characters could be located on particular chromosomes. Adverse linkage relationships could be predicted before crosses were made and the appropriate selection procedures devised.

In 1980 a Joint European Trial series (JET) was grown at some thirteen sites throughout Europe including Austria, Britain, Czechoslovakia, France, Federal Republic of Germany, Holland, Poland and Sweden. Thirty spring barley varieties, chosen to represent a wide range of modern types, were included in the trial. The objective of the trial series, which will be continued for three years, is to investigate genotype by environment interaction in yield and quality characters. Yield variation will be analysed statistically at the Plant Breeding Institute, Cambridge. At the SPBS, small scale tests will be used to assess grain quality. Grain nitrogen and beta-glucan content will be predicted by infra-red techniques and value for malting will be assessed by the measurement of milling energy.

Barley Physiology

SPRING BARLEY

In 1980 the collaboration with Dr E. J. M. Kirby (PBI) on physiological studies (*Ann. Rep. 1979-80*, 58) was continued with an exploration of the variation present between inbred lines derived from the cross Golden Promise × Ark Royal. These lines were produced during the collaborative investigation of the triple test cross with the University of Birmingham. The cross was chosen for further physiologial examination as the two parents exhibit great contrasts. For example, Ark Royal is tall, relatively late maturing, and well adapted to growing conditions in the South of England.

By contrast, Golden Promise has a short, erect growth habit, is earlier and is well adapted to Scottish conditions. Several investigations, of both wheat and of barley, have demonstrated that between closely related inbred lines there is a possibility that the possession of erectly held leaves can confer a yield advantage. Erect leaves are believed to intercept light more efficiently than those which droop. However, varieties with an erect habit will not always out yield those with an indeterminate habit. Many factors other than light interception can limit yield, especially the drought and/or disease susceptibility of a particular cultivar.

In the winter of 1979–80, single plants, selected from plots of the F_6 generation, were sent to New Zealand for multiplication and the seed returned was used to sow trials at both PBI and SPBS in 1980. Ninety lines were investigated and characters such as maturity, plant habit and grain yield were recorded (Table 2).

Table 2

Yield of genotypes from the cross Golden Promise × Ark Royal classified by presence or absence of the erectoid dwarfing gene. Growth habit was scored as 5 = indeterminate and 9 = erect; Camb. = PBI, Cambridge, Edin. = SPBS, Murrays, East Lothian.

Genotype	*Number of Entries*	*Growth Habit*		*Yield (gm^{-2})*	
		Camb.	*Edin.*	*Camb.*	*Edin.*
Ark Royal	3	5·6	5·0	451	535
G. Promise	3	8·0	8·3	376	385
Indeterminate Types	64	5·7	5·0	409	459
Erect Types	26	8·0	8·9	347	400
General Mean		6·0	6·0	394	443

The pattern of yield was similar to that seen in previous seasons. The lowest yield was given by erect types in Cambridge. In 1981 a small number of selected genotypes will be tested again so that the relationships between rates of development, lengths of growth period, and yield can be examined, together with the effects that different locations have on them.

A similar study has been started to examine the effects of exchanging varieties between Scotland and New Zealand. The use of the Southern Hemisphere has greatly speeded up the rate at which barley varieties can be produced. A series of yield trials grown in both Gore, New Zealand and at the Murrays, East Lothian, established that there was no significant genotype by environment interaction between these sites. It has often been observed, however, that some components of yield differ. For example, grain size is considerably larger in plots grown at Gore, than in plots of the same genotype grown at the Murrays. Several varieties which show differences in maturity, grain size, and yield have been selected and will be studied in both environments. This may lead to a better understanding of the way in which yield components can develop in diverse environments.

WINTER BARLEY

The studies on spring and winter barley varieties started in 1978–79 have been continued in collaboration with Professor G. M. Milbourn and Dr G. Russell of the Edinburgh School of Agriculture (*Ann. Rep. 1979-80*, 60). From a rather late 1979 autumn sowing plant development was slower, the proportion of primordia surviving to produce grain was higher, and yields were higher than from a spring 1980 sowing. Spring-sown plots tended to have more grains than those from winter sowing and the yield advantage from the latter appeared to be due to the development of larger grains. Autumn-sown plots were found to absorb higher amounts of Photosynthetically Active Radiation (PAR) during the development of the earlier spikelet primordia. The earlier anthesis of the winter plots, however, led to lower levels of absorbed PAR at the later stages of development, and lower numbers of grains per unit area.

Further developmental studies were carried out on the winter and spring barley varieties. This field experimentation was assisted by Miss F. M. Black, a sandwich course student from Napier College of Commerce and Technology. The development of the genotypes Golden Promise, HJ57/2, Maris Otter and Video was followed in both spring- and autumn-sown plots. Golden Promise showed slower development of apical primordia from winter than spring sowing. This was not true of the winter varieties, especially HJ57/2 and Video, whose vernalisation requirements led to a delay in ear emergence from the spring sowing. As in previous seasons, the results from these developmental studies will be compared with yield data collected from the same plots. In 1980–81 these experiments have been extended to include two dates of autumn and spring sowing.

Barley Breeding

SPRING BARLEY

The early autumn sowing of the winter barley Maris Otter in the spring cereal field encouraged a heavy epidemic of powdery mildew (*Erysiphe graminis*) and also generated an epidemic of *Rhynchosporium secalis* in areas of the F_2 nurseries. Syringe inoculations of yellow rust (*Puccinia striiformis*) were again carried out on spreader rows in the F_3 and F_4 progeny nurseries. Although these were successful, the disease failed to develop into a widespread epidemic in the breeding material and, consequently, only localised selection for yellow rust resistance was possible.

One barley variety, Esk (SPBS MM 39/16) completed National List Trials but because of its unsatisfactory performance and a distinctness problem was withdrawn from further trials. Five varieties completed the first year of National List Trials. One, SPBS 63/4/1/13 was withdrawn because of problems with uniformity of stocks. Two further varieties, SPBS 4/200/5/90

and SPBS 213/11/4, had stocks which were infected with *Helminthosporium gramineum* and were rejected from the DUS plots by the testing authority. One of these, SPBS 213/11/4, will be resubmitted in 1981. Two further varieties, SPBS 648/18/85 and SPBS 648/18/68, satisfactorily completed the first year of National List Trials and will continue to be tested in 1981. Their performances in 1980 were encouraging.

In 1980 a series of discussions led to the setting up of a common trials system between the three ARS Institutes engaged in spring barley breeding. At the stage before submission to National List Trials a Joint Main Trials (JMT) Series containing many of the likely candidates for National List submission was grown. These trials were grown as 7 × 7 lattice squares in three replicates at twelve sites (five centred on SPBS; five centred on PBI; and two centred on WPBS). The entries in these trials were also extensively tested in disease nurseries at each centre. Submissions made for National List Trials in 1981 were therefore based on more information than it was previously possible to provide. From these trials three National List Trial submissions were made for 1981. SPBS 650/15/18 ((Akka × Maris Mink) × Maris Mink) is a high yielding selection with semi-prostrate juvenile growth habit that combines medium maturity with good mildew resistance and adult plant resistance to both yellow and brown rust. Results from micro-malting tests suggest that it also has potential malting quality. SPBS 297/1/2/3 (Trumpf × Ark Royal) is also a high yielding selection with the semi-prostrate growth habit. Though late maturing, it combines good mildew, yellow and brown rust resistance, with potential malting quality. SPBS 176/293/34 (Ark Royal × Trumpf) is an early maturing semi-prostrate type that consistently out-yielded Golden Promise. It also combines good disease resistance with potential malting quality.

Entries into JMT in 1981 include selections from the following crosses: Georgie × Trumpf; Trumpf × Aramir; Trumpf × Hassan; Trumpf × HB855/467/7; Universe M32 × Ark Royal; (Akka × Mink) × Aramir; (Akka × Midas) × Hoppel; (Georgie × Porthos) × Minak; and (MM23 × Aramir) × Trumpf. Some 180 stocks from more than 30 selections originating from some 600 entries in preliminary trials in 1980 will be entered into intermediate trials and multiplication in 1981. In addition, some extra selections from the preliminary trials will be put through an extra generation of single plant selection and evaluation in 1981 for possible entry into intermediate trials in 1982.

Nurseries totalling some 20,000 F_3 progenies were grown in 1980 using two main sowing methods. In one, each progeny was sown as a paired row using the Scottish plot seeder with controls at the end of each bed and the frequent occurrence of disease spreader rows. In the other method each progeny was sown as a small 3-row plot, using the twin-plot Øyjord drill, with a diagonal arrangement of controls. Both systems have advantages and disadvantages and it is probable that both will continue to be used. For the first time, all of the selections from the F_3 nurseries have been screened using

the Comparamill to identify lines with low milling energy and hence potential malting quality. A total of 170 substantial F_2 populations was sown using the adapted Monosem spaced-plant seeder. It was felt that this system, with four drills within the tractor wheelings, together with a subsequent sowing of a fifth control row using a hand-pushed Mini-Nibex drill greatly improved single plant selection at F_2.

A further result of the collaboration between SPBS, PBI and WPBS in spring barley breeding was the exchange of F_4 selections between Stations. These were grown as small rows for selection and evaluation at each site. SPBS received a total of 1,600 selections from PBI and WPBS and more than 40 selections from this material will be further evaluated in 1981. The benefits of this scheme are two-fold. First, it will provide extra information for selection at the F_4 generation by the originating centres. Secondly, it will ensure that material discarded by the originating centre can be assessed for its potential in different environments if the collaborating centres wish to continue evaluation.

A series of split-plot trials was carried out in 1980. Entries comprised named varieties, some of our National List entries and pre-National List entries. Main plots were split for the presence or absence of a fungicidal seed dressing. Heavy epidemics of mildew developed at two sites, and whereas some named varieties showed a yield benefit from the seed dressing, our breeding entries generally did not exhibit a similar effect. This was presumed to be due to their effective genetic resistance to mildew.

A series of four trials was grown in 1980, each evaluating 40 barley genotypes from the station collection, chosen for their early maturity, or shortness of straw, or good disease resistance, or high malting quality (low milling energy). Ten control varieties common to each trial were also included. (A similar series of oat trials was also grown.) Yield performances and agronomic attributes were recorded for these trials and single plants were recovered from each plot to assess a number of additional attributes in the laboratory. These trials are part of a deliberate attempt at diversification within the breeding programmes, evaluating selected genotypes from the Station collection as potential parents.

The station continues to use facilities in New Zealand provided by the Crop Research Division of the DSIR. This year 5,000 lines are being grown, mainly from the F_3 and F_4 generations and R. J. Giles will select the most promising to return for trials at SPBS in 1981.

Edge effects (*Ann. Rep. 1979-80*, 63) were not very apparent in 1981. Consequently no further progress with this study has been possible. Progress will be delayed until another suitable season occurs.

There was a change in the location of some off-station sites in 1980. It was felt that both Cockle Park and Aberdeen were too remote to be serviced and assessed economically. These sites were replaced by Ayton (near Eyemouth, Berwickshire) and SCRI (Invergowrie, Dundee). It is now possible to visit the Queenstonbank and Ayton sites or the Rossie and SCRI sites in one day.

There is a need to increase our efficiency in data-handling procedures. Besides extensive use of the CVT package in the design and analysis of trials and nurseries, various computer programs have been written to aid the general administration of fieldwork. Furthermore, a station requirement for efficient data-logging methods and associated work with micro-computers has been identified and is being developed by the Statistics Unit. Balances have been bought for interfacing with Apple II micro-computers and these, together with hand-held data-capture terminals are being assessed for the field scoring of trials.

WINTER BARLEY

The first winter barley breeding material was sown as spaced plants at F_2 and selection was practised for the presence of a dwarfing gene, usually (but not always) the erectoides gene from Golden Promise, and other desirable agronomic characteristics. Approximately 2,000 F_3 progenies were autumn-sown in October under good conditions. At F_4, breeding material was exchanged with the PBI, Cambridge. In 1979, 325 progenies were autumn-sown and scored for a number of agronomic characteristics in 1980. This year, 365 progenies have been sown for the same purposes. A winter barley yield trial was also grown as a part of the agreed exchange of breeding material and 22 lines from advanced generations were examined. A trial containing 28 winter barleys was also grown as a part of the BAPB series of National List Entry trials. These provided valuable experience and information for winter barley breeding. Two similar trials were sown for 1981 but a decision has now been taken to stop winter barley breeding in Scotland and thus responsibility has now been transferred to PBI, Cambridge.

Oat Breeding

For a second year Fyne has received a Provisional Recommendation by NIAB for use in England and Wales. However, it has failed to be placed on the Scottish Colleges Recommended List and will not continue any further in their trials. The merits of Fyne have already been outlined (*Ann. Rep. 1979-80*, 64).

The breeding and experimental material was early sown and avoided frit-fly (*Oscinella frit*) attack at the seedling stage, with the exception of the F_2 material which required preventative spraying. The use of heavily infected transplants encouraged a heavy epidemic of oat mildew (*Erysiphe graminis* f. sp. *avenae*) among the breeding and experimental trials. An epidemic of crown rust (*Puccinia coronata*) spread from the disease nursery onto the late sown breeding material but this occurred too late to be useful on the early sown material.

The most advanced material from the pedigree breeding programme entered F_4 yield trials in 1980. A number of lines combining early maturity, resistance to powdery mildew and short stiff straw with high yield were identified from the F_4 material. The most promising emerged from the cross Leven × Omihi. The F_4 progeny rows of the selected bulks were evaluated for the same characteristics and the resultant selections will enter trials in 1981. The bulks from the trial plots will be grown in a number of off-station trials in 1981 to further evaluate their potential. Worthwhile selection was possible in the F_3 nursery and the selections will be advanced to yield trials and progeny plots in 1981. Owing to a late sowing followed by low rainfall in April and May, the F_2 nursery suffered irregular germination. Assessment of maturity and stature was difficult, though worthwhile selection for resistance to powdery mildew was possible, together with some selection for crown rust resistance.

It was felt that the spring oat crop warranted a greater input (*Ann. Rep. 1979-80*, 64) and consequently, in order to broaden the genetic base, the crossing programme included diverse lines from the oat collection, together with more conventional parents, to provide sources of variation to satisy the selection criteria necessary to meet the objectives for oats in Scotland. Large F_2 populations of a number of pair crosses have been produced and will be grown in 1981. To further extend parental choice, the four yield trials with common controls already described under Spring Barley Breeding were also grown.

Single plants recovered from each row of the genetic experiment (*Ann Rep. 1979-80*, 65) were scored for a number of characters relating to morphology, yield and quality. Preliminary analyses of some of the characters suggest relatively simple patterns of inheritance, although the results await the full model-fitting analyses. The investigation of cross-prediction in barley is being extended to oats. Five pair crosses (Omihi × Maris Tabard; Karin × Trafalgar; Otee × Maris Tabard; Karin × a dominant short-strawed mutant, and Omihi × Forward) have been chosen for F_2 triple test cross analysis in 1981. The information obtained will complement that obtained from the model-fitting analyses.

Avena sativa is a natural allohexaploid ($2n = 6x = 42$) and triplication of genetic material enables *Avena* to tolerate loss or addition of entire chromosomes without disastrous phenotypic consequences. Fifteen monosomic lines of Sun II have been crossed with a dominant short-strawed oat mutant. The resultant F_2 populations will be used for genetic analysis of the dwarfing gene and to identify the chromosomal location(s) of this and other genes present in the mutant.

Cereal Pathology

Powdery mildew (*Erysiphe graminis*) developed early in the season

throughout the trials area, encouraged, in barley, by the early autumn sowing of a surrounding strip of Maris Otter and by the widespread use of a susceptible spreader variety and, in oats, by the introduction of inoculum on infected seedlings from the glasshouse. The disease was well established prior to the onset of wet weather that persisted from June onwards and effective selection for resistance was possible. Data from mobile barley seedling nurseries indicated that the relative frequency of most of the different virulence factors in the pathogen population was the same as in previous years (*Ann. Rep. 1979-80*, 62). However, virulence for BMR group 4 (Vada virulence) was less and that for BMR group 6 (Ark Royal virulence) considerably more common than in 1978 and 1979.

Disease nurseries were established for yellow rust (*Puccinia striiformis*), brown rust (*P. hordei*) and leaf blotch (*Rhynchosporium secalis*) of barley as well as for crown rust (*P. coronata*) of oats. Following syringe inoculation with a widely virulent race (24 VV, islolate 75/101) at the two-leaf stage, yellow rust developed rapidly in a spring-sown nursery without the need for overhead irrigation. Crown rust progressed more slowly but eventually produced a severe epidemic late in the season and an assessment of the reaction of approximately 1,000 accessions in the oat germplasm collection to Race 251 of this disease was possible. Autumn-sown strips of a *Rhynchosporium*-susceptible winter barley were inoculated in November and February with finely-chopped, infected straw and test entries were sown in this nursery in late April. Mildew control, but no irrigation, was necessary this year. High levels of disease were recorded on susceptible entries throughout the nursery at heading.

For the first time this year the SPBS participated in a co-operative venture with PBI and WPBS in which some 40 advanced breeding lines of spring barley from the three institutes were tested for their resistance to a number of foliar diseases at each site. This provided extensive and valuable information on the performance of these lines against different pathogen races and in different environments.

Selection for partial mildew resistance (PMR) in agronomically well-adapted spring barley genotypes continued. (See *Ann. Rep. 1979-80*, 62). Thirty lines from the barley germplasm collection were grown in a replicated field trial in which individually spaced seeds were dibbed in rows alternating with a mildew susceptible "spreader" variety. Inoculum with a wide range of virulence factors was introduced from the glasshouse on infected seedlings and the progress of the epidemic monitored throughout the growing season. High levels of disease were recorded on susceptible control varieties. The majority of putative PMR selections was susceptible as seedlings but exhibited increasing degrees of resistance at later growth stages. Twelve genotypes were selected for further study as showing high levels of adult plant resistance.

Seedling tests with isolates of known virulence revealed the presence of some common major resistance genes in several of these twelve PMR test

lines. However, data from mobile seedling nurseries indicated that the frequency of corresponding virulence factors in the pathogen population at the Murrays was relatively high in all years in which PMR was selected.

The development of resistance in mature plants was confirmed in artificial inoculation experiments. Detached leaf segments from glasshouse-grown plants of different ages were inoculated in a settling tower, using a single isolate virulent on all twelve PMR hosts. Some resistance was detected in the first, seedling leaf but its magnitude increased successively in later developed leaves. On seedling leaves the resistance was found to be due to a reduction in the number of sporulating pustules (infection frequency) accompanied by, in the majority of cases, lower spore production per pustule (sporulation intensity). Further work is in progress to determine the relative contribution of an extended latent period to this type of resistance and to examine the components of resistance in older leaves.

A crossing and backcrossing programme, involving several PMR genotypes and a common, mildew-susceptible parent variety was carried out in the glasshouse this year with a view to implementing a small-scale genetic investigation and a programme of selection in the field in 1981.

The selection and identification of novel sources of major gene resistance for incorporation into the breeding programme continued, in both field and glasshouse trials.

Estimating spore production by foliar pathogens has become increasingly important as a means of detecting small differences in resistance that may be epidemiologically significant. Preliminary work in collaboration with the Chemistry Division suggested that it may be possible to rapidly estimate spore numbers of barley powdery mildew by infra-red reflectance. Aqueous suspensions of spores from detached leaf segments were dried on glass-fibre filter disks and scanned in the Neotec 6350 infra red analyser (*Ann. Rep. 1979-80*, 31). At certain selected wavelengths, predictions by this method were highly correlated ($r > 0{\cdot}9$) with estimates derived from counts of the same samples on a haemocytometer slide (over the range 0–20,000 spores). Further work is in progress to improve methods of spore collection, to establish that the wavelengths selected for optimum prediction have widespread validity and to extend the technique to other foliar pathogens of barley.

Cereal Collections

Small increases over the year have brought the barley and oat collections to 3,068 and 1,167 entries respectively. Both collections were spring-sown at the Murrays and, in addition, were grown in disease nurseries as hill plots.

An experiment was conducted to examine the relationship between the amount of photosynthetic tissue produced at the earliest stage in plant

development, the first leaf, and floret production, expressed as a proportion of the total number of primordium initials which survive in the mature plant. The average length of first leaves, measured in a sample of each variety in the barley collection, was used to identify ten varieties exhibiting a range of first leaf sizes but otherwise having similar morphology. The number of primordial initials was counted through the growing season and compared with subsequent counts of florets per ear in mature main tillers. It was not possible to detect any significant correlation between first leaf size and eventual primordium number or ontogenetic destiny.

ARC DATA BANK

Updating has resulted in the deposit of some information for every genotype in the barley collection. This represents a significant improvement over the previous year and will provide a useful breeding and research tool for plant breeders.

COMPUTER PROGRAMS

The most significant progress in the development of software for the cereal collections has been the drawing together of several programs into one package. This is designed to cater for the maintenance and cataloguing of all stock information, and for the production of lists, field plans, harvest labels and other useful functions. The new package utilises a data base structure whereas formerly collection information was stored on a number of separate computer files. Since the work has become increasingly computer based there has been a requirement for this type of software which would enable an operator without computer training to manipulate the necessary software. A package is also under development which will meet the needs of data handling for the collections. This too draws chiefly on existing programs, and may have wide applications in the department.

DAFS Package 1
ARC Projects 04001–04004 inc.
04006–04008 inc.
04013–04015 inc.

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POTATO DIVISION

Of the four varieties which were in second year National List Trials, Provost, Baillie and Sheriff continued to perform well in our trials and in those of collaborators. Official reports are expected later in the year. In the case of Guardian, however, further evidence accrued of this variety's liability to growth cracking of the tubers. This defect, which has occurred occasionally at different sites and in different seasons, can affect a high proportion of the tubers. The further evidence of this weakness during 1980 led to a review of the prospects for Guardian and a subsequent internal decision to withdraw it from official trials.

The performance of Baillie was again very good in trials in Spain and arrangements have been made to enter it into official registration trials in that country.

The two clones in first year National List and Plant Varieties Rights Trials have been provisionally named Fiona (8911 abc 15) and Elsa (9006(6)).

There were no new submissions to Statutory Trials in 1980.

The future of our small trials and selection programmes in Spain has been under review during the year. Hitherto this work had been financed by our collaborator, the NSDO agent, Matutano S.A. A formal commitment is still awaited, but it seems likely that NSDO will henceforth assume part financial responsibility for trialling clones from SCRI, PBI and DANI at four sites in Spain. Restriction of entry to clones which have reached, or are within one year of reaching, British National List Trials, will severely limit the entrants to clones which have been bred and rigorously selected for adaptation to British conditions. Although we should prefer to see our interests in overseas markets expand rather than contract we are nevertheless thankful for this opportunity to maintain a working link with potato activities outside the United Kingdom.

It is a pleasure to record the continuation of our collaborative relationship with the potato processing industry through the Technical Committee of the Potato Processors Association. The Committee undertook a detailed assessment of clones for crisping and chipping purposes and reported their findings in some detail for which we are very grateful. It is particularly valuable to have independent assessments of processing value which are made under factory conditions and after commercial storage. At our annual meeting with the Committee they offered continued collaboration for 1981 although on a necessarily reduced scale.

The first year of joint SPBS/PBI regional trials was successfully completed. We are grateful to our colleagues at Cambridge and are currently engaged with them in a study of how we might extend the scale and scope of

our collaboration in future.

On the subject of collaboration it is appropriate to record here an acknowledgment of our debt to Mr Eric Allen and his colleagues of the University College of Wales, Aberystwyth, for their outstanding help over the past six years, in the multiplication of stocks and in the planting and management of our first-early trials in Pembrokeshire.

The screening of the Commonwealth Potato Collection for potato spindle tuber viroid (PSTV) has been completed and we have received confirmation from the Department of Agriculture and Fisheries for Scotland, Agricultural Scientific Services, that all material in the CPC may be regarded as free from infection by PSTV, that is to say that, given the detailed procedures for ensuring phytosanitary security defined by DAFS and observed by us during the whole ten year screening process, all material surviving in the Collection has either been tested and found free from infection, or alternatively has been derived from parents found free of infection.

Distribution of germplasm has been resumed at a low level in recent years from those parts of the Collection which had passed through the screening process. There have been no accessions since 1970. Now that the PSTV screening is at an end the time has come to reactivate the CPC as a major potato germplasm collection, receiving new accessions and resuming its role as an active distributor of research and breeding material on an international scale.

Work in the Strategic Breeding Department has concentrated almost wholly on the evaluation of material developed from South American cultivated diploids and tetraploids. This group of materials includes Neo-Tuberosum, Neo-Tuberosum × Tuberosum hybrids, diploid clones developed from *S. phureja*, diploid (Phureja × Dihaploid) and tetraploid (Phureja × Tuberosum) hybrids and tetraploid hybrids derived from disease resistant dihaploids crossed with selected tetraploid Tuberosum clones. Extensive disease resistance screening was done on this material and yield and rate of bulking trials were made on clones of which sufficient seed was available. Multiplication of other clones was done to provide seed for replicated trials in 1981. It is not possible yet objectively to assess the potential of this body of material as a potato breeding resource, since quantitative data are still scanty. However, visual assessments of rate of canopy development diversity of canopy form, tuber shapes and size distributions together with estimates of yield, bulking rates and tuber quality are all very encouraging. A demonstration of some of this material aroused great interest among European potato breeders attending the joint EAPR/Eucarpia potato breeding meeting held in Edinburgh in June.

As usual the greater part of the work of the Potato Pathology Department was concerned with the application of established screening techniques for assessing resistance/susceptibility reactions to viral, fungal and nematode pathogens. Although it is of a routine nature it is important to recognise the significance of this screening work to the commercial and strategic breeding

programmes. They are both orientated towards disease resistance breeding, although in different ways, and are heavily dependent on the closely integrated collaboration of the Pathology Department. In an annual report of the Division's work there is a tendency to confine comment to new varieties, new techniques and research findings and to omit reference to those parts of the work which lack novelty. In a team activity such as plant breeding this would be unfair and I record with pleasure that as usual the Department increased both the quality and quantity of its contribution to the Division's work.

However, in addition to routine, there were interesting developments in new screening methods. As noted in the *Annual Report 1979-80*, 68, when screening for reaction to TRV and PMTV by means of field trials, good results are infrequent and there is a need for laboratory or glasshouse tests which can be conducted under controlled conditions. Preliminary work during the past year has revealed a promising new approach to controlled screening for each virus. In addition further progress was made in establishing a screening test for tuber soft rot due to *Erwinia* and also for potato cyst nematode resistance in pot grown seedling populations, as an aid to assessing genotypic breeding value of parents.

Continued work on the application of enzyme-linked immunosorbent assay to the problems of screening large numbers of genotypes in a breeding programme is now revealing the particular merits and apparent limitations to the application of this serological technique. For example it seems unlikely that it will be possible, as had been hoped, to screen tubers for the presence of PVY or PLRV, because of variable but usually large background reactions. Nevertheless, it is clear that it will have an important part to play as a sensitive test of foliage infection.

J. H. W. Holden

Commercial Breeding Department

THE 1980 CROSSING PROGRAMME

In view of the failure to secure sufficient seed in previous blight resistance crossing programmes (*Ann. Rep. 1979-80*, 68), an extensive blight resistance crossing programme was attempted in 1980, with three objectives in mind. These being: to hybridise a number of blight resistant clones of proven value (by progeny testing) with each other to build up a pool of blight resistant material of known genetic worth; to intercross a number of resistant clones of unknown breeding value with each other, and with resistant clones of proven

value, to obtain progenies from a more speculative provenance which, when their blight resistance status is ascertained, will enable us to identify new sources of resistance; and to hybridise all of these with a sample of named varieties such as Croft, Cara and Desirée for straightforward commercial breeding purposes, with an emphasis on blight resistance. A maximum of 255 crosses was theoretically possible in this schedule, 224 were attempted and 198 were successful. The only significant gap in the schedule was due to the National List clone 9006(6), which is very resistant to tuber blight, but which failed to produce flowers until too late in the season for crossing purposes. With this exception this crossing programme has been extremely successful and has provided a substantial stock of seed for research and breeding purposes. The first samples of seed will be screened as seedlings for resistance to foliage blight this season by the Pathology Department.

There is now a fairly extensive pool of potato cyst nematode (PCN) resistant material in the SPBS programme deriving its resistance to *G. pallida* from *Solanum vernei* (this report p. 101). However, there is paucity of the *S. andigena G. pallida* resistance (H_3) and in view of this an attempt was made to regenerate a source of H_3 type resistance within the programme by intercrossing clones known to possess the H_1 gene (resistance to *G. rostochiensis*, pathotype Ro1) and the H_3 type resistance to *G. pallida* and crossing them with a selection of standard parents such as 3683 a 2 (blight, leafroll and virus Y resistant) and with several advanced clones possessing PCN resistance *ex. S. vernei*. This too proved a very successful schedule, seed having been secured from 146 of 155 potential crosses; it should provide a valuable source of material both for selection and research into the nature of the inheritance of resistance to PCN.

For some time now the major emphasis in breeding for PCN resistance has concentrated on those sources deriving from *S. andigena* (H_1 and H_3) and *S. vernei*. Other sources such as H_2, *ex. S. multidissectum* were abandoned as having only limited resistance to a specific pathotype, British B, thought to be rare and therefore of limited value (Dunnett, J.M., *Ann. Rep. 1961*, 39–46). In the long term, such sources of resistance may prove of value either in their own right or as supplements to H_3 and/or *S. vernei* types of resistance. With this in mind a number of museum clones possessing the H_2 gene were intercrossed with each other, with a selection of H_3 and *S. vernei* derived resisters and a series of standard parents; of 163 possible crosses, 133 were attempted and seed secured from 109; thus concluding an extremely successful year in the pollinating glasshouses.

VIRUS RESISTANCE

In view of the very large and successful crossing schedule of 1979 (*Ann. Rep. 1979-80*, 69) no further crossing schedules in this specialised area of the breeding programme were carried out or are planned until data from the

results of that schedule are available and interpreted. As a first step in this direction it was decided to sow samples of those progenies deriving from crosses between virus resistant clones and the varieties Maris Piper and Pentland Squire, both of which are immune to virus X (PVX) but neither of which possess comprehensive resistance to virus Y (PVY). By inoculating these seedlings separately with PVX and PVY and examining the proportions of resistant : susceptible individuals amongst the progenies it was expected that some conclusion about the genotypes of the non-recurrent, virus resistant parents, might be drawn. Preliminary interpretation of the data is encouraging and on the basis of the segregation ratios observed a number of clones have been identified which appear to be duplex for one or other of the comprehensive PVY resistance genes available in this material (see Pathology Report, p. 94).

From the 8,000 single tuber plots planted at the Murrays in 1980, 570 have been selected for further multiplication and selection in 1981; 107 of 420 third year clones have been selected and will be sent to Cambridge for field exposure to Potato Leaf Roll Virus (PLRV) in 1981 and 81 clones have been retained to await the results of their field exposure in 1979. The 1979 data from the 1978 field exposure trial suggested a very high level of aphid infestation and though a number of clones have been identified as possessing very high levels of PVY resistance most, including the control (Pentland Crown), succumbed to PLRV and apart from twelve apparently very resistant clones, it was not possible to differentiate between susceptibles and moderate resisters. The twelve apparently PLRV resistant clones will be resubmitted for trial in 1981 and if their resistance is confirmed in 1982 may be useful for breeding purposes but none was considered sufficiently "commercial" to submit for evaluation as a potential variety in the commercial breeding programme.

Several advanced and proven virus resistant clones are now being evaluated in the commercial programme and though this year's data are not yet fully interpreted some clones are showing promise and will continue to more advanced stages of evaluation.

FIRST EARLIES

The 1979 first early breeding programme provided ample seed for selection purposes and no further crosses were attempted in 1980. The first sowings from this programme are now undergoing clonal selection and as data become available additional sowings of the better progenies are anticipated.

POTATO CYST NEMATODE RESISTANCE

The successful development of a seedling test to assess the PCN resistance of different progenies (see Pathology Report, p. 101) may have a significant

effect on the efficiency of the breeding programme. The test has been initially applied to the 1979 crossing schedule which was sown during the summer of 1980. The 100 progenies tested exhibited significant differences with regard to levels of resistance to *Globodera pallida*. Tuber samples were also taken from the glasshouse seedlings of the same progenies and tested by the Pathology Department; the results of these canister tests are awaited to confirm the validity of the seedling test. Nine of the progenies have been identified as possessing high levels of resistance and further sowings of these are planned for 1981. The future utilisation of a seedling test promises to shorten the breeding/selection cycle and also to improve the genotypic selection of parental material.

The overwinter screening of third year clones (M_1) with resistance derived from *S. vernei* and *S. andigena* proved slightly disappointing with only thirteen per cent of the material exhibiting useful levels of resistance (less than fifteen per cent cyst number of controls). This is offset by a large number of clones derived from *S. vernei* with high levels of resistance in the 1980 M_2; of 162 clones approximately one half had confirmed the same high levels of resistance that were observed in the M_1. Sixty of these clones will progress into the M_3 for further commercial assessment.

At more advanced stages of assessment eight clones with potentially useful levels of resistance to both *G. rostochiensis* and *G. pallida* are progressing into regional trials in 1981, prior to consideration for NLT submissions.

QUALITY TESTING

All clones in the commercial breeding assessment stages M_1 to M_4, the regional trials and material from the Strategic Breeding Department were routinely tested for cooking quality, and crisping (colour) as usual.

Despite the rather cold wet summer specific gravities (dry matter) were, on average, higher than 1979, with the standard control cultivar (Record) having a mean of 1·095.

TRIALS AT THE MURRAYS

This year the Commercial Breeding Department plots were planted in Folly Field and by taking advantage of an area of lighter soil at the southern end of the field it was possible to complete the planting of the first earlies by 8th April. However, following a wet spring it was not possible to prepare the ground for the maincrop at the same time. Once the drills were drawn, planting proceeded without delay and was completed within four days by 25th April. An extensive dry spell following planting delayed emergence and threatened to negate the early application, post planting, of the herbicide, Sencorex (Metribuzin). However, a re-application of herbicide at half strength, post emergence, proved very successful, though one or two clones which were either more fully emerged or perhaps sensitive to this herbicide,

showed symptoms of damage. Weed control was successful.

Once the early summer drought ended emergence was rapid and a good canopy was established by mid-June. The higher than average rainfall led to higher yields than in 1979; Pentland Crown, the standard maincrop control, gave an average of 28·3 kg per plot, some 20 per cent higher than in 1979.

Harvest was later than in 1979 but proceeded with few delays and with the exception of the virus resistance programme all plots were lifted and stored by the end of October.

1980 REGIONAL TRIALS

In 1980 SPBS and PBI began joint trialling of their advanced material. This permitted more extensive trialling than previously, and allowed a direct comparison between SPBS and PBI clones. We are indebted to our PBI colleagues for their collaboration and look forward to continuing this successful venture in the future.

In first early trials a total of seven SPBS clones, three PBI clones and eight controls were grown. In south Wales the trial at Penrice was limited to eight entries, but at Trefloyne there were fifteen entries grown in a split plot design. This allowed two lifting dates, the first thirteen weeks after planting and the second two weeks later. In Scotland both trials, at Stranraer and the Murrays, had the same thirteen entries. 7169(10), Provost, which last year gave comparatively disappointing yields in Scotland, did rather better this year. At the Murrays it outyielded (in saleable ware tubers) four of the five controls including Maris Bard. Elsewhere it was outyielded by Maris Bard but the differences were not always statistically significant, and at each site it invariably outyielded some of the controls. 8906 abc (11), Guardian, did well at the Murrays, where it produced the highest saleable yield. It yielded well, too, at Penrice and at the first lift at Trefloyne. Unfortunately it did less well at Stranraer and at the second Trefloyne lift due to growth cracking, which much reduced the saleable yield. This tendency to growth cracking has been noted previously and has now led to an SPBS decision to withdraw Guardian from NLT. 9114 ce (2) continued to show promise and 10337 de (40), which was grown only at the Scottish sites, showed interesting potential. Fifteen unreplicated observation plots of less advanced material were also grown at the centres; data from these will allow selection of candidates for the 1981 trials.

The maincrop trials were grown at five sites; the Murrays, Gleadthorpe EHF, Terrington EHF, Arthur Rickwood EHF and Trumpington (PBI). Each consisted of eighteen SPBS clones, six PBI clones and four controls—Pentland Crown, Maris Piper, Record and Estima. Each entry was represented by a plot of 24 plants grown in three complete replications. 9006(6), currently in year one of National List Trials, outyielded (in saleable ware) Record at every site except Trumpington. Otherwise it was generally outyielded by the controls, although the differences were not always

statistically significant. There was a tendency to produce some cracked tubers and this was pronounced at Terrington. Its specific gravity was higher than that of Estima, but generally lower than the other controls. 9559 ab (2), the highest yielding clone, produced very satisfactory marketable yields, competitive with the controls. However, its specific gravity was the lowest of any entry, and its future will depend upon further critical assessment of its cooking qualities. More recently bred material showed high yields combined with satisfactory specific gravities, which augurs well for the future. Sixty unreplicated observation plots of M_4 material were grown at all sites except Trumpington. The most promising of these clones will be trialled in 1981.

As in 1979 the maincrop trials were laid out as generalised lattice designs, although for selection they were anlaysed as randomised complete blocks. The more complex generalised lattice analyses were made in order to assess the additional precision with might be expected from them. The results were encouraging although further comparisons are needed before the benefits of the newer design can be properly assessed.

SEED PRODUCTION

Planting of the high grade seed at Blythbank was carried out during the second week in May. To make more efficient use of the land this year the planted breaks were increased from nine to ten drills and the sprayways reduced to three drills from four. After planting, the three sprayway drills were split back to give two drills and a half drill on each side for the tractor to run on, so leaving 75 cm between the centre of the wheel and the first planted ridge. The system worked well with very little damage to the shaws; had four drill sprayways been used extra land would have been required to accommodate all the plots. Seven clones from the Department of Agriculture, Northern Ireland (DANI) were planted, to produce seed for the joint SPBS, PBI, DANI trials in 1981. Drochil Castle again provided a site for growing on a small number of clones for a health check before their entry to Blythbank. The cool wet weather encouraged the plants to grow well but slowly and disease in the stocks continued to fall, 0·5 per cent overall compared with 0·9 per cent last year. All the clones submitted for Approved Stock Certificate were granted the certificate.

Defoliation of the main areas of plots was carried out during the third week in August and the harvest began on the 8th of September. Considering the wet summer, harvest was remarkably easy and only one complete day was lost due to rain. The use of flat pallets on which the trays from the small plots could be stacked as the harvest proceeded facilitated the loading and off-loading of the trailers using the fork-lift truck, thus saving much time and double handling. It is planned to have enough pallets next year to allow all boxes to be handled and stored in this way. The completion of the ancillary building finished the building operations at Blythbank and the office, dining facilities and toilets are a welcome improvement. The ambient air cooling

system in the new store worked well. Comparing the temperature graphs of the sheds the new shed showed lower peaks in March and April when the weather started to warm up.

SUBMISSIONS TO NATIONAL LIST TRIALS

No new submissions were made in 1980. 8911 abc (15) and 9006(6), submitted in 1979 (*Ann. Rep. 1979-80*, 73), performed satisfactorily in SPBS trials in 1980 and they have been resubmitted for their second year of statutory trials; we expect a preliminary report from the NLT authorities in early Spring 1981.

Of those clones in their second year of National List Trials (*Ann Rep. 1978-79*, 59 and *Ann. Rep. 1979-80*, 67), Provost, Baillie and Sheriff have performed satisfactorily in SPBS and our collaborators' trials. Final reports on their performance in NLT are expected in June or July 1981. Guardian, however, had displayed a marked tendency to growth cracking under some conditions (see this report p. 91) and the decision to withdraw it from National List Trials was taken by the SPBS NLT Committee in Autumn 1980. Baillie continues to perform extremely well in Majorca and Spain (see this report p. 94) and the decision to submit it to the Spanish authorities for statutory trials was taken. Three hundred and fifty kg of seed tubers were sent to Spain in November 1980 for this purpose.

COLLABORATION

1. *Industrial Processors*

A full report on the performance of Sheriff (7495(6)), supplied for crisping evaluation trials in 1979 is still awaited (*Ann. Rep. 1979-80*, 75). However, the interest shown by the crisping industry in this variety leads us to conclude that it has performed very satisfactorily.

Further samples of 100 seed tubers of each of ten clones reaching the SPBS regional trial stage were supplied to the PPA and, following multiplication by them at Helmsley in Yorkshire, the ware so produced was assessed for various processing characteristics. Data from these evaluations have been received and are being interpreted. A meeting with the PPA technical group is planned for February 1981 at which the results will be discussed and plans for 1981 made.

2. *United Kingdom*

In addition to continuing our collaboration with ADAS, UCW and PBI for the routine trialling of advanced clones, Sheriff, Baillie, 9006(6) and 9559 ab (2) were also trialled for us by Mr J. Mason, ADAS, March; A. and H. Worth & Co. Holbeach and Saphir Foods Ltd., by arrangement through NSDO.

Data are still being received and all appeared to have performed up to expectations. 9559 ab (2) yielded extremely well in the trials of Mr J. Mason and as a second early maturity clone with H_1 resistance to *G. rostochiensis* (Ro1) is of real interest in his area. Unfortunately doubts about its cooking quality/consumer acceptability led to a decision to defer submission to NLT, pending more information.

3. *Overseas*

Samples of Provost, Baillie, Sheriff and Guardian have been dispatched to Algeria, Tunisia, Egypt, Cyprus and West Germany, by arrangements with NSDO, for preliminary evaluation in those countries; results are still awaited.

Baillie, 9735 a (23) and 10533 ab (14) were trialled in replicated trials and ten M_4 clones were grown in unreplicated observation plots at La Puebla, Majorca and Valencia, Spain. Baillie performed outstandingly well, outyielding all other entries at Majorca and equalling the control at Valencia. 9735 a (23) and 10533 ae (14) did not perform up to expectations, 10533 ae (14) failing particularly badly at Majorca where fewer than 25 per cent of the planted seed pieces emerged. The fact that at Valencia this same clone was the highest yielding entry underlines the necessity of multiple site trials.

On the basis of its performance and previous record, Baillie has now been submitted for Spanish National List Trials and 8911 abc (15) which performed well in the observation plots has been returned to Spain for replicated trial in 1981.

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SCREENING FOR RESISTANCE TO POTATO VIRUSES X AND Y

Progeny tests for resistance to PVX and PVY were done on 62 progenies of crosses with Pentland Squire and Maris Piper as recurrent parents (20,000 seedlings), to identify the best parents for future use in the breeding programme, and to select the Y resistant seedlings. The seedlings were spray-inoculated with virus, and the healthy survivors were sap-inoculated again later by hand to detect any susceptible "escapes". Eight parents were identified as duplex for Y resistance, and some X-susceptible parents were identified.

About 200 clones were screened for resistance to PVX and PVY (the common strain of each) by sap inoculation, and another 100 clones were

screened in more detail by graft inoculation with two strains of PVX and four strains of PVY.

FIELD TRIAL FOR RESISTANCE TO POTATO LEAFROLL VIRUS AND POTATO VIRUS Y

Replicated plots of 400 clones were interspersed with infector plants in a trial at the Plant Breeding Institute, Cambridge, in 1979. Samples of the tuber progenies were grown on in 1980 and scored for secondary symptoms of PLRV and PVY by visual recognition, and in cases of doubt ELISA tests were done. Infection levels with both viruses were high, even in the resistant control variety Pentland Crown, of which 62 per cent of the plants had PLRV and 58 per cent had PVY.

Some clones appeared to have very good leafroll resistance, with only one or two plants infected out of twelve, and five clones showed no leafroll infection. Two of these were from crosses made for virus resistance, and three were Neo-Tuberosum. Two clones bred from *Solanum phureja* appeared to have very good field resistance to PVY, since a greenhouse test had shown that they have no major gene resistance. One of these clones was also free of leafroll.

SEROLOGY

In collaboration with Dr D. G. Rose (DAFS) a comparative study was made of ELISA (enzyme-linked immunosorbent assay) and SSEM (serum-specific electron microscopy) for detecting PVY and PLRV. SSEM is more time-consuming but was found to be more sensitive than ELISA, and therefore useful as a confirmatory test where ELISA results were doubtful due to a low concentration of virus or a high background reaction. Variable background reactions in healthy sap have continued to prevent reliable testing of tubers and sprouts with ELISA, particularly tubers, and attempts to eliminate these effects have been unsuccessful. The diversity of clones to be tested aggravates the problem, for there is a large variation between clones in the level of virus in sap from infected tubers, and in the background reaction of healthy tuber sap.

Leaf samples were taken from many plants in the 1979 field exposure to PLRV and PVY and ELISA-tested for both viruses. Where every stem of a plant was tested they were very rarely all infected. Plants grown from excised eyes from daughter tubers of these tested plants were examined for secondary infection. It was found that only half the plants which subsequently passed on virus to their tubers had detectable levels of virus in the foliage at the time of sampling in mid-August 1979. For these reasons, and because of the many plants under trial (6,000 in the exposure year) and variability in the time of aphid arrival, it is not feasible to use ELISA to detect infected plants in the year of exposure. However, it has proved useful in cases where there was doubt about secondary symptoms in the following year. The test has also

been found useful for plants undergoing routine screening for resistance to PVY (when many plants can be tested at the same time), for checking miscellaneous field samples for virus infection, and for testing plants after attempts to eliminate virus infection by heat therapy and meristem culture.

THE SPRAING VIRUSES

Tobacco rattle virus (TRV)

A field trial was grown in infested soil at Tayport (Fife) in 1979. The mean incidence of spraing symptoms (based on presence or absence in each tuber) in 50 sub-plots of the susceptible control variety Pentland Dell was only 4·3 per cent, and 21 of these plots had no spraing. Nevertheless, 44 of 103 clones were identified as susceptible, many of them with more spraing than any Pentland Dell sub-plot. The rest are not necessarily resistant, but four advanced clones showed little or no spraing in any of four sub-plots, with infected Pentland Dell sub-plots nearby, and are therefore likely to be resistant. Twenty one other clones, including four maintained for their TRV resistance, and two Neo-Tuberosum clones, had no spraing in duplicate sub-plots.

Pentland Lustre and Croft still appeared to be resistant at this location as in previous years, with little or no spraing in four sub-plots. This conflicts with NIAB assessments, which rate them as susceptible. The resistant varieties Stormont Enterprise, Arran Pilot and Redskin showed only a low incidence of internal rust spot, which may be due to TRV. Pentland Squire showed some susceptibility, and Strath appeared slightly susceptible, or very susceptible if internal rust spot is counted as spraing. Baillie and Sheriff appeared fairly susceptible, corroborating the 1978 data.

In a glasshouse experiment carried out by Dr M. Waś, a visiting worker from the Institute for Potato Research, Młochów, Poland, detached leaves of several clones and varieties were sap-inoculated with TRV. The clones already known to be resistant were mostly found to develop distinct necrotic lesions on the leaves, whilst those known to be susceptible mainly showed either no lesions or indistinct ones. The same had been found with some Polish varieties at Młochów (Waś, 1980, *TagBer. dt. Akad. Landw. Wiss. 184,* 215–220). This suggests the possibility of a rapid preliminary test for TRV resistance.

Potato mop-top virus (PMTV)

A field trial for resistance to PMTV was grown in infested soil near Braco (Perthshire) in 1979. Twenty one clones out of 189 were identified as susceptible, but there was neither enough spraing nor subsequent haulm symptoms to conclude that the rest were necessarily resistant. The mean incidence of spraing in 34 control sub-plots of the susceptible variety Arran Pilot was seven per cent, and seven of these plots had no spraing. Only two

per cent of the Arran Pilot plants showed secondary haulm symptoms.

PMTV infestation was discovered in some proprietory peat-based compost. Preliminary trials with it indicate that infection with *Spongospora subterranea* (the vector), and also PMTV spraing symptoms, can be produced by growing tubers in pots or small closed canisters, but it appears likely that added inoculum would be necessary to obtain exposure uniform enough for resistance tests in such small containers, as the incidence of spraing was low.

APHID COUNTS

A weekly aphid survey was made in Folly Field at the Murrays from 3rd July to 6th August 1980. Each week 50 to 100 whole plants were examined. Relatively few aphids were found until 30th July when a heavy infestation with *Macrosiphum euphorbiae* was observed; 84 per cent of the plants were infested, one third of these with more than 50 aphids per plant (mostly apterous). The field was sprayed with pirimicarb on 1st August, and fewer aphids were found on 6th August; 27 per cent of the plants examined were infested, but with fewer than three aphids. The field was sprayed again with pirimicarb on 12th and 24th August and with demephion on 15th August. No aphids were found in the final survey on 20th August. No more than seven *Myzus persicae* (mostly apterous) were found on any occasion.

FOLIAGE AND TUBER BLIGHT (*PHYTOPHTHORA INFESTANS*)

Clones from the Strategic Breeding Department comprised a larger proportion than usual of the material tested in the glasshouse in 1980 for resistance to foliage blight. Thirteen per cent of 196 Neo-Tuberosum clones and eighteen per cent of 206 diploid clones showed good resistance, scoring six or more on the one to nine scale of increasing resistance. Of commercial breeding programme selections, fourteen per cent of 237 fifth year clones, none of which had been bred for blight resistance, showed this level of resistance, as did 38 per cent of 81 sixth year clones from blight resistant parents and eight per cent of 102 clones from other crosses. Thirty of 33 sixth year clones found resistant in 1979 were resistant also in 1980.

Progenies of virus resistant × blight resistant parents were screened in a seed-pan test to identify those progenies with the highest proportion of resistant individuals. An attempt was also made to identify seedlings with good foliage resistance by spraying a zoospore suspension on 400 six-week old seedlings of each of 34 progenies of blight resistant parents. Susceptible seedlings were removed after seven days and the survivors sprayed with Maneb and grown on in a glasshouse. To confirm the validity of this method of selection, tubers from these seedlings will be planted in a field trial in 1981 and the foliage resistance compared with that of unselected (for blight resistance) plants of the same progenies.

Routine laboratory assessments of resistance to tuber blight were made on

574 fifth year and more advanced clones from the commercial breeding programme. The plots of clones for the test were excluded from the Murrays routine blight fungicide treatments, but the incidence of blight in the maincrop clones was again too low to allow reliable assessment of susceptibility. The aggressiveness of the race of *P. infestans* used is being compared with that of other complex isolates in a further attempt to explain the failure of the test. An adequate level of infection was obtained in early clones, however, and 34 of 82 fifth year selections were as resistant as the resistant control variety Maris Peer, as were 24 of 45 sixth year selections and thirteen of twenty more advanced clones. A satisfactory test was also carried out on some 300 clones from the Strategic Breeding Department. The results for seventeen Neo-Tuberosum clones tested over two years showed close agreement, for seven of nine clones identified as resistant in 1979 were resistant also in 1980.

A field trial to assess the foliage resistance of advanced clones was carried out again at Yonderton Farm in Ayrshire. Four weekly observations on the progress of infection were made from 6th August. Of 30 early clones, seven showed resistance equal to that of Maris Peer, and nine of 70 maincrop clones were as resistant as Désirée, scoring five or more on the one to nine scale. As in previous years Sheriff proved particularly resistant, with foliage less than five per cent blighted whilst that of Désirée was 25 per cent infected. Ninety six diploid and dihaploid clones were also included in the trial, and the high resistance of the dihaploids, previously indicated by laboratory tests, was confirmed. Since levels of tuber infection in the field trial in previous years had proved too low for assessment of susceptibility, this year's assessments were confined to observations at lifting, and advanced clones were included in the routine laboratory test.

An examination was made of the effect of the habit of growth of plants in the glasshouse on their resistance to foliage blight. Plants are normally raised in five-inch pots tightly packed together on the greenhouse bench. Pots in the middle of the bench tend to produce tall straggly plants whereas those on the edge are shorter and more sturdy. Straggly plants were found to be more susceptible than sturdy plants of the same variety in five varieties tested.

Work on the effect of tuber age on the susceptibility of a range of varieties confirmed last year's findings (*Ann. Rep. 1979-80*, 78–81). Delaying inoculation of five early and five maincrop clones for one, two, four and eight days after lifting again reduced the level of infection, more so in some varieties than others. Lifting tubers at fortnightly intervals between mid-July and mid-September for five early varieties and between early August and early October for five maincrop varieties resulted in a decrease in the level of infection as the season progressed.

GANGRENE (*PHOMA EXIGUA* VAR. *FOVEATA*)

Routine cornmeal-sand tests were carried out on 1,053 clones from the

commercial and strategic breeding programme in the winter of 1979–80. A test on ten-tuber samples of 273 fifth year selections identified 26 very susceptible clones to be discarded. A ten-tuber sample of the sixth year clones had been tested the previous winter; the two years' results showed some agreement in that 136 of 170 clones received the same or adjacent susceptibility ratings in both years. A similar level of agreement was found in 57 of 70 clones which had been tested on twenty-tuber samples in both 1978–79 and 1979–80. Results from ten and twenty-tuber samples are being compared in the winter of 1980–81 to determine whether the sample size can be reduced to ten tubers.

Cornmeal-sand and cornmeal-peat cultures were compared as sources of infection in the standard rolling test. The mean disease score for three twenty-tuber samples of each of six cultivars, after ten weeks incubation at 4°C, was 2·0 after inoculation with cornmeal-sand and 0·8 with cornmeal-peat. Assessments were made on the nought to twenty four scale (see *Ann. Rep. 1978-79*, 66). Wounding the tubers with a nail-board before rolling in cornmeal-sand inoculum increased the mean disease score to 16·2.

SKINSPOT (*POLYSCYTALUM PUSTULANS*)

In 1979–80 resistance tests were carried out on clones from the sixth year of commercial selection onwards. As in 1978, tubers were surface-sterilised in two per cent formaldehyde solution and inoculated within two days of harvest. In contrast to the previous year (see *Ann. Rep. 1979-80*, 82) the clones showed a wide range of susceptibility, possibly because incubation (at 4°C) was shorter (for sixteen weeks instead of 21), and disease levels were therefore lower overall. Nevertheless, the range of susceptibility exhibited by the ten standard varieties was exceeded: thirty seven clones (of 272 tested) scored one on the one, three, five, seven, nine scale of increasing resistance, whereas the expected susceptible cultivars King Edward, Craigs Royal and Kerr's Pink scored five. Thirty nine clones were as resistant as Home Guard. Seven of the very susceptible clones had been rated very susceptible in 1978. Of four clones which appeared resistant in 1978, two received a rating of five, and two a rating of seven, when re-tested in 1979.

COMMON SCAB (*STREPTOMYCES SCABIES*)

In 1979 the resistance of fifth year commercial selections was assessed in polythene tunnels at the Murrays. As in 1978 the amount of scab varied between tunnels, and the overall level was too low to allow more than very susceptible clones to be identified, the susceptible control varieties having only some twenty per cent of tubers with more than one sixteenth of the surface infected.

Sixth and seventh year selections were assessed in a trial carried out at

Scoughall Farm, near Whitekirk, East Lothian. Of 256 clones, 43 per cent were rated as resistant, scoring seven or nine on a one, three, five, seven, nine scale of increasing resistance. Fifty seven of these clones had been assessed in trials both at Scoughall Farm and Archerfield in 1978. The level of agreement between the two years' results was poor, for although 35 clones had received the same or adjacent susceptibility ratings at Scoughall in 1978, only 28 had been similarly rated at Archerfield in 1978.

Eighth year and more advanced selections were tested at Archerfield in 1979; of 34 clones twelve showed resistance equal to or better than that of Pentland Crown. Clones from the Strategic Breeding Department were also included in the trial, and a particularly high proportion showed this level of resistance; 67 of 89 Neo-Tuberosum clones and all of 23 diploid clones.

DRY ROT (*FUSARIUM SOLANI* VAR. *COERULEUM*)

Thirty nine advanced clones with potential as processing varieties were assessed for resistance to dry rot in the winter of 1979–80. The tubers were wounded with a glass rod, rolled in cornmeal-sand inoculum and assessed after eight weeks' incubation at 10°C and 100 per cent relative humidity. Sixteen clones showed resistance equal to that of the most resistant control variety Pentland Ivory, and seven clones were more susceptible than Record.

A comparison was made between the susceptibility of twelve varieties to *F. solani* var. *coeruleum* and *F. sulphureum* in October 1979 and January 1980. The tubers (three boxes of twenty tubers per variety) were inoculated and incubated as described above, and the proportion of rotted tissue calculated on the nought to twenty four scale. The tubers were in general more susceptible in January than October, particularly to *F. sulphureum*. As already reported (*Ann. Rep. 1979-80*, 84) there were large differences in susceptibility to the two pathogens, Pentland Ivory and Arran Pilot being relatively much more susceptible to *F. sulphureum*.

WART (*SYNCHYTRIUM ENDOBIOTICUM*)

In 1979–80, 188 clones from the commercial breeding programme were tested by DAFS for resistance to wart. Eighty five per cent of 39 virus-resistant clones, 76 per cent of 55 sixth year and 90 per cent of 39 seventh year clones were found to be completely or partially resistant. Twenty five of 34 clones tested the previous year were given the same rating in both years; seven of the remainder varied between resistance grades one and two.

SOFT ROT (*ERWINIA CAROTOVORA* VAR. *ATROSEPTICA*)

The screening method developed in 1979 (see *Ann. Rep. 1979-80*, 84) has been used by Mr D. McCalmont to repeat Dr W. F. Bourne's work. Varieties

appeared to differ in their relative susceptibility during the winter, King Edward becoming more resistant with storage. An apparent correlation between resistance to tuber blight and soft rot is being investigated.

POTATO CYST NEMATODE

Screening for resistance

The closed container technique was used for all routine screening in 1980. Four hundred clones derived from *S. tuberosum* × *S. vernei* and *S. tuberosum* × *S. tuberosum* ssp. *andigena* were screened for resistance to *Globodera pallida* (? Pa_2), and 123 of them were also screened against *G. rostochiensis* (Ro1) using four canisters per clone. In addition 875 clones from the Strategic Breeding programme were screened against *G. pallida* (? Pa_2), using two canisters per clone. Six clones (0·7 per cent) from a random selection from the Strategic Breeding programme and 91 clones (23 per cent) from the Commercial Breeding programme for PCN resistance were less than ten per cent susceptible when compared with Pentland Crown.

Over 1,500 tubers representing 67 different progenies (25 tubers per progeny) grown from *S. vernei* × *S. tuberosum* seedlings were tested against *G. pallida* (? Pa_2) in small canisters. The mean number of cysts per progeny ranged from 24 to 160. This measure of resistance is being used to identify progenies with the most promising levels of resistance among those already planted as single plants at Blythbank.

Work continued on the development of a pot test suitable for screening bulks of seedlings (*Ann. Rep. 1979-80*, 85). Fifteen seeds from each of eighteen progenies derived either from *S. tuberosum* × *S. tuberosum* ssp. *andigena* (CPC 2802) or *S. tuberosum* × *S. vernei* were sown in pots with J.I. No. 2 compost previously inoculated with cysts to give 40 eggs g^{-1} of *G. pallida*. The cysts visible on the exterior of the root ball were counted after twelve weeks. Twenty five tubers were taken at random from a separate sowing of the same progenies and assessed for resistance in closed containers in the usual way. There was a significant correlation ($r = 0{\cdot}88$, $p < 0{\cdot}001$) between the mean number of cysts per progeny in each test. A larger test involving some 100 progenies is now being conducted to confirm these results prior to considering the introduction of this test on a routine basis, as an indication of which progenies contain useful levels of resistance to *G. pallida*.

Invasion and development

Invasion and development of *G. pallida* (? Pa_2) were investigated in the susceptible variety Pentland Crown and in two resistant clones 8917 b (3) and 12380 ab (2), which have a susceptibility of ten per cent and less than one per cent respectively. Sprouts were planted in canisters containing cyst-inoculated compost at levels of 10, 20, 40 or 80 eggs g^{-1}. Roots were examined at intervals between the sixth and the twenty seventh day. The

number of juveniles per unit length of root of Pentland Crown and 8917 b (3) increased over the first thirteen days and declined after twenty days, but did not differ significantly between these two clones. However, the rate of establishment of juveniles was significantly slower in 12380 ab (2) ($p < 0{\cdot}001$) at all sampling dates except the last. By the twentieth day, 85 per cent of juveniles in Pentland Crown had reached fourth stage or adult, but the corresponding figures for 8917 b (3) and 12380 ab (2) were 50 per cent and 40 per cent respectively. The number of females present at the end of the experiment correlated well with the susceptibility of each clone derived from pot tests.

Durability of resistance

In the spring of 1978, 1979 and 1980 outdoor plots containing Lindley E (? Pa_2) population (*Ann. Rep. 1979-80*, 88) were planted with 25 tubers of Pentland Crown, 8917 b (3) or 8906 abc (11). The latter clones have a susceptibility of ten per cent and twenty per cent respectively. After planting, 700 g of an organic based general garden fertiliser was applied to each plot. After natural senescence, foliage and tubers were removed and roots laid on the soil surface to be weathered before being rubbed (to remove the cysts) to estimate the initial population of potato cyst nematode in eggs g^{-1}, by sampling in winter 1978, 1979 and 1980. Results for the past three years are shown in Table 3. The P_f is still increasing under 8906 abc (11) and Pentland Crown, but not under 8917 b (3). There is, however, no evidence of a disproportionate increase under 8906 abc (11) which would lead to the conclusion that aggressive nematodes are being selected.

Table 3

Changes in the numbers of eggs of *G. pallida* (Lindley, ? Pa_2) in plots of three clones.

Clone		*1978*		*1979*	*1980*
		*Pi**	*Pf**	*Pf**	*Pf**
8917 b (3)	*eggs* g^{-1}	36	66	30	33
	range	(28–43)	(31–161)	(19–44)	(15–44)
8906 abc (11)	*eggs* g^{-1}	36	119	128	165
	range	(26–41)	(64–157)	(28–227)	(45–382)
Pentland Crown	*eggs* g^{-1}	59	543	685	828
	range	(40–90)	(357–769)	(373–894)	(612–1,002)

* *Pi* = initial population
* *Pf* = final population

Pathotype differentiation

As a result of successful meristem culture (*Ann. Rep. 1979-80*, 87) and multiplication, healthy stocks of most clones of the pathotype differential

series (Kort *et al.*, *Nematologica* 23, 333–339) are now available. These are intended for use in the national pathotype survey, and also for the definitive typing of populations in connection with routine screening and nematological research at SPBS.

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THE COMMONWEALTH POTATO COLLECTION

Over the 1979–80 winter the Plant Quarantine Authorities found evidence of infection with PSTV in a batch of eighty Collection lines under suspicion from previous tests (*Ann. Rep. 1979-80*, 88–89). The individual line involved was not identified, but all lines in that batch together with all possible contacts were destroyed.

All material now remaining in the Collection is confirmed by the Plant Quarantine Branch of the DAFS to be "derived from plants tested and found free from PSTV".

The approximately 420 lines cleared of suspicion over the 1978–79 winter together with others (previously cleared) from which insufficient seed had been obtained, about 550 lines in all, were grown in 1980 for the production of true seed. Over ten thousand pollinations were made and seed was obtained from about 240 lines, although only about 50 were adequately seeded in the sense that at least five plants of the line bore berries. Tubers of the others are being kept for replanting and further efforts to obtain seed.

Forty-six seed samples have been issued in the year, most of them to the SPBS eelworm resistance programme but others to the Universities of Aberystwyth and Birmingham and to the PBI, Cambridge.

EVALUATION OF STRATEGIC BREEDING MATERIALS

The Department's research and development programmes are now aligned towards evaluation of its products as a resource for commercial breeding (*Ann. Rep. 1979-80*, 88). All development work in Neo-Tuberosum is suspended while the properties of existing material are surveyed. In the diploid-dihaploid programmes some work continues on obtaining tetraploid derivatives, which as yet are inadequately representative of the variation available at the diploid level, but the emphasis is on evaluation of clones in hand.

Evaluations fall into three main categories: yield in relation to maturity,

taking account of tuber size and other agronomic properties; disease resistance; and culinary properties, including processing and nutritional aspects.

Considerable quantities of planting material are required for satisfactory yield evaluation, and hitherto the programmes have not involved large-scale multiplication of clones. However, following notification of the requirement for re-alignment of the programme, a Neo-Tuberosum multiplication planting was made in late June 1979 at the Murrays and this provided seed for three trials and a number of demonstration plots in 1980. Spare tubers from the commercial breeding programmes were used for experiments with Neo-Tuberosum × Tuberosum hybrid material. Fewer diploid-derived clones were available in adequate quantity, but a yield trial and an "earlies" observation planting were conducted and some demonstration plots were grown. Meanwhile, promising clones were multiplied at Blythbank for 1981 experiments.

Our allocations of testing facilities by the Pathology Department have been greatly extended, for some diseases ten-fold. Some clones have been sent to Israel for screening for resistance to *Verticillium dahliae*.

Evaluations of processing quality are being made by the PPA, and studies of protein and vitamin C contents commenced in the Chemistry Division. The Food Research Institute are unable to provide further assistance with flavour profiling (see *Ann. Rep. 1979-80*, 91 and 93).

SOUTH AMERICAN CULTIVATED TETRAPLOIDS (NEO-TUBEROSUM)

Three yield trials were conducted at the Murrays each with four replications and twenty tuber plots. One involved two Neo-Tuberosum "earlies" and was planted in early April and harvested in mid-July. The others, planted in late April and defoliated in mid-September, involved twelve Neo-Tuberosum clones and nineteen Tuberosum × Neo-Tuberosum hybrid clones respectively. Spacing was 38 cm between tuber centres in the "earlies" trial and 45 cm in the others.

In the "earlies" trial Gl.77M/54 significantly outyielded Pentland Javelin while Gl.76B/13 was inferior, yields being 19·1, 15·7 and 11·2 kg per plot respectively (± 1·07 kg).

In the Neo-Tuberosum maincrop trial maturities ranged from slightly earlier than Record to slightly later than Croft and were not overtly associated with yields. Total yields ranged from 22 to 37 kg per plot (± 1·2). The highest yielding clone was a Neo-Tuberosum selection but four of the five control varieties, Pentland Crown (36 kg), Maris Piper (35 kg), Majestic (35 kg) and Croft (34 kg) outyielded all the other clones; however, Record, with 28 kg, was outyielded by six Neo-Tuberosum clones. The proportion of undersized tubers was generally small but Majestic, Croft and Pentland Crown together with some of the clones had many oversized tubers. When attention was restricted to yields in the ware size range (40–80 mm) the

relative performances of the clones appeared better with eight outyielding Majestic and five of those eight also outyielding Croft. Specific gravities fell mostly between the 1·087 of Record and the 1·077 to 1·079 of the other control varieties. The highest yielding clones for both total and ware yields, Gl.76B/92, was one of the earliest maturing, slightly earlier than Record.

In the trial of Tuberosum × Neo-Tuberosum clones there was a wider range of maturities, from as early as Pentland Javelin to later than Maris Piper. Total yields ranged from 22 to 45 kg per plot (± 1·8) and tended to be lower on the earlier maturing clones, although the latest maturing clone was also low yielding. All but two of the nineteen clones, the earliest and the latest, significantly outyielded the 23 kg of Pentland Javelin. As in the Neo-Tuberosum trial, the control varieties (except Maris Piper) had many oversized tubers and for yields in the ware size range (40–80 mm) the relative performances of the hybrid clones appeared still better. Thirteen clones had specific gravities exceeding the 1·077 of Pentland Crown, other control varieties having lower values.

The clones in this trial derived from seedlings raised in 1975 and had survived selection in the commercial breeding programme up to 1979, when they were finally discarded after assessment for a wide range of characters. Other clones deriving from the same progenies remain under selection at an advanced stage in the commercial programme.

The very good performance of the Tuberosum × Neo-Tuberosum hybrids could in part be due to hybrid vigour. To investigate the question of hybrid vigour and its converse, inbreeding depression, a small trial involving the selfed and intercrossed progenies of three parents was grown in four replications. Twelve genotypes from each progeny were sampled and grown in twelve plant plots. Mean yields were 14·9 kg per plot for selfed and 19·7 for crossed progenies. The selfed progeny of one of the parents outyielded the other two selfs while the two crosses involving it outyielded the third; however, these three progenies had lower specific gravities than the others and in estimated dry-matter yields there was little apparent difference in parental contributions. Specific gravities appeared to be unaffected by the selfed or crossed status of the progenies.

Twenty-five Neo-Tuberosum clones were exposed to infection by PLRV and virus Y at Cambridge in 1979, then regrown in 1980 for assessment of their reaction. They were not a random sample of Neo-Tuberosum, having been chosen on the basis of previous field data and glasshouse tests for virus Y resistance. Leafroll incidence averaged 43 per cent, lower than in any of the controls, with a range from zero (three clones) to over 90 per cent. Of four clones having Gl.71/160 as one parent, two had no leafroll and the others about 10 per cent. Gl.71/109 also seems a promising parent; of three clones derived from this by crossing with two clones (not including /160) one had zero, one 8 per cent, and one 50 per cent leafroll. The mean overall incidence of virus Y infection at 71 per cent was higher than in Pentland Crown but lower than in Majestic; it ranged from zero (three clones) to 100 per cent and

was over 90 per cent for fifteen of the clones. The three with zero infection consisted of one of unknown parentage which had survived the Murrays virus epidemics of the mid-late 1970s and two from the progeny Gl.71/112 × /151, these parents having shown evidence of resistance in previous glasshouse tests.

Further studies of resistance to potato cyst nematode (*G. pallida* ? Pa_2) were made in the Gl.76B series of clones. Combining the new with previous data, 125 clones have received from one to four tests each and, of these, seven have mean scores under 20 per cent, a further nineteen have under 40 per cent, 83 have between 40 and 100 per cent and fourteen have over 100 per cent of the cyst numbers on Pentland Crown controls. It is difficult to determine the sources of resistance in these clones as the 23 parents from which they derive were crossed in various combinations and provenances cannot be traced. However, the following are possible sources: Gl.71/96, /101, /109, /125, /128, /148, /160 and /175. Clone Gl.71/96, with four of its 24 derivatives (crossed with various of the other parents) having under 20 per cent and a further four under 40 per cent relative infestation, has clearly been a major contributor. About 350 other clones have undergone preliminary tests over the 1979–80 winter, or previously, and of these about twenty have mean scores under 20 per cent relative infestation.

Seven clones were grown by Golden Wonder Ltd. in 1979 and assessed for crisping potential immediately after harvest and again in February and July 1980. The colours of the crisps of all clones were as good as or better than those of the control variety, Record, at each date. Nine, including four of those grown by Golden Wonder Ltd., were grown in 1980 by the PPA. In an initial assessment of crisping potential in October, one had a lower and six had a higher colour rating than Record. Five had higher specific gravities than Record while only one had as high a reducing sugar content; four had lower oil contents in the crisps. In an assessment of their potential for making chips all had good scores for the time of year with relatively high dry matter contents, exceeding 25 per cent in three of the clones.

Professor Sharon Desborough of the University of Minnesota, USA, in a preliminary assessment of protein content in 200 clones from the 1979 harvest, as freeze-dried powders, found a range of from 3·5 to over 11 per cent. Repeat tests on a sample of the clones from the 1980 harvest by herself and by the Chemistry Division, applying different techniques, have given somewhat variable results but it is clear that there is a wide range of protein contents in Neo-Tuberosum, including some high values.

A batch of 23 clones and six control varieties were assessed for vitamin C content, a range from about 4 to 22 mg per 100 g fresh weight being found. The range in the controls was from 6 to 13 mg and eight clones gave values exceeding the best control.

SOUTH AMERICAN CULTIVATED DIPLOIDS

Many tetraploid clones obtained by crossing Group Phureja diploids with

commercial-type tetraploids show vigorous early-season growth, the canopy closing rapidly, and good yields are often obtained in the short growing season at Blythbank. To assess their early tubering potential, 27 such clones were planted at the Murrays on the 8th April and lifted on the 9th July. Before harvest fifteen clones had fully closed canopies and another eight were almost closed, while Pentland Javelin was rated "fully open". In yields of marketable tubers (> 35 mm) seven clones significantly ($P < 0{\cdot}05$) exceeded the 0·69 kg per plant of Pentland Javelin, the three highest yielders giving 0·86, 0·85 and 0·78 kg and having good sized tubers.

High yields of ware-sized (40–80 mm) tubers have previously been reported for such hybrid clones when grown, for autumn harvesting, as widely spaced plants (*Ann. Rep. 1979-80*, 91–92). To assess them at "commercial" spacing, eleven were compared with five cultivars in a four-replicate trial with nine-plant plots at 30 cm spacing. The trial was planted in late April and defoliated in mid-September. Table 4 shows the yields of ware-sized tubers of the four highest yielders and the highest-yielding control, Maris Piper, together with the percentages of the total yield which fell within this size-range. None of these yields differed significantly. One of these clones, AP52(10), had a specific gravity of 1·100 which exceeded Record, the highest among the controls (1·094).

Table 4

Yields of tetraploid Phureja × Tuberosum hybrids compared with Maris Piper at commercial spacing.

Clone	*Ware yield (kg/plot)*	*Ware as % of total yield*
AP52(10)	16·3	95
AP56(22)	15·3	93
AP56(145)	18·1	93
AP82(78)	16·5	89
Maris Piper	16·8	95
S.E. ±	1·1	

A survey of resistance to potato cyst nematode (*G. pallida* ? Pa_2) in diploid-derived material commenced with 381 clones being assessed in duplicate canister tests. Of these, 41 had under 40 per cent of the cyst numbers on Pentland Crown controls (best result, two per cent) and are being re-tested with more replication. The 381 clones consisted of 156 Phureja diploids, 108 diploid Tuberosum × Phureja hybrids of which 34 were first-generation hybrids and 74 from later generations of intercrossing, and 117 tetraploid hybrids. Of the 41 judged worthy of further testing 37 were Phureja diploids and only four were hybrids involving Tuberosum. This suggests that Phureja-derived resistance may be recessive in such crosses.

In an initial survey of 25 clones for virus resistance three appeared resistant

to virus Y (local-lesion reaction) while sixteen were uninfected with virus X and are being re-tested. The three apparent Y resisters consisted of a Phureja clone, a diploid hybrid and a tetraploid hybrid.

Although testing for resistance to common scab under field conditions commenced in 1974 facilities were limited and only a few clones were examined annually until 1980 when 67 were tested. Of these, 50 appeared resistant (scores of 7 or 8) and will be tested again. One Phureja clone, 51T22, has appeared resistant in three successive seasons of testing while eleven others have achieved high scores in two seasons.

DIHAPLOIDS

Three tetraploid progenies obtained by crossing a susceptible tetraploid with the dihaploids PDH 182 and PDH 247, both of which are highly resistant to foliage blight, were studied. One progeny had PDH 182 as the seed parent, while of the others one had PDH 247 as seed and one as pollen parent. All clones tested in the progenies having dihaploids as seed parents (29 and eight respectively) were found to be highly resistant but of eight tested from the progeny having PDH 247 as pollen parent only two appeared highly resistant. This suggests that there may be fundamental differences in the genotypes of unreduced male and female gametes from the dihaploids, and that female gametes tend to transmit all the genes of the parent while segregation of genes occurs in the formation of unreduced male gametes. This is unexpected since the mechanism most frequently associated with the formation of unreduced male gametes, the parallel spindle phenomenon in the second meiotic division, is believed to be equivalent in its effects to a first meiotic division restitution (FDR) which should involve very little segregation. Nothing seems to be known of the way in which unreduced female gametes are formed.

The tetraploid parent of the above progenies, though blight susceptible, was highly resistant to potato cyst nematode (*G. pallida* ? Pa_2) and in each of the progenies about half the clones tested appeared highly resistant, having under twenty per cent of the cyst numbers of Pentland Crown controls (canister tests). In all, seventeen out of 41 clones tested for resistance to both blight and potato cyst nematode were highly resistant to both.

Screening of dihaploids for disease resistance continued, with special interest in determining whether any have superior resistances to their parents (*Ann. Rep. 1978-79*, 78–79) though this is difficult to prove when the parent is already highly resistant. Four clones which in replicated tests have appeared more resistant to potato cyst nematode than their *vernei*-derived parents, are being studied further. As far as other characters are concerned, one dihaploid has been found to give paler (superior) crisps than its parent, and while most dihaploids obtained from Pentland Crown are similar to it in specific gravities one has consistently exceeded it over four seasons.

Dihaploids tend to be low yielding, some producing only few and small

tubers unsuitable for field planting and others giving up to 55 per cent of the yield of Pentland Crown. However, tetraploid progenies of dihaploid parents appear reasonably productive. A progeny of PDH 40, a relatively productive dihaploid (40 per cent of Pentland Crown) gives about 90 per cent of Pentland Crown's yield and progenies of PDH 182 and PDH 247, which are very low yielding dihaploids looked reasonably promising in the multiplication plots.

Previous studies of the effects of doubling the chromosome number of dihaploids using colchicine have revealed no changes in levels of foliage blight resistance or in yield, tuber number or tuber size, although in some cases fertility may have been slightly improved (*Ann. Rep. 1978-79*, 79 and *1979-80*, 94). In a recent test, a doubled dihaploid appeared to be no different in any aspect of cooking quality from the original dihaploid.

Seed setting in crosses between dihaploids and tetraploids in 1979 was unsatisfactory and, although this was probably due mainly to low fertility in the parents used, efforts were made to improve the conditions for pollination this year. The glasshouse was shaded, a dilute nutrient solution was added to the water in which cut stems were maintained and, after pollination, flowers were lightly sprayed with water, particularly where stored pollen had been used. About 1,650 seeds were obtained from 1,850 pollinations, which is an improvement on the previous best year (0·57 seeds per pollination in 1978).

DAFS Package 8
ARC Projects 15016–15020 inc.

D. R. Glendinning
C. P. Carroll
M. J. De Maine

STRATEGIC PATHOLOGY UNIT

Mechanisms of Field Resistance to Potato Blight and Variability of the Pathogen

Work has continued in three main areas; the races of *Phytophthora infestans* occuring on commercial crops were monitored, investigation continued on the role of maturity on the incidence of blight in tubers and *P. infestans* and blight tissues were examined by scanning electron microscopy.

As in recent years, only common, simple races of *P. infestans* (race 4, race 4, 10 and race 4, 10, 11) were identified in samples of blight from commercial crops in the east of Scotland and the border areas. Although a considerable acreage of cultivars with R genes is now grown commercially, there were no reports of blight on them. Therefore, under normal cultural practice where protective sprays are applied, the introduction of cultivars such as Pentland Dell ($R_1R_2R_3$), Pentland Hawk (R_3) and Maris Peer (R_1R_2) apparently has no bearing on the spectrum of races which occurs.

Resistance to blight in tubers is reputed to increase with maturity in the growing crop. This has not been clearly evident from substantial trials carried out during the past few years but increased maturity after lifting has been consistently correlated with increased resistance. Further investigation was made in 1980.

Plots of Pentland Crown and Majestic were planted on 29th April, 13th and 27th May and harvested on 21st August. The tubers were stored at 4°C to retard maturity until planted so that there was little difference in the maturity of the seed planted. Therefore differences in maturity at harvest were almost entirely related to the length of the growing season and this was evident from the quantities and sizes of the tubers harvested from the three plantings. As in previous tests the tubers were carefully lifted and placed on moist peat, rose end uppermost, in boxes. They were sprayed with a suspension of sporangia and zoospores of *P. infestans* on the day of harvest or the following day or eight days later and kept damp for 4 days before being allowed to dry off naturally.

The number of tubers showing lesions was determined in mid-October. As has been noted previously, a number of tubers showed atypical, thread like lesions which are the subject of separate study. Considering only the standard lesions, Majestic was more susceptible than Pentland Crown. The date of planting, and therefore maturity, had no influence on the incidence of blight recorded. As was evident in previous studies the timing of inoculation had a marked effect; inoculation on the day of harvest resulted in 36 per cent of the tubers becoming infected whereas only 6 per cent were blighted when inoculation was delayed for a week. Both varieties were consistent in their reactions to these factors. When the standard and thread like lesions were recorded together as positive infections there appeared to be no effect of

variety, planting date or inoculation date on the incidence of infection. However, these factors influenced the balance between the two types of lesion. Pentland Crown produced a higher proportion of thread like lesions than did Majestic and in both varieties the proportion of such lesions increased as inoculation was delayed. Thus, of infected tubers from the first and third inoculations 63 per cent and 93 per cent respectively showed thread like lesions. Thread like lesions therefore appear to involve a resistance mechanism.

P. infestans and blight have been the subjects of much and varied investigation but comparatively few studies have been made of the fungus both on and within the host's tissues. The application of scanning electron microscopy in this area has been made possible using the Cambridge S180 Scanning Electron Microscope, generously made available at the MRC Clinical and Population Cytogenetics Unit, Edinburgh.

Methods of preparing material for examination have been established. Preparations for this purpose have revealed information on the behaviour of sporangia and zoospores applied to leaf and tuber surfaces (Figure 1), on the emergence of hyphae from the leaf surface (Figures 2 and 3) and details of hyphae within leaf (Figure 4) and tuber tissues.

It has been noted that, under optimal conditions, germination of sporangia on leaves is almost entirely indirect. Only direct germination has been evident on tubers. Germ tubes developed from encysted zoospores have either terminated with an appressorium or have continued growth with an appressorial hypha. Intercellular hyphae have been observed in leaf and tuber tissues but haustoria were rare. Hyphae were noted emerging through stomata or directly through the epidermis of leaves. Many emerging through stomata were differentiated into sporangiophores.

In one specimen there were several instances of hyphal anastomoses. This has implications in explaining the generation of many races of *P. infestans* in situations where only one of its mating types exists.

DAFS Package 7
ARC Projects 05028
05029

Jean F. Malcolmson

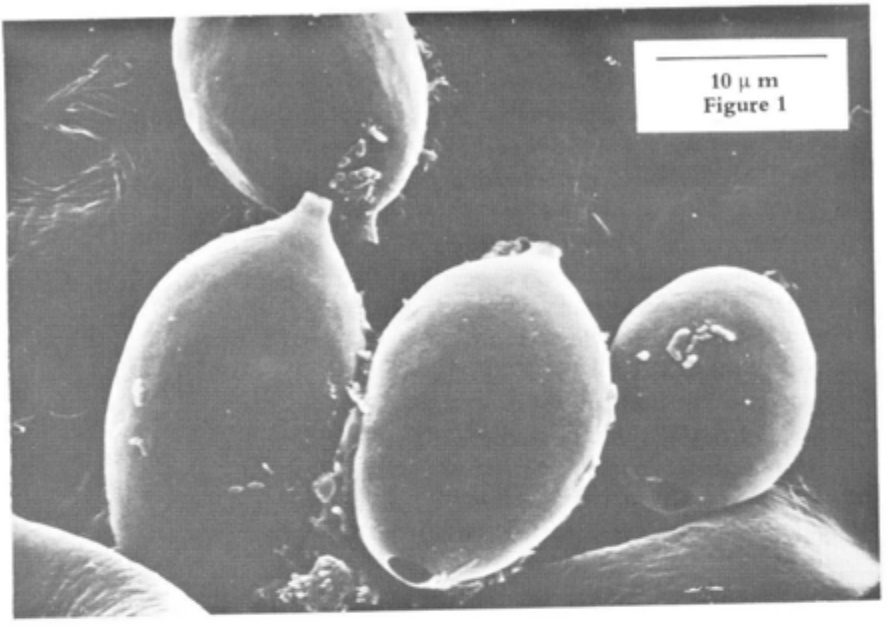
Explanation of Micrographs (pages 112-113)

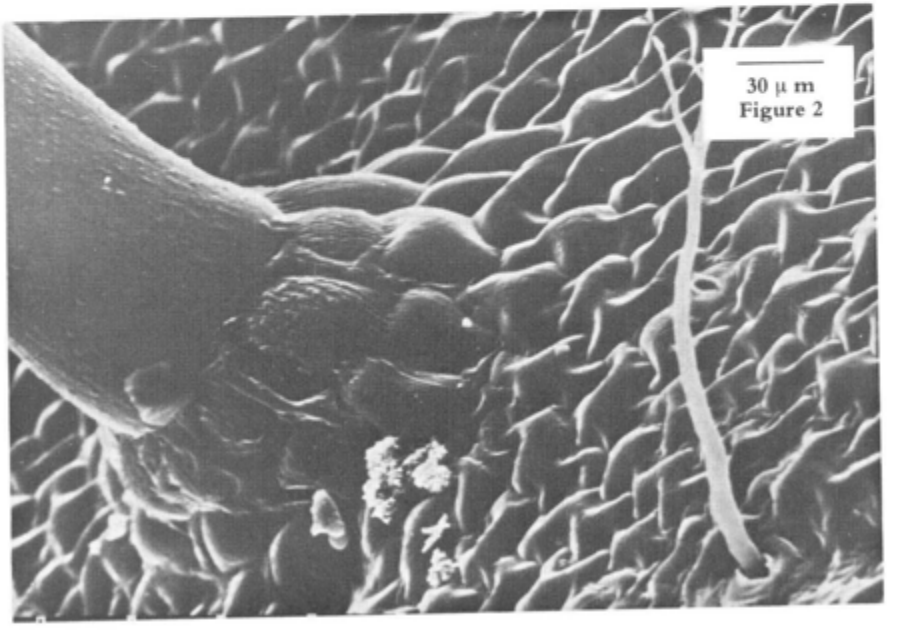
Figure 1. Sporangia of *P. infestans* on the surface of a potato leaf. In the two sporangia on the right, the exit pores through which zoospores are released indicate that indirect germination has occurred. The pedicel with which the sporangium is attached to the sporangiophore (Figure 2) is evident on the three sporangia on the left.

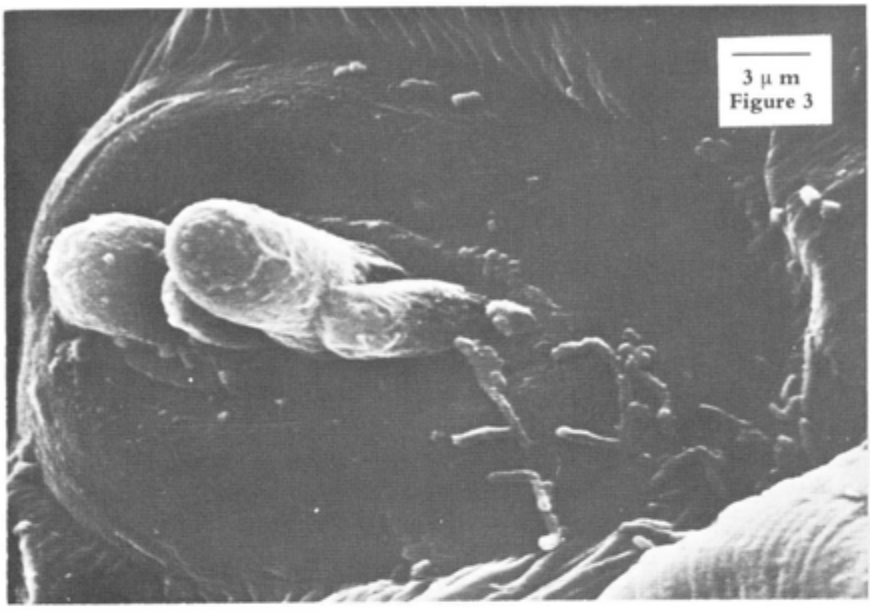
Figure 2. Area of the surface of a potato leaf showing a sporangiophore (right) emerging through a stoma and details of the base of a leaf hair (left).

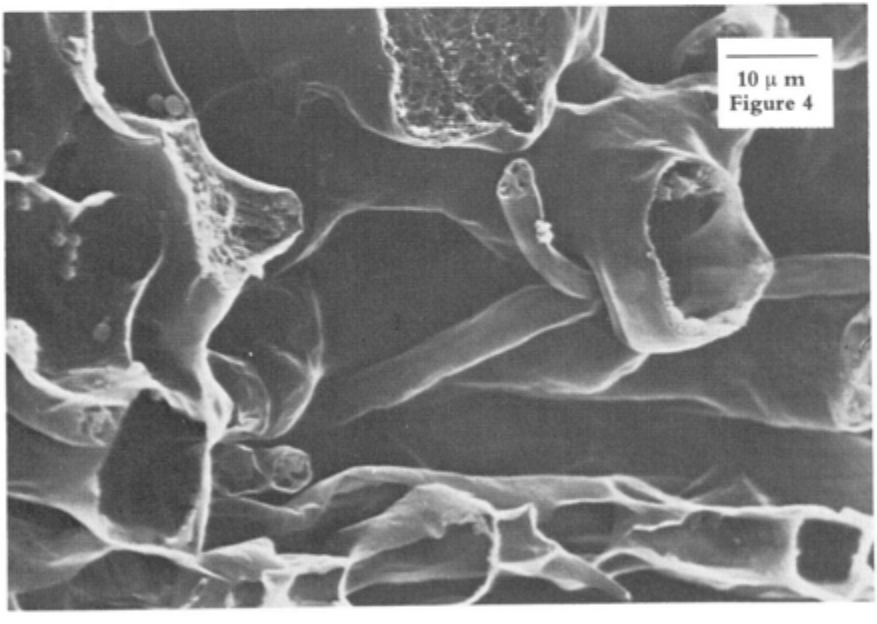
Figure 3. Hyphae of *P. infestans* emerging from between the guard cells of a stoma of a potato leaf.

Figure 4. Fractured tissues of potato leaf showing hyphae of *P. infestans* among mesophyll cells. The cell at the top, centre and the fractured hypha immediately below it show cytoplasmic contents. The cells on the left contain a number of chloroplasts.


10 μ m
Figure 1


30 μ m
Figure 2


3 μ m
Figure 3


10 μ m
Figure 4

SERVICE UNITS

Statistics and Computing

During the past year the Data Preparation/Statistics Unit has been heavily involved in designing and implementing a system to provide integrated data capture facilities throughout the Station.

The main aims of this scheme are to allow small data sets, taken from both field and laboratory, to be transferred directly to a microcomputer without any written records being involved, to process these data sets on the microcomputer or, if desired, transfer them to ERCC mainframe machines. To this end three Apple II microcomputers, three hand held data terminals and three Mettler PK electronic balances were acquired.

As the equipment was purchased during the second half of the year, there has not been sufficient time to give a thorough assessment of the scheme. However our first impressions are favourable.

The hand held terminals, which can be battery operated, have proved very successful for data recording in laboratories. At the end of each day the data can be transferred to the Apple microcomputer, and immediately listed. This approach achieves a substantial saving in time and effort in comparison with using punched cards. We have so far had much less experience in the use of these terminals for field scoring. They were successfully used to score one group of brassica trials, but there are difficulties in reading the display in strong sunlight, which might affect their use during summer months.

The balances chosen were from the Mettler PK range because they can be plugged directly into the Apple microcomputers and weighings can be recorded immediately on to disk.

Using programs provided by ERCC, data files held on disk in the Apple can be transferred to the local mainframe, an ICL 2980. Similarly files can be brought from the 2980 to the Apple. These features, together with the processing power and sophisticated editing facilities of the Apples provide a flexible and integrated data capture system which we look forward to developing fully in the coming year.

Apart from the data capture scheme, the role of the Unit continued as before. We still depend heavily on ERCC for computing facilities and support. The number of jobs run using ERCC facilities was 4,320 an increase of 230 over the previous year.

The Chemistry Division made extensive use of our Wang 2200 computer, but the number of other users has increased as a result of the programs provided last year by a sandwich student, Mr Stephen Ng.

Perhaps the most noticeable feature of the year has been the increase in the number of staff making use of computing facilities. We expect this growth of interest will continue next year.

J. W. McNicol

Library

The Library provides an information and loans service to all members of staff of the Station and to interested outside enquirers. It is open all year from 8.00 a.m. to 6.30 p.m. Over 170 periodicals are currently received with a book stock of around 1,200 items. In addition, there are collections of reports, technical information and reprints.

During 1980, Library facilities have been used to full capacity. A continuing interest in on-line retrieval services was maintained and 27 new bibliographies were compiled on different topics. In spite of threatened cutbacks, the Library budget remained secure which enabled the acquisition of 118 new titles for the bookstock as well as the addition of one new journal subscription.

The classified current awareness list continued to be issued fortnightly and this partly accounted for the further increase in the number of loans handled. Interlibrary borrowing increased by over twelve per cent and items lent by 38 per cent. Closer co-operation among the group of Scottish agricultural libraries has proved invaluable in view of the present high cost of British Library loans.

Increased use has also been made of the translation service provided and a total of ten translations were undertaken during the year.

B. E. Asher

Photography and Illustration

The demands on the photographic and illustrative services have continued, and preparing demonstrations has again been the major proportion of the year's work. The general format of the displays has been redesigned, using a minimum of necessary text and with illustrations providing most of the required information. This gives a more colourful and visually pleasing effect.

A Badger 150 XF Airbrush with compressor has been purchased. It will be used mainly for preparing displays. The addition of the Rotoboard, a small, portable draughting board, has provided a more efficient method of drawing graphs and charts. The centre of the board rotates around a pivot, allowing any measured angle to be drawn with ease.

With the slide collection continuously expanding it is intended to use the

Apple microcomputer to store descriptive information concerning each slide. This information can be recalled by a member of staff at any time.

G. Cruickshank

Cytology

A large proportion of the Unit's time was taken up with screening of potato material for the Strategic Breeding Department. In addition, pollen stainability determinations were made on a routine basis for the Commercial Potato Breeding Department, exact chromosome counts were supplied to the Brassica breeders, and exploratory work was carried out on screening for a monosomic type in spring oats.

Material examined for the Strategic Breeding Department included diploid potatoes being bred for an increased frequency of diplandroids (pollen grains with twice the usual chromosome number). Results illustrated the success of this programme. Diplandroids are customarily found in about twelve per cent of diploid clones. However, the frequency in the bred material was 40·7 per cent for group Phureja, and 38 per cent in diploid Tuberosum × Phureja hybrids. Diplandroids are also of importance for the utilization of dihaploid Tuberosum in disease resistance breeding; four experimental dihaploids were identified with this character. Routine chromosome counting of seedlings from tetraploid Tuberosum × diploid Phureja crosses gave 374 eutetraploids, 93 aneutetraploids (with chromosome numbers ranging between $2n = 46$ and $2n = 50$), seven triploids, and one dihaploid. Fifteen new dihaploids were identified from induction pollinations designed to obtain particular disease-resistances at the dihaploid level. Screening of colchicine-doubled dihaploid material continued with the aim of isolating clones doubled in all three genetic layers.

Chromosome counting of hybrids between *Brassica campestris* and *B. napus* continued: of 76 hybrids, 47 were euploids with $2n = 38$ and the remainder had numbers ranging from $2n = 36$ to $2n = 40$.

Experiments to see whether the less toxic Crystal Violet could be substituted for the standard Feulgen technique in staining root-tip chromosomes of oats showed that Feulgen was in fact superior.

C. P. Carroll

VARIETIES BRED BY THE STATION

The following are commercially available in Britain:

Stubble-turnip
Appin

Horticultural kale
Pentland Brig

Oats
Fyne*†

Potatoes
Craigs Alliance†
Craigs Royal
Red Craigs Royal†
Pentland Crown†
Pentland Dell†
Pentland Hawk*
Pentland Ivory*†
Pentland Javelin*†
Pentland Lustre*
Pentland Meteor*
Pentland Raven*
Pentland Squire*†
Croft*

Varieties marked * have been granted Plant Breeder's Rights and licences to reproduce and sell stocks have been issued. The rights are held jointly by the Society and the National Seed Development Organisation and applications for licences should be made to the Executive Officer, NSDO Ltd., Newton Hall, Newton, Cambridge.

Varieties marked † are on the NIAB Recommended List.

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LIST OF PROJECTS

The work described in this Annual Report has been commissioned by DAFS under the following package numbers. (ARC project numbers are also shown.)

DAFS Package	*ARC Project*	
1		**To provide improved cereal varieties suitable for production and utilization in Northern Britain**
	04001	Collect, assess and maintain oat and barley genotypes of use to breeders. Use computer-based data systems.
	04002	Survey physiological characters related to crop performance in barley and oats and construct breeding models.
	04003	Study inheritance of cereal performance characters. Design procedures to maximise and exploit variability.
	04004	Evaluate techniques for choosing parents and selecting offspring. Design data handling system for breeders.
	04005	Test cereals locally from this and other institutes. Explore potential of unfamiliar crops.
	04006	Survey virulence genes in pathogens of oats and barley. Design strategies for disease resistance breeding.
	04007	Study mechanisms of partial resistance of oats and barley to *Erysiphe* and their use in resistance breeding.
	04008	Improve methods to establish oat and barley disease nurseries. Assemble virulence genes of main pathogens.
	04009	Study biochemical components of barley and oat grains related to malting, feeding and processing quality.
	04010	Develop and automate small-scale tests for malting, distilling, brewing and milling quality.
	04011	Study enzymic, hormonal and other biochemical factors affecting cereal development performance and yield.
	04012	Investigate inheritance of biochemical components of significance in breeding oats and barley.
	04013	Breed malting and feed barley cultivars.
	04014	Breed spring oat cultivars.
	04015	Produce pure seed stocks of new cultivars. Investigate diagnostic features of oats and barley.
	06001	Study of trial designs and field management for plant breeding.

DAFS Package	*ARC Project*	
4		**To provide improved varieties of swedes and forage brassicas for livestock feeding**
	03001	Exploit interspecific and intergeneric crosses as sources of variation for brassica and radicole breeding.
	03002	Develop and apply screening tests for useful and harmful biochemical components in brassicas and related spp.
	03003	Collect, assess and maintain genetic material of use to brassica breeders.
	03004	Agronomic, physiological, biochemical and genetic investigations to formulate brassica breeding objectives.
	03005	Identify and maintain S-alleles in brassicas. Study their strength and dominance relations.
	03006	Survey virulence genes in pathogens of brassicas. Design and initiate strategies for resistance breeding.
	03007	Improve methods for assessing brassica diseases and for estimating yield losses caused by them.
	03008	Assemble and test genetic sources of resistance to diseases of brassicas. Produce improved parents.
	03009	Breed F_1 hybrid and inbred swede cultivars.
	03010	Breed rape cultivars from natural and artificial genotypes of *Brassica napus* and related species.
	03011	Breed kale and fodder cabbage cultivars.
	03012	Breed turnip cultivars especially for Scottish uplands.
	03013	Breed brassica and radish catch crops for late sowing and autumn grazing. Breed fodder radish cultivars.
	03014	Breed radicole cultivars as substitutes for rape from hybrids of *Raphanus* and *Brassica*.
	03015	Test and multiply brassica, radish and radicole cultivars.
7		**Potato breeding and related pathological and genetical studies**
	05001	Breed maincrop potato cultivars for quality, disease resistance and yield for fresh use and for processing.
	05002	Breed early potato cultivars for early yield and quality in relation to fresh use, crisping and canning.
	05003	Maintain and multiply healthy breeding and experimental stocks. Develop and apply improved health control procedures.
	05004	Screen breeding material for cooking and processing quality. Develop and use improved screening techniques.
	05005	Evaluate advanced potato selections in field trials in Scotland, England and Wales.

DAFS Package	*ARC Project*	
	05006	Study biometrical genetics of potato characters and devise improved breeding schemes.
	05007	Research into design and predictive efficiency of potato field trials and into G × E interactions.
	05008	Evaluate potato selection procedures and devise improvements for application in breeding programme.
	05009	Establish and manage computerised data bank on clones under selection in potato breeding programme.
	05010	Study biology of potato cyst eelworm including host parasite relationships and the nature of resistance.
	05011	Assess potato breeding material for resistance to potato cyst eelworm. Improve screening techniques.
	05012	Assess potato breeding material for resistance to and infection with viruses X, Y and leafroll.
	05013	Assess potato breeding material for resistance to soil-borne viruses. Improve screening techniques.
	05014	Study the biology of common scab, gangrene, skin spot and dry rot.
	05015	Assess potato breeding material for resistance to fungal diseases. Improve screening techniques.
	05028	Study mechanisms of genetic variability in *Phytophthora infestans* and the evolution of new pathogenic types.
	05029	Study mechanisms of quantitative resistance to potato late blight and identify resistant parental material.
8		**Commonwealth Potato Collection and related genetic/breeding studies**
	05016	Manage the Commonwealth Potato Collection of Latin American origin. Liaise with the Dutch/German gene bank.
	05017	Breed Neo-Tuberosum potatoes from Andigena origin for use in breeding cultivars.
	05018	Evaluate Neo-Tuberosum potatoes as parental material for use in breeding cultivars.
	05019	Breed diploid potatoes and evaluate as potential parents for diploid and tetraploid cultivars.
	05020	Produce, breed and maintain collection of dihaploid potatoes. Use dihaploids to enhance disease resistance.
9		**New Crops**
	06002	Studies of the contribution which plant breeding may make to the development of crops new to Scotland.

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
Institute of Animal Physiology	Babraham, Cambridge CB2 4AT
Institute for Research on Animal Diseases ..	Compton, Newbury, Berks. RG16 0NN
* Food Research Institute	Colney Lane, Norwich NR47UA
Letcombe Laboratory	Letcombe Regis, Wantage, Berks. OX12 9JT
Meat Research Institute	Langford, Bristol BS18 7DY
* Poultry Research Centre	Roslin, Midlothian EH25 9PS
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, Littlehampton, Sussex BN16 3PU
* Grassland Research Institute	Hurley, Maidenhead, Berks. SL6 5LR
Houghton Poultry Research Station	Houghton, Huntingdon PE17 2DA
* John Innes Institute	Colney Lane, Norwich NR47UA
Long Ashton Research Station	Long Ashton, Bristol BS18 9AF
National Institute of Agricultural Engineering	Wrest Park, Silsoe, Beds. MK45 4HS
National Institute for Research in Dairying .	Shinfield, Reading, Berks. RG2 9AT

* National Vegetable Research Station	Wellesbourne, Warwick CV35 9EF
* Plant Breeding Institute	Maris Lane, Trumpington, Cambridge CB2 2LQ
* Rothamsted Experimental Station	Harpenden, Herts. AL5 2JQ
* Welsh Plant Breeding Station	Plas Gogerddan, Aberystwyth, Cardiganshire SY23 3EB
Wye College, Department of Hop Research	Ashford, Kent TN25 5AH
State-aided Institutes in Scotland:	
Animal Disease Research Association	Moredun Institute, 408 Gilmerton Road, Edinburgh EH17 7JH
* Hannah Research Institute	Kirkhill, Ayr 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 Crop Research Institute	Invergowrie, Dundee DD2 5DA
* Scottish Institute of Agricultural Engineering	Bush Estate, Penicuik, Midlothian EH26 0PH
Scottish Crop Research Institute	Pentlandfield, Roslin, Midlothian EH25 9RF

* There has been collaboration during the year between these institutes and the SPBS.

REPORT

to the

SIXTIETH
ANNUAL GENERAL MEETING

of

THE SCOTTISH SOCIETY
FOR RESEARCH
IN PLANT BREEDING

23rd July 1981

by the

BOARD OF DIRECTORS

BOARD OF DIRECTORS

1980/81

Trustees

H.M. SECRETARY OF STATE FOR SCOTLAND, Scottish Office, New St Andrew's House, Edinburgh EH1 3TB.
JOHN ARBUCKLE, O.B.E., Barony Cottage, Newburgh, Fife KY14 6HL.
W. ANDREW BIGGAR, C.B.E., M.C., B.Sc., F.R.Ag.S., Magdalene Hall, St Boswells TD6 0EB.
G. B. R. GRAY, Smeaton, East Linton, East Lothian.
JAMES GRAY, O.B.E., T.D., Dalrannoch, Sunnylaw, Bridge of Allan, Stirlingshire FK9 4PP.

Chairman of Directors

JAMES GRAY, O.B.E., T.D., Dalrannoch, Sunnylaw, Bridge of Allan, Stirlingshire FK9 4PP.

Vice-Chairman

W. ANDREW BIGGAR, C.B.E., M.C., B.Sc., F.R.Ag.S., Magdalene Hall, St Boswells TD6 0EB.

Ordinary Directors

1978

M. DOUGLAS HENDERSON, Carse Farmhouse, Aberfeldy, Perthshire PH15 2JQ.
A. GORDON PORTER, J.P., East Scryne, Carnoustie, Angus DD7 6LL.
J. RICHARD ROBERTSON, Mains of Gallery, Montrose, Angus.
G. A. STORRAR, M.C., B.Sc.(Agric.), J.P., Rossie, Auchtermuchty, Fife KY14 7EH.
J. M. HARLEY, Milnathort, Kinross-shire
J. WATSON, Jnr., P.O. Box 23, Ayr KA7 1RY } Co-opted July 1980 to fill casual vacancies.

1979

G. GAMMIE, Westerton of Pitarrow, Laurencekirk AB3 1RT.
Mrs B. A. GORDON, B.Sc., Rosefarm, Cromarty IV11 8XU.
Prof. J. L. JINKS, D.Sc., F.I.Biol., F.R.S., Department of Genetics, University of Birmingham, Birmingham B15 2TT.
A. D. KAY, Esq., B.Sc., Easter Pitscottie, Cupar KY15 5TA.
J. McFARLANE, Kames, East Mains, Leithholm, Coldstream TD12 4JW.
Prof. D. H. N. SPENCE, Department of Botany, University of St Andrews, St Andrews KY16 9AL.

1980

G. BRUCE, Garlowbank, Kirriemuir, Angus.
W. H. M. GILL, Achintoul, Invergordon, Ross-shire IV18 0PL.
J. A. INVERARITY, Cransley, Liff, By Dundee, Angus.
G. D. MORRISON, Slatefield, Forfar, Angus DD8 1XD.
C. G. SPENCE, J.P., Biel, Dunbar, East Lothian EH42 1SY.

Directors Co-opted

G. CLAPPERTON, Sheriffhall Mains, Dalkeith EH22 1RX.
A. J. CLARK, B.Sc., Cast Farm, Leuchars, Fife KY16 0DP.
A. PATTULLO, M.C., J.P., Littleton of Airlie, Kirriemuir, Angus.

Directors nominated by H.M. Secretary of State for Scotland

Prof. G. R. DICKSON, B.Sc.(Agric.), Ph.D., M.I.Biol., Faculty of Agriculture, The University, Newcastle-upon-Tyne NE1 7RU.
J. M. TODD, B.Sc., A.I.C.T.A., Department of Agriculture and Fisheries for Scotland, Agricultural Scientific Services, East Craigs, Edinburgh EH12 8NJ.
Prof. M. M. YEOMAN, M.Sc., Ph.D., Department of Botany, University of Edinburgh, King's Buildings, Mayfield Road, Edinburgh EH9 3JH.
Sir MAURICE YONGE, C.B.E., D.Sc., F.R.S., F.R.S.E., 13 Cumin Place, Edinburgh EH9 21X.

COMPOSITION OF COMMITTEES

1. Standing Committee—Finance

JAMES GRAY, *Convener*
W. A. BIGGAR
G. CLAPPERTON
Prof. G. R. DICKSON
G. B. R. GRAY
J. McFARLANE
A. PATTULLO
A. G. PORTER
J. ARBUCKLE

2. Brassica Research Committee

Prof. G. R. DICKSON, *Convener*
G. GAMMIE
A. D. KAY
G. BRUCE
A. G. PORTER
Prof. M. M. YEOMAN
CHAIRMAN (*ex-officio*)
VICE-CHAIRMAN (*ex-officio*)

3. Cereals Research Committee

A. PATTULLO, *Convener*
Prof. J. L. JINKS
A. D. KAY
Sir DAVID LOWE
J. WATSON, Jnr.
J. RICHARD ROBERTSON
C. G. SPENCE
Prof. M. M. YEOMAN
J. HARLEY
CHAIRMAN (*ex-officio*)
VICE-CHAIRMAN (*ex-officio*)

4. Potatoes Research Committee

J. McFARLANE, *Convener*
G. GAMMIE
W. H. M. GILL
Mrs B. A. GORDON
M. D. HENDERSON
J. A. INVERARITY
Prof. D. H. N. SPENCE
J. M. TODD
CHAIRMAN (*ex-officio*)
VICE-CHAIRMAN (*ex-officio*)

5. Farm Advisory Committee

G. CLAPPERTON, *Convener*
A. J. CLARK
D. MORRISON
A. G. PORTER
C. G. SPENCE
G. A. STORRAR
CHAIRMAN (*ex-officio*)
VICE-CHAIRMAN (*ex-officio*)

ADMINISTRATION

Membership

At 31st March 1981 the total membership was 319, comprising 231 Life Members and 88 Annual Members. Four new members were elected during the year, and six died or resigned.

Meetings

The Board of Directors met on six occasions during the year, these being:—

17th April 1980	10th September 1980
5th June 1980	13th November 1980
24th July 1980	28th January 1981

The Finance Committee, Research Committees and Farm Advisory Committee met during the year on the dates shown below:—

Finance Committee	5th June 1980
Brassica Research Committee	23rd October 1980
Potato Research Committee	27th February 1981
Farm Advisory Committee	1st May 1980

Board of Directors

Messrs G. Clapperton, A. J. Clark, G. H. Millar, A. Pattullo and J. M. Roy demitted office as Ordinary Directors at the Annual General Meeting held on 24th July 1980, in accordance with the provisions of the Society Rules.

New Ordinary Directors elected at the Annual General Meeting were Messrs G. Bruce, W. H. M. Gill, J. A. Inverarity, G. D. Morrison, C. G. Spence and Sir David Lowe.

The Board has regretfully to record the death of Sir David Lowe, Elvingston, Tranent, East Lothian, on 3rd November 1980. A tribute to Sir David's service to the Society appears below.

The undernoted Ordinary Directors are due to retire from the Board at the 1981 Annual General Meeting:—

Mr M. Douglas Henderson
Mr A. Gordon Porter, J.P.
Mr J. Richard Robertson
Mr G. A. Storrar, M.C., B.Sc.(Agric.), J.P.

Messrs J. M. Harley and J. Watson, Jnr., who were co-opted during 1980/81 to fill two casual vacancies in the 1978 elections list, will also retire but will be eligible for re-election

Dr R. C. F. Macer

On Wednesday 28th January the Board entertained Dr and Mrs Macer and senior members of staff and their wives to a farewell luncheon at Bush House, in honour of Dr Macer's departure.

Speeches of appreciation of Dr Macer's contributions to the work of the Station and to the quality of his leadership were made by the Chairman, by Mr John Arbuckle, Chairman SCRI, who was Chairman of SSRPB during the greater part of Dr Macer's Directorship, and by Mr R. N. H. Whitehouse, Acting Director, speaking on behalf of the Staff. All paid tribute to his stimulating influence and to his complete dedication to the Station and all its work. The Chairman presented him with a cheque on behalf of the Society. After expressing his thanks, Dr Macer referred to the problems of the last few years, despite which he was optimistic for the future. The SPBS breeding programmes were viable and he hoped that they would so continue. Recruitment of new staff over the last few years had been of a high calibre and, given flexibility, this promised well for the SCRI. Dr Macer concluded by proposing a toast to the new Institute.

Sir David Lowe, C.B.E., D.L., D.Sc., F.R.S.E., F.R.Ag.S.

Sir David Lowe died suddenly and unexpectedly on Monday, 3rd November 1980. He had been a member of the Society since 1949 and served for many years as a member of the Board of Directors and of various Society committees.

Sir David was also a member of the Governing Body of the National Vegetable Research Station at Wellesbourne, from 1949 to 1979 and served as Chairman of the Governing Body from 1957 to 1979. He was the Founder Chairman of the NVRS Association in 1958 and he was made an Honorary President of the NVRS Association in 1979 in recognition of his long and devoted service to the Station and Association. In addition to these activities, Sir David also served on the Agricultural Research Council from 1954 to 1964, being Deputy Chairman of the Council from 1958 to 1964. He served on many other committees and public bodies, including the Scottish Council Development & Industry and was Chairman of the Scottish Agricultural and Horticultural Apprenticeship Scheme from 1949 to 1974. Sir David was awarded the C.B.E. in 1950, was knighted in 1962, and was elected F.R.S.E. in 1961. He served as Deputy Lieutenant for the County of East Lothian since 1975.

He was a noted farmer and horticulturalist and an enthusiastic amateur plant breeder who produced varieties of both wheat and potatoes.

Sir David is survived by his wife and three daughters, and will be remembered with great affection by all who knew him.

FIFTY-NINTH ANNUAL GENERAL MEETING

MINUTE OF PROCEEDINGS AT THE FIFTY-NINTH ANNUAL GENERAL MEETING OF MEMBERS OF THE SCOTTISH SOCIETY FOR RESEARCH IN PLANT BREEDING, held at Pentlandfield, Roslin, Midlothian, on Thursday, 24th July 1980.

Mr John Arbuckle, O.B.E.
Barony Cottage, Newburgh, Fife, presided.

Present.

1. There was an attendance of 29 members of the Society and invited guests, and 52 members of the Station staff, as recorded in the Sederunt Book.

Notice convening meeting.

2. At the request of the Chairman, the Secretary read the formal notice convening the meeting.

Apologies for absence.

3. Apologies for absence from the meeting, as recorded in the Appendix to these Minutes, were intimated by the Secretary.

Minutes of Fifty-eighth AGM.

4. The minutes of the 58th Annual General Meeting held on Thursday, 26th July 1979, having been circulated in advance to members, it was agreed that these should be taken as read. There being no objection to the minutes as circulated, they were approved as a correct record of that meeting.

Annual Reports and Accounts.

5. The 59th Annual Report of the Directors of the Society, incorporating the audited accounts for the year ended 31st March 1980, which had been distributed to members in advance, was formally presented to the meeting by the Chairman. At the conclusion of a brief speech in which he paid tribute to the work of the Convener and members of the Editorial Board which had been responsible for production of the Report, the Chairman formally proposed that the Report and Accounts be adopted. This was seconded by Mr A. G. Porter and approved unanimously.

Election of Directors.

6. It was proposed by Mr James Gray, and seconded by Mr M. D. Henderson, that the undernoted members be elected to serve

on the Board of Directors for a period of three years as from the date of this meeting:—

Mr G. Bruce	Sir David Lowe
Mr W. H. M. Gill	Mr D. Morrison
Mr J. A. Inverarity	Mr C. G. Spence

There being no further nominations, the proposal was carried without dissent.

Appointment of Auditors

7. Mr D. A. J. Randall proposed, and it was seconded by Mr A. J. Clark that Messrs Brown, MacDonald and Fleming be re-appointed as Auditors of the Society. This proposal was carried *nem. con.*

This concluded the formal business of the meeting.

The Chairman opened the informal part of the meeting by inviting the Director to present his report on the year's work of the Station.

The Director commenced by saying that it was the fourth occasion upon which he had had the privilege of presenting the Director's Report to Members and also of introducing the Station's Annual Report. By tradition, the presentation was a short one. The printed 1979/80 Report, the 59th Report of the Station, had been published and it followed the same format as in recent years.

The Director said he would make a few comments upon the year under review and highlight some of the main activities and achievements of the Station.

Before doing so, he welcomed the main guest—Mr J. S. Gibson from the Department of Agriculture and Fisheries for Scotland, who had recently been transferred to the Department as an Under Secretary. Mr Gibson was visiting the Station officially for the first time.

The Director said that the year's work had been influenced by three major events and, inevitably, by the weather.

The major events were, first, that in December 1979 the Secretary of State had announced his intention to form the new Scottish Crop Research Institute and that this new Institute would result from an amalgamation of SPBS and SHRI. It would be situated at Dundee. The decision had been long awaited and it would have far-reaching consequences for the staff, for the research programme, and for the future of Scottish crop production. Before the decision had been announced a great deal of time and effort had been given to the preparation of documents and in discussions with various groups and organisations within the Station and with DAFS. The Director reported that the decision was received with very mixed feelings by staff and most, for a variety of reasons, at that time and perhaps still, were unhappy about one aspect or another of the consequences of the decision.

The second event was that immediately following the announcement

about the new Institute a Programme Review Group had been convened by the Agricultural Research Council, under the Chairmanship of Professor J. L. Jinks, to advise DAFS on the future research programme of the new Institute. As far as SPBS was concerned, this amounted almost to a Visiting Group at short notice. A great deal of effort was put into providing documentation for the Group and a representative from every Research Division and Department of the Station had appeared before it. The Director said he had every expectation that when DAFS commissioned the research programme for the new Institute the commissions would include provision for a continuation of virtually all work within the Station's major crops and also for a greater component of scientific support for the breeding programmes.

The Director said it was his view that the establishment of the new Institute would provide a challenge and an opportunity to develop in Scotland a large, efficient, science-based crop research Institute to meet the needs of farmers, growers and processors in Scotland and in Northern England and beyond. Its establishment, its building, the formulation of the research programme and the accumulation of facilities was an immense task which would require great care and had not yet begun. In the meantime, the on-going programmes of work at SPBS would have to be sustained and the interests, rights and careers of all staff at Pentlandfield and at Dundee would have to be safeguarded.

The Director stated that the development of the new Institute provided opportunities—it did so both positively and negatively. Positively, the new Institute could offer the facilities for more and better research and, ultimately, it should provide more satisfying and more secure careers for staff. But, negatively, the opportunity also existed for dangers to arise. The Director repeated his views, expressed in previous years, that plant breeding programmes were by their very nature long-term and delicately balanced research operations which, if wrongly handled, could easily be damaged or destroyed. Ill-judged, ill-timed or plainly wrong administrative decisions could do irreparable damage. The staff, therefore, looked to the Governing Body of the new Institute and to DAFS to give wise counsel. The Director noted that the present Chairman of the Society, Mr John Arbuckle, was the Chairman of the Governing Body designate of the new Institute and a great deal depended upon him. The staff trusted his absolute integrity and impartiality in formulating the research programmes and establishing the staff of the new Institute. The Director continued that the staff and the members of the Society were confident that Mr Arbuckle's experience and long service on the Board of SSRPB and on the Governing Body of SHRI, gave him a full understanding of all that was involved. The staff of SPBS and their families were more directly affected then were those of SHRI, but now the decision had been taken by the Secretary of State the Director believed that he spoke for all staff when he said that they wished the new Institute to be a success.

The third event had been the enforcement by the Government of strict cash

limits on the Station's expenditure. The Station had operated, as the accounts had shown, within the cash limits—but with a loss of efficiency, with delays in some of the programmes, and with a good deal of frustration. To improve efficiency, the management structure at the Station had been modified. A Chemistry Division had been formed and new Heads of Divisions identified—Mr J. R. Love (Administration), Dr M. J. Allison (Chemistry) and Dr F. J. W. England (Agronomy) and these, together with Mr R. N. H. Whitehouse and Dr J. H. W. Holden, now formed the Management Advisory Group.

Other organisational changes had also been introduced. A Unit for Strategic Brassica Breeding had been established under the leadership of Dr I. H. McNaughton. Dr W. H. Macfarlane Smith had become Head of the Brassica Department. Following the retirement of Dr T. M. W. Davidson in January, Mr G. R. Mackay had been appointed Head of the Commercial Potato Breeding Department.

The Director then referred to the weather and the fact that plant breeding, where for so many activities "the fields are our laboratories", was one of the most weather-dependent of the applied sciences. He also mentioned that outside plant breeding circles it was not generally realised how much effect weather conditions had on the activities at the Station. For each of the last four years the weather had been unusual in one way or another, with late springs, cold winters and wet summers, all of which had affected field and subsequent operations. The year under review had been no exception, being extremely dry in April and May 1980 and cool and wet later; sowing conditions had been particularly difficult.

During the year the Station had continued to submit varieties for National List Testing. Five spring barley varieties and two potato varieties had been entered into first year National List Trials in 1980 and a total of six barley varieties, six potato varieties and two swede varieties were now in National List trials. The oat variety Fyne had been placed on the NIAB Recommended List in Category PG and the potato variety Pentland Squire had been transferred from Category PG to Category G.

The Director said he was pleased to report that the infra red reflectance analysis work in the Chemistry Division had developed well. The commissioning in August 1979 of the Neotec 6350 continuous scanning equipment had confirmed the Station's position as the leading plant breeding station using this technique.

During the year planning for two major international conferences had taken place at the Station. The EAPR Conference had been held in June and had been very successful. The Fourth International Barley Genetics Symposium would be held in Edinburgh in 1981. Many staff had been deeply involved with the planning of both Conferences.

The Director drew attention to the continuing process of training at the Station, both in professional skills and in general education, and upon which, in recent years, greater emphasis had been placed. Four members of staff had

obtained Higher National Certificates—Miss D. C. Page, Miss J. E. Middlefell, Miss E. A. Young and Miss F. Mathison. Miss Middlefell had been awarded the Preece Memorial Prize by the Institute of Biology for the best HNC student in Scotland. All deserved congratulations.

The Director then stated that staff were the main asset of any research organisation. He thanked all staff for their work and their endeavours during the year. It had been a very difficult and unsettling year for everyone. The achievements were on display in the demonstrations set up for the Open Day.

During the year improved consultative procedures with staff had been established at the Station and now, in addition to the previously existing bodies, the various Trade Unions and the Staff Association, a Local Whitley Committee had been established.

The Director concluded by thanking the Chairman for devoting so much of his time to the Station's affairs, Mr James Gray, Vice-Chairman, for his continuing guidance on the legal affairs of the Society, and the Board. He also thanked the Society on behalf of the staff who have benefited from the increasing amount of private funds made available for visits to research centres overseas and in support of research projects and visiting workers, and the Department of Agriculture and Fisheries for Scotland for the continued funding of the Station.

The Chairman, Mr J. Arbuckle thanked Dr Macer for augmenting the Annual Report so comprehensively. He said that he did not know how many members had had an opportunity to read the full Report, but the oral exposition had helped us to understand the many and varied activities of the Station during the past year. The Chairman noted the Director's deep involvement in these activities, and said that on behalf of the industry, on behalf of our staff and of his Board a very sincere and generous thank you for his untiring efforts on many fronts.

The Chairman then said he would like to comment on several aspects of 1979/80 activity. This was the 59th AGM of the Society and he had now served for nine years as Chairman. This was approaching the end of one phase of the Society's life and the start of another. More opportunities were opening up for the Society. The Board had been very active during the year—there was an ever greater involvement by the Board in the management of the Station and in co-ordinating practical interests of the industry with the scientific skills of the staff.

The Research and Advisory Committees were planning guidelines for future policy. Mr Arbuckle said that the Director had dealt with most aspects of the Station's work during the year. He wished, however, to comment on three matters of great interest to Members.

Firstly, the Society now had an oat variety on the NIAB Recommended List—but the decision of the Scottish Colleges on recommendation was still awaited. It has been named Fyne and he now looked forward with interest to its performance on farms.

Secondly, the potato variety Pentland Squire has been placed on the fully recommended list of NIAB. This variety has already made a substantial impact upon potato growing in the UK and it has potential for overseas use.

Thirdly, the Chemistry Department's work with infra red reflectance analysis techniques had increased. The Society now had at SPBS the most advanced equipment of its type in the UK. This was installed in the summer of 1979 and was now contributing to the work of the Station.

The Chairman said he now wished to devote the remainder of his address to developments concerning the new Scottish Crop Research Institute and to the future of SSRPB. He recognised these matters were of very great interest to Members, to staff and to the agricultural community.

He then referred briefly to the Working Party of 1978, its recommendations, and the broad acceptance of these by the Secretary of State in his announcement in Parliament on 19th December 1978 (see *Ann. Rep. 1979-80*, 8–9).

Later, during Spring of this year, the Secretary of State had announced the names of individuals appointed to the new Governing Body of SCRI. Mr Arbuckle said he was honoured in being appointed Chairman, and as such he was very conscious of the tremendous responsibility placed upon him in ensuring that the well-considered recommendations of the Working Party were put in hand and implemented to the early benefit of the industry. His responsibilities as Chairman were wide, and included people, research projects, targets, land resources, consultations with SSRPB, and many more. He was, however, supported in the knowledge that he had a strong and widely representative Board which was still to be added to. All members were equally conscious of the need to achieve the merger and of furthering plant breeding and R & D in the northern area of the UK.

The Governing Body designate of SCRI had already met on two occasions. He hoped to achieve formal status within about another six weeks. The first step would be to appoint a Director, a Secretary and then with the help of these people begin to formulate structures, and timetables for the new organisation; all decisions would be for the new Governing Body to take.

In order to devote more time to these important matters Mr Arbuckle wished to intimate his intention to resign as Chairman SSRPB at the close of this meeting—he still hoped to remain a member of the Board as a Trustee. This procedure would ensure that the new Chairman would be free and uninhibited in making representation to SCRI on any matter of concern or especial interest to SSRPB. In this connection Mr Arbuckle hoped the Board would see fit to elect as his successor Mr James Gray, currently Vice-Chairman, and who had shown great interest and involvement in everything pertaining to SSRPB, and who has given him tremendous support over recent months. Mr Arbuckle then assured Members that in his new role the SSRPB interests would not be overlooked.

The Chairman then having referred to the new organisation SCRI—turned to the continuing role of SSRPB and the SHRI Association. Talks

were going on to achieve a merger between these organisations as both had common interests.

The new joint SSRPB—SHRI Association (still to be named) would have opportunities to safeguard the interests of staff, consideration of timing in respect to SCRI take-over, financial matters and disposal of buildings, etc., etc. At an early future date SSRPB will, of course, relinquish responsibility for the management of SPBS to SCRI.

He was not going to forecast a date for management take-over by SCRI, this was a matter for later decision, but beyond that date and the handing over of management responsibility, he expected the new joint supporting organisation SSRPB/SHRI to have a very important role and serve several important functions.

They will have right of nomination of at least 5 names to any future SCRI Board.

It is expected that they will have participation and involvement on Research Advisory Committees.

They will have funds to supply, to support the new Institute; to hold seminars, lectures, etc.

Mr Arbuckle had no doubt the new joint organisation would make their influence felt with SCRI.

Mr Arbuckle then conceded that some Members might feel that his survey was a very sketchy outline of the future. His response to this was, that today for a brief moment he wore two hats those of SCRI and SSRPB, tomorrow it would be only one: SCRI. He said he was determined in that capacity, along with his Board of Governors to carry through the procedures of merger to the best interests of everyone and with the minimum of disturbance to individuals or programmes. He wanted to ensure that the concept seen by the Working Party was realised, that the Minister of State's green light was acted upon and he hoped that those involved, whether they be research workers or farmers would very soon realise the great new opportunities he hoped to provide.

Finally, the Chairman thanked fellow Directors for their sound and active support over the past year. Many serious matters had been discussed and some difficult decisions taken. He was very pleased by the manner in which these decisions had been achieved.

At the invitation of the Chairman, Mr J. S. Gibson spoke briefly on behalf of the Department of Agriculture and Fisheries for Scotland, expressing appreciation of the great contribution made by the Society and the staff of Pentlandfield over the years to plant breeding in Scotland.

At the close of the meeting Mr W. A. Biggar spoke saying that he welcomed the opportunity to attempt, on behalf of everyone present, and all those members of the Society who were unable to be present, to pay tribute to the service which Mr John Arbuckle had rendered to the Society.

Few people in Scottish agriculture had given more freely and widely of their time and skill for the benefit of the industry over a long period of time as

Mr Arbuckle. In particular his efforts on behalf of the Society, of which he had been a member for 40 years and had served as a Director for 20 years, have been concentrated in the recent years of his Chairmanship, which has been a time of great difficulty in the history of the Society and the Station. Those members of the Board of Directors and the Society who had served closely with him knew well how much the Society had benefited from his strength of character, total commitment to the task in hand, tenacity of purpose, and his delicate sense of judgement. At all times he handled difficult situations with firmness and fairness and never allowed the problems of today to cloud the opportunities for the future. Mr Biggar posed the question as to how suitable acknowledgement could be made to Mr Arbuckle's great efforts and suggested that if members of the Society and the Board of Directors resolved to do everything possible to ensure the future success of the new amalgamated Institute, Mr Arbuckle would feel fully gratified.

Mr Biggar's tribute to Mr Arbuckle was greeted with acclamation by those present.

ABSTRACT OF ACCOUNTS

INCOME AND EXPENDITURE ACCOUNT

for year ended 31st March 1981

1980				
	Income			
	Department of Agriculture and Fisheries for Scotland—			
£1,035,000	Maintenance grants		£1,242,410	
12,216	Transfer from unexpended maintenance grants brought forward at 1st April 1980		10,442	
£1,047,216				£1,252,852
91	Annual Subscriptions			71
1,429	Other income			5,145
£1,048,736				£1,258,068
	Less *Expenditure*			
	Scientific and technical staff salaries, wages and			
£ 606,796	National Insurance contributions		£ 747,905	
15,893	Implements and apparatus		33,203	
66,109	Other research expenditure		77,385	
7,583	Staff recruitment and training		8,783	
46,555	Additions to fixed assets (see note 1)		45,191	
116,251	Property and buildings (see note 2)		139,459	
42,990	Travel and transport		47,766	
	Administration and office expenses (including			
72,107	salaries etc. £59,142; 1980 £46,581)		88,572	
17,355	Pensions and supplementation		16,699	
	The Murrays Farm—			
37,792	Net operating cost	£53,105		
3,974	Improvements	—		
		£53,105		
	Less capital grants from Department of			
(3,974)	Agriculture and Fisheries for Scotland	—		
			53,105	
1,029,431				1,258,068
£ 19,035	Unexpended balance of maintenance grant carried to Balance Sheet (see note 3)			—

BALANCE SHEET

as at 31st March 1981

1980				
	£953,036	*Fixed Assets* (see note 4) Heritable property	£975,303	
	295,582	Capital equipment	340,364	
£1,248,618				£1,315,667
		Current Assets		
	£ 3,612	Sundry debtors and deposits	£ 6,483	
	65,488	Cash and bank balances	52,331	
69,100				58,814
£1,317,718				£1,374,481
		Less *Current Liabilities*		
	£ 1,858	Sundry creditors	£ 1,598	
		Department of Agriculture and Fisheries for Scotland— Unexpended maintenance grants		
	66,590	(see note 3)	—	
		Scottish Crop Research Institute, Mylnefield—		
	—	Advance on 1981/82 maintenance grant	56,148	
68,448				57,746
£1,249,270				£1,316,735
		Represented by		
£1,124,356		Funds as at 1st April 1980		£1,249,270
		Add grants received from Department of Agriculture and Fisheries for Scotland—		
	£ 48,725	Capital works	£ 22,267	
	76,589	Capital equipment	45,198	
	£125,314		£ 67,465	
	400	*Less* sale of fixed asset	—	
124,914				67,465
£1,249,270				£1,316,735

JAMES GRAY
Convener, Finance Committee.

NOTES TO INCOME AND EXPENDITURE ACCOUNT AND BALANCE SHEET

(Year ended 31st March 1981)

1. Additions to fixed assets—

Apparatus and equipment	£ 19,166
Safety equipment	1,159
Library books etc.	5,197
Motor vehicles	18,033
Furniture and fittings	1,636
	£ 45,191

2. Property and buildings—

Rates, taxes, insurance	£ 35,031
Power, light, heat	76,717
Property repairs	7,976
Edinburgh Centre of Rural Economy	19,735
	£ 139,459

3. Unexpended maintenance grants—

Balance brought forward at 1st April 1980	£ 66,590
Less transfer to Income	10,442
	£ 56,148
Less transfer to Scottish Crop Research Institute, Mylnefield	56,148
Balance carried forward at 31st March 1981	—

4. Fixed assets as at 31st March 1981—

	Cost	*Less charged to Revenue Ac.*	*Net*
Heritable property	£ 975,303	£ —	£ 975,303
Capital equipment	340,780	416	340,364
	£1,316,083	£ 416	£1,315,667
Implements and tools	92,687	92,687	—
Vehicles	57,830	57,830	—
Laboratory apparatus	149,753	149,753	—
Furniture and fittings	29,122	29,122	—
Library books	29,891	29,891	—
	£1,675,366	£359,699	£1,315,667

FUNDS AND BEQUESTS

INCOME AND EXPENDITURE ACCOUNT

for year ended 31st March 1981

1980				
	Income			
	Gross interest and dividends on investments (see note 1)—			
£1,028	Narrower range		£1,140	
1,494	Wider range		1,513	
£2,522				£2,653
259	Interest on bank deposit accounts			245
82	Life subscriptions			10
178	Donations			75
£3,041				£2,983
	Less *Expenditure*			
£ 9	Registrar of Friendly Societies		£ 13	
129	S.S.R.P.B. lecture		239	
75	Redundancy presentation		507	
—	Travel grants and travelling expenses		580	
299	Research grants		133	
180	Donations		150	
64	Revaluation of investments		—	
207	Open day expenses and hospitality		650	
119	Bank charges		363	
—	Miscellaneous		22	
1,082				2,657
£1,959	Net revenue carried to Balance Sheet			£ 326

FUNDS AND BEQUESTS

BALANCE SHEET

as at 31st March 1981

1980		Narrower range	Wider range	
	Assets			
	Investments at cost or valuation (see note 2)—			
£18,567	Life Membership Subscriptions and Donations Fund	£ 8,319	£10,248	£18,567
2,808	W. J. Reid and James Munro Bequests	2,059	749	2,808
712	Dr Wilson Memorial Fund	365	347	712
2,097	J. C. Thyne Bequest	1,049	1,048	2,097
£24,184		£11,792	£12,392	£24,184
768	Recoverable income tax		£ 796	
2,486	Bank of Scotland—current and deposit accounts		2,810	
			£ 3,606	
(10)	*Less* sundry creditors		36	
				3,570
£27,428				£27,754

Represented by

		Funds at 1st April 1980	Net revenue/ (loss) for year	
£20,134	Life Membership Subscriptions and Donations Fund	£20,134	£ (62)	£20,072
3,553	W. J. Reid and James Munro Bequests	3,553	119	3,672
920	Dr Wilson Memorial Fund	920	66	986
2,821	J. C. Thyne Bequest	2,821	203	3,024
£27,428		£27,428	£ 326	£27,754

FUNDS AND BEQUESTS

NOTES TO INCOME AND EXPENDITURE ACCOUNT AND BALANCE SHEET

1 Full details of gross interest and dividends received are given in the appended schedules.

2. Full details of the investments appertaining to each Fund are given in the schedule. No changes were made in the investments during the year.

3. The Society has ceased to exercise managerial responsibility at Pentlandfield, and when research in plant breeding on the ground and in the buildings at Pentlandfield has ceased, the question of compensation under the terms of the Feu Charters held by the Society will be pursued.

APPENDIX

Investments as at 31st March 1981

LIFE MEMBERSHIP SUBSCRIPTIONS AND DONATIONS FUND ("B" ACCOUNT)

	Book value	*Market value as at date*	*Gross interest/ dividends for year to date*
(Narrower range)			
£1,000·00 14% Exchequer Stock 1984	£ 999	£ 1,030	£ 121
£1,581·40 6½% Funding Stock 1985/87	1,508	1,225	103
£2,359,35 8¾% Treasury Loan 1997	2,254	1,758	206
£450·00 City of Westminster 13% Redeemable Stock 1981	445	450	59
£4,039·00 Agricultural Mortgage Corporation Ltd. 7¾% Debenture Stock 1991/93	3,113	2,646	313
	£ 8,319	£ 7,109	£ 802
(Wider range)			
£1,000·00 14% Exchequer Stock 1984	£ 998	£ 1,030	£ 121
£450·00 City of Westminster 13% Redeemable Stock 1981	445	450	58
£3,660·00 Agricultural Mortgage Corporation Ltd. 7¾% Debenture Stock 1991/93	2,722	2,397	284
413 ord. 25p shares Guardian Royal Exchange Assurance Co. Ltd.	714	1,392	86
1,980 ord. 25p shares Royal Bank of Scotland Group	864	2,772	139
690 ord. 25p shares Shell Transport and Trading Co. Ltd.	1,373	2,594	198
388 ord. stock units Imperial Chemical Industries Ltd.	751	951	127
1,420 ord. 50p shares Claverhouse Investment Trust Ltd.	795	1,803	130
913 ord. 5p shares London and Manchester Assurance Co. Ltd.	1,586	2,283	119
	£10,248	£15,672	£1,262
"B" ACCOUNT TOTAL	£18,567	£22,781	£2,064

W. J. REID AND JAMES MUNRO BEQUESTS ("C" ACCOUNT)

(Narrower range)			
£1,359·29 6% Funding Stock 1985/87	£ 1,334	£ 1,053	£ 88
£689·00 Agricultural Mortgage Corporation Ltd. 7¾% Debenture Stock 1991/93	498	451	53
£288·00 City of Westminster 13% Redeemable Stock 1981	227	228	30
	£ 2,059	£ 1,732	£ 171
(Wider range)			
£72·00 City of Westminster 13% Redeemable Stock 1981	£ 72	£ 72	£ 9
521 ord. 25p shares English and International Trust Ltd.	479	620	37
90 ord. £1 stock units Imperial Chemical Industries Ltd.	198	221	30
	£ 749	£ 913	£ 76
"C" ACCOUNT TOTAL	£ 2,808	£ 2,645	£ 247

DR WILSON MEMORIAL FUND ("D" ACCOUNT)

	Book value	Market value as at date	Gross interest/ dividends for year to date
(Narrower range)			
£276·60 6½% Funding Stock 1985/87	£ 266	£ 214	£ 18
£143·00 Agricultural Mortgage Corporation Ltd. 7¾% Debenture Stock 1991/93	99	94	11
	£ 365	£ 308	£ 29
(Wider range)			
£39·00 Agricultural Mortgage Corporation Ltd. 7¾% Debenture Stock 1991/93	£ 28	£ 26	£ 3
85 ord. 25p shares English and International Trust Ltd.	87	101	6
133 ord. 25p shares Guardian Royal Exchange Assurance Co. Ltd.	232	448	28
	£ 347	£ 575	£ 37
"D" ACCOUNT TOTAL	£ 712	£ 883	£ 66

J. C. THYNE TRUST ("E" ACCOUNT)

(Narrower range)			
£1,060·00 City of Westminster 13% Redeemable Stock 1981	£ 1,049	£ 1,060	£ 138
(Wider range)			
£1,060·00 City of Westminster 13% Redeemable Stock 1981	£ 1,048	£ 1,060	£ 138
"E" ACCOUNT TOTAL	£ 2,097	£ 2,120	£ 276
TOTAL INVESTMENTS	£24,184	£28,429	£2,653
			(10·97% on invested capital)

AUDITORS' REPORT

In our opinion the Income and Expenditure Accounts and Balance Sheets set out on pages 140 to 147 which have been prepared on a historical cost basis give a true and fair view of the state of affairs as at 31st March 1981 and of the income and expenditure for the year ended on that date.

BROWN, MACDONALD & FLEMING
Auditors.

16 Alva Street, Edinburgh.
29th May 1981.

THE SCOTTISH SOCIETY FOR RESEARCH IN PLANT BREEDING AND THE SCOTTISH PLANT BREEDING STATION

The Scottish Society for Research in Plant Breeding was founded in 1920 with the dual aims of conducting scientific investigations into plant breeding and of breeding crops for Scottish agriculture. Membership of the Society is open to any interested person whether farmer, merchant, scientist or other, in or out of Scotland. Its management is vested in a Board of Directors which is partly elected by the members and partly nominated by the Secretary of State for Scotland, and its principal activity until 31st January 1981, has been to look after the affairs of the Scottish Plant Breeding Station.

Acting on advice from an independent Working Party, the Secretary of State for Scotland announced in December 1979 that the work of the Scottish Plant Breeding Station and of the Scottish Horticultural Research Institute would be integrated by the amalgamation of the two Institutes and that the new Institute so formed, subsequently named as the Scottish Crop Research Institute, would be located at Mylnefield, Dundee, under the control of one Governing body.

Under the constitution of SCRI the SSRPB has the power to nominate five out of a maximum of twenty members of the Governing Body and in this way will continue to maintain a direct connection with the management of crop research in Scotland.

In addition, through the funds at its disposal, it proposes to support and encourage areas of research and plant breeding which it deems to be of particular interest or significance.

The Board of Directors of the Society is currently exploring the possibility of combining with the Scottish Horticultural Research Association so that in its enlarged form it may take an informed and active interest in the work on both the horticultural and agricultural crops at the Scottish Crop Research Institute.

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