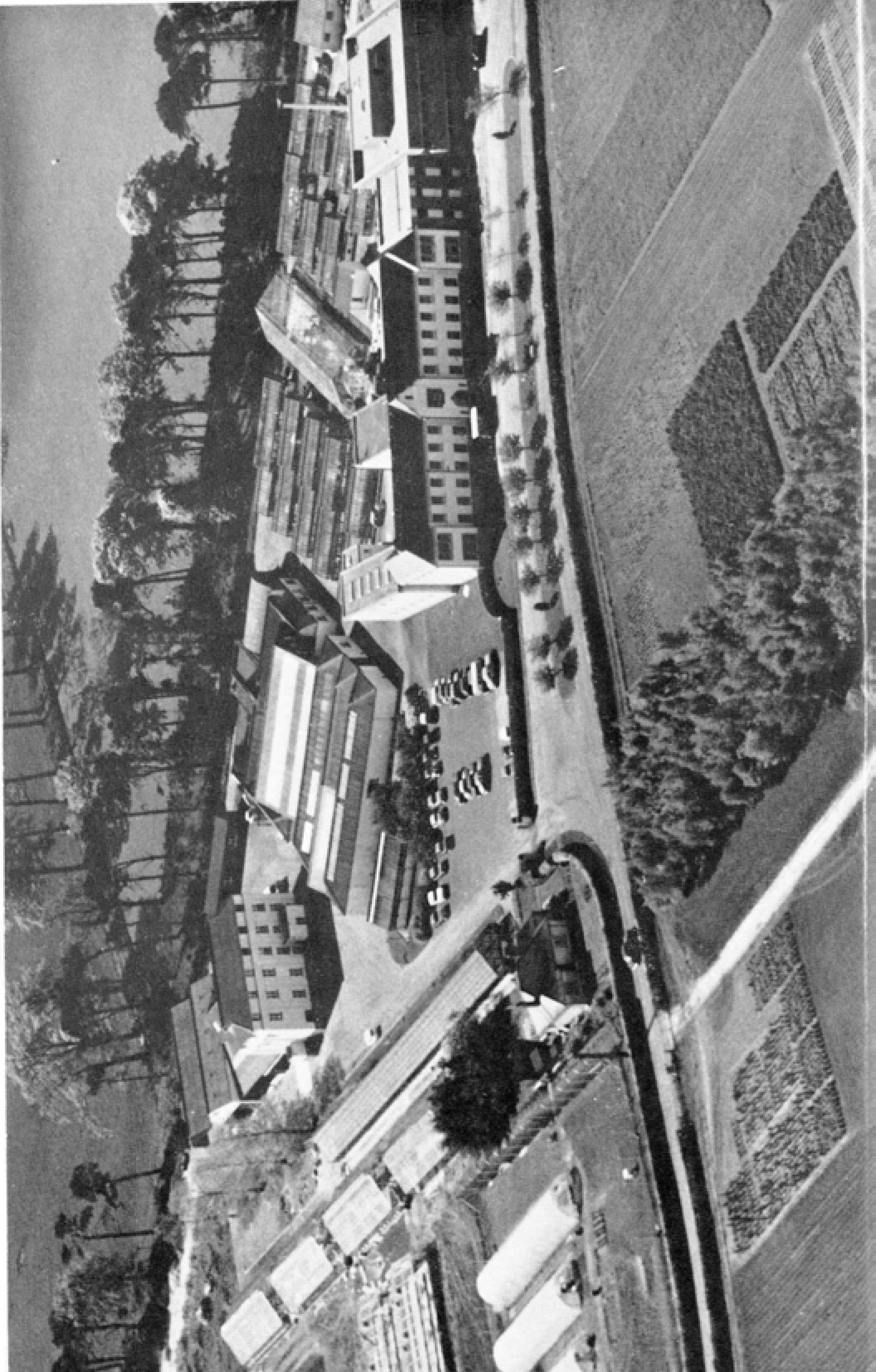

SCOTTISH PLANT BREEDING STATION

PENTLANDFIELD, ROSLIN, MIDLOTHIAN

REPORT

TO THE

ANNUAL GENERAL MEETING

OF

THE SCOTTISH SOCIETY FOR RESEARCH IN PLANT BREEDING

22nd JULY 1971

BY THE

BOARD OF DIRECTORS

Published in Edinburgh, 1971

Price 25p

NTLANDFIELD 1971

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1. REPORT BY THE DIRECTOR

General

This is the fiftieth Annual Report of the Scottish Plant Breeding Station and readers will see that we have taken this as a suitable occasion to review, in retrospect and prospect, the work of the Station. We are fortunate to have, in Mr Gallie, Dr Gregor and Dr Black, three authors particularly well suited by long experience to their tasks. Collectively, they have served the Station for just over 100 years.

The fiftieth anniversary has been and is being marked in other ways. On 22nd October 1970 a dinner was held at the Caledonian Hotel, Edinburgh. Thirty members of the Board and Staff entertained some forty guests drawn from a very wide circle of bodies interested in agriculture and the advancement of the work of the Station. The principal guest was the Secretary of State for Scotland, the Rt. Hon. Gordon Campbell, P.C., M.P.; Professor Helen Porter, F.R.S., Second Secretary of the Agricultural Research Council, replied to the toast of the guests. The Chairman of the Board of Directors, Sir James Denby Roberts, Bt., presided. The next event, being planned at the time of writing, is to take place on 15th April 1971. This is to be a lecture by Sir Frederick Bawden, F.R.S., Director of Rothamsted Experimental Station, entitled " Science and Crop Yields ". The lecture will be at the Kellogg Hall, Bush Estate, and we hope to attract a strong audience from the Society, the Station, and guests. This will be the first in a series of annual SSRPB lectures at which some person distinguished in agriculture or agricultural science is asked to speak on a subject of his choice. We are fortunate to have a scientist as eminent as Sir Frederick to start the series. The third event designed to mark the anniversary is also in the planning stage but will have taken place by the time this report is issued. The Department of Agriculture and Fisheries for Scotland proposed that the work of the Station should form the subject of the Department exhibit at the Royal Highland and Agricultural Society Show in June 1971. The Board welcomed this proposal as providing an excellent means by which the work of the Station might become deservedly better known.

During the year good progress was made in improving the research facilities of the Station. Three growth chambers were installed, two new glasshouses started, two cottages completed and construction of the new west wing was well advanced; if all continues well, the new wing should be completed by the time of the Annual General Meeting in July 1971. The search for a farm ended in the autumn of 1970 with the acquisition by the Department of

Agriculture and Fisheries for Scotland of the Murrays, Ford, Midlothian. This excellent farm is as well suited to the purposes of the Station as could ever reasonably be expected. It is owned by Government and rented to the Station. We obtained occupation on 1st December 1970, so 1971 will be the first crop year. In next year's report, and thereafter annually, we shall report upon its operation.

One event which must be a source of great satisfaction to the Station and the Society took place during the year. In 1970, according to Potato Marketing Board statistics, Pentland Crown became the leading potato variety in Great Britain. With a total registered acreage in England, Wales and Scotland of 109·3 thousand it just surpassed Majestic, the acreage of which is shrinking steadily. With Pentland Dell at 50·2 thousand acres, the two varieties occupied about one-third of the maincrop acreage.

Potato Investigations

Final reports were received on the Statutory Performance Trials of the four selections briefly described in the Annual Report for 1969–70. These selections have been named and their full descriptions as given in the official reports are reproduced below:—

Pentland Meteor 4634a(1)

1. *General Characteristics*

(*a*) Emergence	up to one week later than Arran Pilot.
(*b*) Vigour and Habit	medium height; vigorous, erect, open foliage with large pointed leaflets.
(*c*) Cover	generally more open than Arran Pilot.
(*d*) Root System	medium to short; tubers held close, occasionally strongly attached, slightly less numerous than for Arran Pilot.
(*e*) Tuber	oval, thick; shape slightly variable; skin white, smooth; flesh white; eyes shallow; sprout pink.
(*f*) Maturity	first early, earlier than Arran Pilot.

2. *Reaction to Diseases and Pests*

A. Fungi

(*a*) Wart Disease	immune from the Common European Race (Race 1).
(*b*) Blight	foliage field-immune from the Common Race (Race 4) but susceptible to certain complex races, tuber susceptible.

(*c*) Gangrene	susceptible.
(*d*) Dry Rot	susceptible.
(*e*) Skinspot	susceptible; subject to eye infection.
(*f*) Common Scab	less susceptible than Arran Pilot.
B. Viruses	
(*a*) Viruses X, A, B and C	immune from viruses X and B, field-immune from viruses A and C.
(*b*) Virus Y	less susceptible than Arran Pilot.
(*c*) Leaf-roll	no special resistance.
C. Potato Cyst Eelworm	
(*a*) Pathotypes A and B	resistant to pathotype A; susceptible to B.

3. *Consumer Quality*

First lift	(*a*) Steamed	flesh firm; distinctly moist off-white, negligible discolouration; insipid or mild flavour, no off-flavours.
	(*b*) Crisped	dark, inferior to Arran Pilot.
	(*c*) Specific Gravity	low, similar to or lower than Arran Pilot.
	(*d*) Enzymic Browning	negligible, similar to Arran Pilot.
	(*e*) Stem-end Blackening	nil, as in Arran Pilot.
Mature Lift	(*a*) Steamed	flesh moderately firm off-white, trace of discolouration as in Arran Pilot; flavour mild, no off-flavours.
	(*b*) Crisped	dark, generally inferior to Arran Pilot.
	(*c*) Specific Gravity	low, similar to or lower than Arran Pilot.
	(*d*) Enzymic Browning	moderate, slightly more intense than Arran Pilot.
	(*e*) Stem-end Blackening	negligible.
December (post storage)	(*a*) Steamed	flesh firm, humid, pale cream, negligible discolouration; flavour slight, sweet.
	(*b*) Enzymic Browning	slight, slightly deeper than Arran Pilot.
	(*c*) Stem-end Blackening	negligible.

4. *Summary*

An early variety which consistently out-yielded Arran Pilot and other early control varieties over two years of trial. The variety sprouted slightly slower than Arran Pilot but bulked earlier and matured slightly earlier.

As with Arran Pilot, the variety proved to be susceptible to Gangrene, Dry Rot and Skin Spot but exhibited field-immunity in the foliage from the common race of blight (Race 4), field-immunity from certain mosaic viruses and immunity from viruses X and B. The variety was resistant to Potato Cyst Eelworm (pathotype A).

Cooked tubers were of firm consistency and moist. No appreciable discolouration occurred. The variety showed no special merit as a crisping variety.

Pentland Marble 5015(1)

1. *General Characteristics*

(*a*) Emergence	up to one week later than Arran Pilot.
(*b*) Vigour and Habit	low to medium height, vigorous, bushy, compact; numerous stems.
(*c*) Cover	local cover good, plot cover rather restricted.
(*d*) Root System	stolons numerous, medium to long, wiry; tubers spread, readily detached at maturity, numerous.
(*e*) Tuber	round to oval, small, even; skin white, lenticels conspicuous; flesh cream to pale yellow; eyes shallow; sprout pink.
(*f*) Maturity	first early, earlier than Arran Pilot.

2. *Reaction to Diseases and Pests*

A. Fungi	
(*a*) Wart Disease	immune from the Common European Race (Race 1).
(*b*) Blight	foliage and tuber field-immune from the Common Race (Race 4), susceptible to some other races.
(*c*) Gangrene	moderately resistant.
(*d*) Dry Rot	resistant.
(*e*) Skin Spot	susceptible.
(*f*) Common Scab	less susceptible than Arran Pilot.
B. Viruses	
(*a*) Viruses X, A, B and C	field-immune from viruses B and C, susceptible to viruses X and A.
(*b*) Virus Y	less susceptible than Arran Pilot, appears to have some hypersensitivity.
(*c*) Leaf-roll	apparently less susceptible than Arran Pilot.
C. Potato Cyst Eelworm	
(*a*) Pathotypes A and B	susceptible to both pathotypes.

3. *Consumer Quality*

First Lift	(*a*) Steamed	flesh firm, moist, pale yellow, no discolouration; flavour mild to insipid.
	(*b*) Crisped	dark, similar to or slightly paler than Arran Pilot.
	(*c*) Specific Gravity	low, slightly higher than Arran Pilot.
	(*d*) Enzymic Browning	negligible.
	(*e*) Stem-end Blackening	nil.
Mature Lift	(*a*) Steamed	flesh firm, moist, pale yellow, no discolouration; flavour mild.

	(*b*) Crisped	moderate to dark, superior to Arran Pilot.
	(*c*) Specific Gravity	low, similar to or higher than Arran Pilot.
	(*d*) Enzymic Browning	slight, similar to Arran Pilot.
	(*e*) Stem-end Blackening	negligible.
DECEMBER (post storage)	(*a*) Steamed	flesh firm, moist, deep yellow, negligible discolouration; flavour mild to distinct, sweet.
	(*b*) Enzymic Browning	negligible.
	(*c*) Stem-end Blackening	nil.

4. *Summary*

An early variety maturing somewhat earlier than Arran Pilot. At all lifts, total yields and yields of tubers marketable as table ware were considerably lower than for Arran Pilot and other early control varieties. A high proportion of the marketable ware comprised small ($1\frac{5}{8}$–$1\frac{1}{4}$), evenly sized tubers produced in large numbers. When lifted immature, yields of tubers under $1\frac{1}{4}$ in. exceeded those over $1\frac{1}{4}$ in. and formed also, a high proportion of the total yield at maturity.

The variety was field-immune in foliage and tuber from the common race of blight (Race 4) but was susceptible to some other races. It was susceptible to Skin Spot but exhibited resistance to Gangrene and Dry Rot. Susceptibility to virsues X and A, field-immunity from viruses B and C and some hypersensitivity to virus Y were recorded.

Tubers were low in dry matter content. On cooking, the flesh was firm, moist and yellowish showing no discolouration or tendency to disintegrate. These qualities, coupled with production of numerous small tubers, are indicative of the suitability of the variety for canning.

Pentland Squire 4232a(3)

1. *General Characteristics*

(*a*) Emergence	similar to or slightly earlier than Majestic.
(*b*) Vigour and Habit	medium to tall, semi-erect, wiry; open leaf; small, dull, pointed leaflets.
(*c*) Cover	moderate, more open than Majestic.
(*d*) Root System	mainly medium to short, occasional longer stolons occur; tubers slightly less numerous than for Majestic.
(*e*) Tuber	oval, bold; skin white, occasional traces of colour at heel; flesh white; eyes medium depth; sprout pink.
(*f*) Maturity	early maincrop, similar to Majestic or slightly earlier.

2. *Reaction to Diseases and Pests*

A. FUNGI

(*a*) Wart Disease	immune from the Common European Race (Race 1).

(*b*) Blight		foliage and tuber field-immune from the Common Race (Race 4), susceptible to some other races.
(*c*) Gangrene		on average, not likely to be seriously affected.
(*d*) Dry Rot		susceptible.
(*e*) Skinspot		susceptibility variable but generally less than average; eyes subject to infection.
(*f*) Common Scab		less susceptible than Majestic.
B. Viruses		
(*a*) Viruses X, A, B and C		field-immune from viruses X and A, susceptible to viruses B and C.
(*b*) Virus Y		slightly less susceptible than Majestic.
(*c*) Leaf-roll		slightly less susceptible than Majestic.
C. Potato Cyst Eelworm		
(*a*) Pathotypes A and B		susceptible to both pathotypes.

3. *Consumer Quality*

At Lifting	(*a*) Steamed	flesh moderately firm, slightly mealy, pale cream, negligible discolouration; flavour mild, no off-flavours.
	(*b*) Crisped	golden brown, even colour distribution, slightly better than Majestic.
	(*c*) Specific Gravity	moderate to high, above Majestic and similar to King Edward.
	(*d*) Enzymic Browning	negligible, less than Majestic and King Edward.
	(*e*) Stem-end Blackening	nil.
February (post storage)	(*a*) Steamed	flesh moderately firm; slightly mealy, cream, no discolouration; flavour slightly pronounced, occasionally sweet.
	(*b*) Crisped	uniformly dark, similar to Majestic.
	(*c*) Reducing Sugar Content	similar to Majestic, higher than Record.
	(*d*) Enzymic Browning	negligible, less than Majestic.
	(*e*) Stem-end Blackening	nil.
March (after conditioning)	(*a*) Crisped	light brown, uneven colour distribution, paler than Majestic but darker than Record.
	(*b*) Reducing Sugar Content	lower than Majestic, slightly higher than Record.

4. *Summary*

A maincrop variety sprouting slightly faster than Majestic and maturing about the same time. The variety consistently out-yielded Majestic and other control varieties in total yield and in yield of large ware. Tubers were less numerous than for Majestic and inclined to coarseness in most of the trials but hollow tubers occurred only in one trial at one centre.

The variety proved field-immune in foliage and tuber from the common race of blight (Race 4) but susceptible to some other races. It exhibited no more than average susceptibility to Gangrene and Skin Spot though slightly more prone to Dry Rot. Field-immunity from viruses X and A was recorded.

On cooking, the tubers were moderately firm and slightly mealy with negligible discolouration. Satisfactory crisps were obtained at lifting of the crop but crisp colour was less satisfactory from later samples after storage and was not sufficiently improved by conditioning.

Pentland Raven 4851(5)

1. *General Characteristics*

(*a*) Emergence	slow, generally later than Majestic.
(*b*) Vigour and Habit	medium to tall, erect, vigorous foliage; robust stems, open leaf with large, pointed leaflets.
(*c*) Cover	similar to Majestic though slow to develop.
(*d*) Root System	short; some tubers firmly attached, closely held, tuber numbers similar to or less than Majestic.
(*e*) Tuber	round to oval; skin white, slightly netted; flesh white to cream; eyes mainly shallow; sprout pink.
(*f*) Maturity	early maincrop, similar to or later than Majestic.

2. *Reaction to Diseases and Pests*

A. Fungi

(*a*) Wart Disease	immune from the Common European Race (Race 1).
(*b*) Blight	foliage and tuber field-immune from the Common Race (Race 4), appears to have some field resistance in the foliage to other races.
(*c*) Gangrene	moderately resistant.
(*d*) Dry Rot	susceptibility variable but generally not above average.
(*e*) Skin Spot	moderately resistant.
(*f*) Common Scab	less susceptible than Majestic.

B. Viruses

(*a*) Viruses X, A, B and C		susceptible to viruses X, A, B and C.
(*b*) Virus Y		slightly less susceptible than Majestic.
(*c*) Leaf-roll		less susceptible than Majestic.

C. Potato Cyst Eelworm

(*a*) Pathotypes A and B		susceptible to both pathotypes.

3. *Consumer Quality*

At lifting	(*a*) Steamed	flesh moderately firm, slightly mealy off-white; discolouration very slight in comparison with Majestic; flavour mild.
	(*b*) Crisped	golden brown colour evenly distributed; intermediate between Majestic and King Edward in quality.
	(*c*) Specific Gravity	high, above Majestic and King Edward.
	(*d*) Enzymic Browning	slight to moderate, similar to Majestic.
	(*e*) Stem-end Blackening	nil.
February (post storage)	(*a*) Steamed	flesh moderately firm, slightly mealy, pale cream, slight discolouration; flavour fairly pronounced, rather sweet.
	(*b*) Crisped	very dark, similar to Majestic.
	(*c*) Reducing Sugar Content	slightly lower than Majestic but higher than Record.
	(*d*) Enzymic Browning	moderate, slightly less marked than Majestic.
	(*e*) Stem-end Blackening	nil.
March (after conditioning)	(*a*) Crisped	dark, similar to Majestic.
	(*b*) Reducing Sugar Content	intermediate between Majestic and Record.

4. *Summary*

A maincrop variety sprouting at a rate similar to Majestic and maturing about the same time. Yield figures were generally superior to Majestic, especially as regards the larger ware tubers, and compared favourably with yield figures for other maincrop control varieties.

The variety was field-immune from the common race of blight (Race 4) in foliage and tuber and appeared to have field-resistance to other races. It exhibited moderate resistance to Gangrene and Skin Spot; to Dry Rot, susceptibility was no more than average. The variety was susceptible to the common mosaic viruses.

Steamed tubers were moderately firm and slightly mealy. Discolouration was negligible. Crisps were satisfactory at lifting but tended to be rather dark at later dates after storage, a condition which improved only slightly on conditioning.

Pentland Marble was released for multiplication in 1970 through a group of seed growers collaborating with NSDO. Canning quality assessments made by processing firms have all confirmed the 1970 reports of the variety's outstanding quality for this purpose. Pentland Raven, P. Squire and P. Meteor were released by the NSDO at public auction in Perth in November.

A noteworthy development during the year concerns clone 2699a(2), which had been rejected as a conventional ware variety because of undesirable tuber characters. This clone possesses resistance to eelworm pathotype A, has a high yield potential and, in particular, produces tubers of very low specific gravity. Messrs Campbells Soups Ltd. have grown, stored and processed it as a potential new specialised variety for dicing purposes. The dice show a negligible tendency to disintegration after cooking and the processor's findings from the first year of trials have been very satisfactory. The intention is to extend the field and processing trials in the coming year.

The problems of assessing quality in potential processing varieties are highlighted by the current work on the selection of a canning variety superior to Pentland Marble. The Fruit and Vegetable Processing Research Association, Chipping Campden (FVPRA), who tested four new canning selections in the past year and found them satisfactory, will repeat the trials in 1971. However, since they are unable to test more than ten selections per annum, a serious blockage in the flow of material through this programme can be expected unless a simple preliminary screening procedure can be devised and operated at Pentlandfield which gives results which correlate well with those of the more sophisticated Chipping Campden tests. The development of such a screening test implies close collaboration with Chipping Campden. It is envisaged that material grown on the diverse soils of the regional trials sites at Gleadthorpe, Terrington and Ely will be used for quality assessment purposes, in addition to that grown at the Station's new farm.

The policy of assessing first early varieties under realistic conditions in early potato growing areas continues. Six of the 23 potential first earlies under trial in Cornwall and Ayrshire are being returned for a second year, together with an additional 18 for first year's trial.

The major reorganisation of the breeding procedure continues. This involves changes in the management and handling of the material and also in the scoring of characters to permit sorting and analysis of data by computer. The whole of the fourth year material, some 3,000 lots each grown in 4×3 tuber plots at Blythbank, was handled in this way for the first time. It was scored for a wide range of characters—nineteen in all, ranging from general habit in the field, blight resistance of tubers and foliage, yield and numbers of tubers, tuber form and size distribution, and specific gravity to various assessments of quality for cooking and processing. This has provided valuable data and experience on which to plan the programme for the recording and computer analysis in 1971 of data from the first wave of test cross progenies in single 3-tuber plots. This computerised analysis of progeny data will enable for the first time the rapid assessment of pilot and test cross progenies for many characters on a large scale and so expedite decisions on the selection of parents for particular purposes. In addition, more refined analyses of suitable sample families will provide estimates of heritabilities of the various selection criteria and estimates of combining abilities of parents for particular characters. The changes in management of the breeding material mentioned above have affected the greater part of the material at Blythbank. This has been grown under a " seed " production regime similar to that obtaining in normal commercial practice. In particular the foliage was burned down as soon as a crop of seed tubers had formed. This prevented significant blight infection of tubers and therefore resulted in loss of data on tuber resistance to this disease. However, duplicate plots of the fifth year élite stocks were planted at Howgate, adjacent to Pentlandfield, and lifted carefully by hand to provide a source of fresh undamaged tubers for inoculation, clamp incubation and assessment of tuber resistance to blight, gangrene and skin spot. Although the techniques used for the induction of the diseases were regarded as experimental, the results have shown a wide range of reaction between selections and can be regarded as highly satisfactory, though no doubt capable of further refinement. The Howgate site provided a welcome bonus in that it induced severe symptoms of " spraing " in some of the material and thus provided the opportunity of screening the breeding material for resistance to tobacco rattle virus. This screening is to continue.

In addition to the development of these techniques for screening for resistance to latent tuber diseases, the routine screening of seedling populations for resistance to foliar blight and of more advanced selections for resistance to common scab continued. One significant result (confirming previously published information) is that field resistance to blight can result from the specific combining ability of certain parents which are themselves lacking in field resistance. Further confirmation of this important conclusion will be sought from this year's data.

The level of resistance to viruses in breeding stocks continued to rise and was associated with a general improvement in the other agronomic characters. Through the use of " advanced " strains of viruses X and Y, capable of infecting all genotypes with specific resistance to strains of these viruses, the breeding material has been purged of strain specific resistance and work in the future will be concerned with the incorporation of comprehensive resistances to virus X (from *S. acaule*, and Andigena Group clones) and to virus Y (from *S. microdontum*, *S. stoloniferum* and *S. demissum*) into lines with other desirable agronomic attributes. In addition to providing virus resistant parental material for use in the main breeding programme, the virus work is producing a steady, if small, flow of clones which are worthy of consideration in their own right as potential new varieties. Two early maincrop selections were included in the regional trials in England while selection G.4140(53), derived from *S. microdontum*, was only debarred from entry into the P.V.R. trials by shortage of tubers of "seed" size. This clone, which appears to outyield Pentland Crown and to possess acceptable tuber characteristics, is immune to virus X, resistant to viruses A, B and C, and has very high field resistance to virus Y.

The routine screening of the breeding material for field resistance to blight has provided some valuable clues to the meaning of this widely used but little understood term. Analysis of the data available to date indicates that there are three components to field resistance which are not necessarily associated, namely: upper leaf surface resistance; stem resistance; and limitation of sporulation. Tests of whole plants showed that clones with the greatest overall resistance had resistant stems and, in some *S. vernei* derivatives, resistant stems were associated with upper leaf surface resistance. Sub-normal sporulation was observed in progenies of certain Andigena parents. There is evidence of specific combining ability between particular parents in the origin of these forms of resistance. The genetics and other aspects of these host-parasite relationships will be investigated in order to gain a better understanding of the nature of field resistance, and so facilitate its exploitation in the breeding programme. In the field at Blythbank an encouraging degree of field resistance was observed in the breeding material. The degree of resistance/susceptibility in foliage and tubers was not always related, and in some selections with marked resistance in the foliage, extreme susceptibility occurred in the tubers. In this connection the development of independent winter screening tests for assessing resistance to tuber diseases (see above) using controlled and uniform levels of inoculation is particularly valuable. The extent to which tuber reaction is genetically and physiologically independent of foliage reaction has yet to be disentangled from the masking effects of varying levels of spore inoculum discharged from aerial parts of plants which differ in their field resistance. The expectation is that the routine screening of breeding material for resistance to tuber diseases will soon reach the stage of standardised routine achieved in the leaf blight screening and so permit a greater concentration of effort on to the basic problems of the host-parasite relationship.

All scientific staff in the department are now using the computer as an aid to the more efficient conduct of their experimental work. Programmes have been written, or are in preparation, for the randomisation of experiments, for the sorting and analysis of data, and for data storage. This has represented a considerable amount of work which may now be expected to decline. Concurrently, work on the biometrical genetics of the potatoes is being developed. This takes the form of study of combining abilities, heritabilities and selection indices as aids to potato breeding.

The routine management of the Neotuberosum selection experiment continued, with seedling population plots and the tuber-planted seed production plots grown at Pentlandfield and Rosewarne. The attempt, made in 1969, to assess the amount of change in the material from its Andigena origin towards the Tuberosum type, was of limited value because the plants were grown from true seed and were not therefore entirely suitable for assessing characters such as date of maturity, tuber weight and number, total tuber yield, etc. The assessment was repeated in 1970 using tuber-grown material derived from the 1969 seedling populations of Andigena, Neotuberosum and Tuberosum. The first lifting was made on 7th September. Andigena plants had a mean yield of tubers per plant of 75 grammes while Neotuberosum and Tuberosum each yielded about 700 grammes/plant. The main lifting occurred on 14th October. Neotuberosum yielded 1,145 grammes/plant; Tuberosum 800 grammes; and Andigena 320 grammes. Other notable changes towards the Tuberosum phenotype had occurred in stem number/plant and in tuber number. Both values were close to the Tuberosum mean. The yield advantage of the Neotuberosums was related to their later maturity. At the October lifting most were still green while the Tuberosums were mature and tuber growth had ceased. Despite the late maturity of the Neotuberosum material it is clear that, apart from a persisting tendency to produce excessive amounts of haulm, it is now close to the conventional Tuberosum phenotype in many characters. The purposes of this experiment when it was set up in 1959 were to test the inference that the Tuberosum Group had evolved during cultivation in W. Europe from initial introductions of S. American Andigena materials and also to broaden the genetic base of the breeding material available for further potato improvement. Present indications are that both purposes are likely to be fulfilled. The present condition of the Neotuberosum populations points strongly to the likelihood that Tuberosum originated from Andigena, and the increasing use of Neotuberosum élite clones (14 in 1970) as parents in the general breeding programme must effectively increase the genetic diversity available to the breeders. Progenies of the first Tuberosum-Neotuberosum crosses reached the single tuber plot stage in 1970, and survival rates following normal selection pressures were satisfactory. In order more accurately to assess the probable value of the élite clones as parents for the general programme, testing for resistance to blight, virus and scab will be continued, and preliminary assessments of cooking quality have begun.

It was expected that extensive cross-fertilisation would occur each year in the seed production plots of the Neotuberosum experiment, thus ensuring maximum gene flow, recombination and genetic diversity on which to practise mass selection. It is likely that cross-fertilisation has been less frequent than hoped for and that in some years, at least, selfing has been common. An attempt to estimate the frequency of crossing in 1970, using marker genes, was inhibited by scarcity of bumble bees—the usual pollinating agent—and of flowers, on many of the plants. In addition, some of the flowering plants produced pollen of low viability. This experience, although disappointing, supports the view that gene flow is less than free. Seed progenies will be scored for frequencies of marker genes in the coming year.

Routine seed renewal in the Commonwealth Potato Collection was, on the whole, successfully accomplished. However, early accessions of Andigena, now undergoing second renewal, are proving more difficult to seed than first renewals, or lines derived from crossing original accessions. In general, failure to set seed is due either to failure of fertilisation following repeated full sib crossing, or to failure to flower, and both may be manifestations of inbreeding depression. In order to rescue these difficult lines they will be crossed in the coming year using pollen from a fertile Andigena line.

In the course of routine testing of material in the C.P.C. by DAFS Agricultural Scientific Services, East Craigs, a single clonal plant of *Solanum commersonii* was found to be infected with Potato Spindle Tuber Virus. The virus was detected by an inoculation test to tomato seedlings, and diagnosis has been confirmed by Dr W. B. Raymer of the Campbell Research Institute, Riverton, New Jersey, U.S.A., who is an authority on the disease. The clone was, like all recent clonal accessions to the Collection, in quarantine, and it has been destroyed. No other material is known to be infected (although more than 200 clonal plants have been tested), but the possibility must be assumed to exist. The virus is one of the few known to be seed and pollen transmissible and, accordingly, a survey has been initiated of C.P.C. seed stocks derived from other clones held in quarantine at the same time as the infected *S. commersonii* and results should start to emerge in the summer of this year. Spindle tuber virus occurs quite commonly in potato crops in Canada and the U.S.A. but not, as far as is known, in western Europe. The combination of seed and pollen transmissibility, often weak symptom expression and difficulty of diagnosis implies that all international potato collections need to be routinely screened for the presence of this virus, a process made possible by the recent development of the "tomato test"; and this point will be stressed when the occurrence is formally reported by the Department under the International Plant Protection Convention.

The mass selection programme, begun with diploid material of the Phureja and Stenotomum Groups of clones, continues to show perceptible progress in improved tuber yield size and shape. Scoring of progenies indicates that high-yielding clones give rise to superior progenies and that their superiority can be detected in the seedling year. Whereas mean yield of tubers per plant was about 0·5 kg. in the starting material, the best of the élite clones selected to date are yielding over 2 kg. per plant. The range of reaction to blight is wide, but evidence points to a slow rise in the general level of resistance in material grown at Rosewarne. A few individuals with marked resistance to tuber blight have been identified. No R gene type resistance has been found in these diploids. The selection pressure which has to be maintained on the tuber-grown populations for freedom from virus, simply to maintain the material in a healthy and vigorous condition, is undesirably severe. Nearly 50 per cent of the population was discarded for this reason in 1970, and this may well limit the rate of progress in selecting for improved yield and shape of tubers. It is hoped that this programme will eventually produce specialised commercial diploid varieties but, probably, its most fruitful contribution will be the supply of parents for intercrossing with selected dihaploids derived from tetraploid cultivars. The first evaluation of 13 pilot progenies, produced at Pentlandfield from intercrossing a range of fertile dihaploids with diploids, was made in 1970. In addition to providing material worthy of further selection, 26 promising clones have been identified, several giving yields up to 2·5 kg. per plant. Tuber sizes and flesh colours were in several cases close to the accepted standards for Tuberosum varieties. Apart from the difficulty of inducing dihaploids the greatest single factor limiting their utilisation is their infertility. Over 50 per cent fail to flower at Pentlandfield, and a further 6 per cent shed initiated flower buds before opening. Of the flowering fraction, half show some degree of female fertility, but only about 6 per cent are male-fertile. Improvement in pollen fertility and tuber yield can be achieved by the inter-crossing of dihaploids with some degree of fertility, followed by selection. However, the most rapid progress can be expected from inter-crossing with fertile diploids. In this way the diploid and dihaploid programmes can be regarded as complementary to each other and, when hybridised at the élite level, to offer the best prospect of contributing genetic material to the Tuberosum breeding programme. The problem remains of how to induce flowering in the non-flowering half of the dihaploids. In their non-flowering state they represent a considerable waste of resources.

The department continues to expand its contacts with overseas breeders, and a selected batch of seedlings has been sent to Kenya to help establish a breeding programme there. Seedlings 3035ab(5) and 3751(5) have been named, for use in Malawi, as Roslin Tsangano and R. Bvumbwe respectively. Seed lots of Pentland Marble have been sent to Canada, Cyprus, France, Holland, New Zealand and the Republic of S. Africa.

The close and active collaboration which exists between this department and the Scientific Services Staff of the Department of Agriculture for Scotland has been further strengthened this year by the expanding programme of wart resistance testing and by the common problems arising from the finding of Spindle Tuber Virus in the Commonwealth Potato Collection. We are happy to record our appreciation of this valued relationship with the East Craigs staff.

The acquisition of the new farm, and of two large glasshouses, now nearly complete, will permit a considerable expansion of the general breeding programme. In addition, the Murrays will provide facilities for field experiments under conditions of low virus infection. It is intended that so far as possible the farm will be reserved for virus-free material. Plots of necessarily virus-infected potatoes will be maintained at Pentlandfield. This segregation of healthy from virus-infected breeding and experimental material, in addition to the greatly increased area available for field experiments which the Murrays will provide, should greatly facilitate the work of the department.

Forage crops investigations

Oat breeding. The pedigree system of making selections in the F_2 generation and following the progress of their progenies in ear-rows through successive generations until segregation had ceased, was practised at the Plant Breeding Station, then at Craigs House, up to 1953. Throughout the segregating generations the rows were hand sown with seeds spaced at 2-in. intervals. During the growing season plots were kept clean by hoeing between the rows and hand weeding within the rows—all under the supervision of an experienced gardener, and all requiring a considerable labour force.

In 1953, segregating breeding material was grown for the first time at centres remote from the station in marginal land areas of Inverness-shire and Argyll. It was immediately apparent that spaced plants gave inadequate ground cover to suppress weed growth and that it was desirable to employ a sowing density which was more in keeping with commercial practice. This required a modification of the pedigree system and from 1954 onwards a sufficient number of ears were selected in each generation to provide an adequate bulk of seed for the succeeding generation. Hybrid populations were separately identified and were compared one with another for performance in replicated trials. Ears selected in the F_6 from the more productive hybrids were then multiplied to give fixed lines for further trial. This change in procedure coincided with the move to Pentlandfield and continued with only slight modification until 1963. During this period it was becoming evident that limitations of space were restricting the number of new hybrids which could be introduced each year and at the same time were necessitating the rejection of entire populations of low overall performance, which may well have contained outstanding individuals. It also appeared that the ultimate success of the project depended largely on a fortunate choice of parents, but fortunate or otherwise, space and effort were committed to these hybrid populations for a number of years in order to assess their merits.

Oats are by nature self-pollinating with no evidence of out-crossing in Scotland. It follows, therefore, that if segregating populations are grown in bulk for a number of generations they will end up as a heterogeneous collection of inbred lines, and if subjected to environmental pressures at the same time, the components of the population best adapted to the environment will be the most productive and, therefore, the most frequent.

With this in mind, 1963 and 1964 hybrids were bulked to give a single bulk population, from which some 100 F_2 plants received random pollen from about 120 of the varieties in the Station's museum collection, to give the first of the composites, A(65). Additional varieties were introduced in succeeding years using a random sample of each most recent composite as either the male or the female parents in a mass pollination operation. The genetic base of the population components was still further extended in 1969 and 1970 by intercrossing within the winter F_1 generation to provide parental material to be crossed with further introductions.

Worthy of note at this point is an improved outcrossing technique which has been developed at the Station and which yields upwards of 1,000 hybrid grains each year.

The immature ear of the mother plant is exposed by cutting away the leaf sheath as soon as the first spikelet emerges at the ligule. Each spikelet is stripped of all floral parts until only the inner pale and the ovary and stigmas of the lower grain remain. Additional heads on the same plant are either similarly emasculated, or they are bagged or cut off to eliminate chance selfing.

The emasculated plants are then placed in close proximity to, and at a lower level than, the normally flowering oat plants which are to be the pollen parents. An occasional shake in passing is sufficient to shower the exposed stigmas with pollen and a success rate of over 50 per cent on a single head has been recorded. The whole operation is carried out in the glasshouse and works equally well when the plants stand in the open house or when the male and female parents are enclosed in a pollen proof bag in cases where specific crosses are being produced.

While these changes were taking place in the field, breeding for resistance to oat stem eelworm continued as a pedigree programme with rigorous selection in the laboratory in successive generations followed by backcrossing of the most highly resistant lines to selected high-yielding parents.

Recent small-scale field trials of 3rd and 4th backcross material show a progressive increase in yielding capacity with some of the lines within 10 per cent of the high-yielding control varieties on uncontaminated land. A further advance in yield is anticipated when 5th backcross material, now in process of laboratory selection becomes available for field trial. With an eye to the future, resistance to the oat stem eelworm has now been introduced into the latest composite (A70).

Selection centres in 1970 were sited on the same farms as in 1969—one in East Lothian, one in Inverness-shire and one in Argyll. Composite populations were grown at all these centres and selections were taken from the 1965 composite (A65), which was in the F_8 generation. Some 700 selected lines from 1963 and 1964 bulk hybrid populations were evaluated for performance in small-scale replicated trials, from which trials 200 lines are being continued in 1971. The 50 highest yielding lines will be in more advanced trials, but since a severe gale at harvest time caused heavy grain losses, particularly in the earlier ripening material, those which attracted favourable comment in the field are being re-evaluated in trials of the same scale as in 1970.

The original source of resistance to the oat stem eelworm, which has been employed at Pentlandfield, is the wild hexaploid species *Avena ludoviciana* and it was observed that hybrids with *Avena sativa*, and later backcrosses to *A. sativa*, showed some degree of tolerance to the alkaline soil conditions responsible for the manganese-deficient " Grey Speck " disease in oats. These observations were made at Archerfield in East Lothian, where facilities for growing oats at pH8 or above are available by courtesy of the Forestry Commission. Alkaline soils present an acute problem on the machair areas of some of the Western Isles and in 1967 a long term selection experiment was instituted on Tiree in conjunction with the County Agricultural Adviser. This involves the growing of bulk populations of hybrids derived from *A. ludoviciana* on soils of pH7 and upwards, with a locally adapted lime-tolerant variety as the ultimate objective. In 1970 a similar exercise was begun in Benbecula, again in collaboration with the County Agricultural Adviser.

In each area foliar spraying with manganese sulphate is practised as an insurance against a total loss of crop, but a proportion of each field is left unsprayed and, where possible, it is the seed from the unsprayed portion which is sown the following year. As the generations succeed each other they are sown on soils of ever-increasing alkalinity.

Barleys. The programme of back-crossing, to transfer the single gene for high content of amylose from the Pentlandfield accession of Glacier barley to commercially useful varieties, has reached the 6th back-cross with Ymer, Proctor, Zephyr and Julia as recurrent parents. The 5th back-cross has been made with all remaining varieties. Pollinations in the winter have been much more successful since fluorescent tubes were replaced by sodium vapour lamps for supplementary lighting. No more than six back-cross generations were intended in this programme. With the varieties named above, it only remains to extract and increase homozygous high-amylose genotypes by selfing to complete the project. In anticipation, heterozygotes from 3rd back-crosses to Ymer and Pirkka were selfed. Homozygotes and heterozygotes were classified and selfed again. Tests by the Chemistry Department, University of Edinburgh, showed that the high-amylose homozygotes had only 37 per cent amylose in their starch compared with 42 per cent in Pentlandfield Glacier. Whether this difference is due to a genetic background effect or to an environmental influence remains to be determined.

The high-amylose project was designed to produce a variety for malt distilling, but the variety may also have a different feeding value from ordinary barley. Samples of normal and high-amylose variants of Glacier have been sent to Dr L. Munck of the Swedish Seed Association, Svalöf, for feeding trials with mice. The Poultry Research Centre, Edinburgh, is also interested in this aspect.

The other project concerned with barley for distilling has the objective of a variety capable of giving profitable yields in Scotland and of producing high-diastatic malt for the grain distillers. Trials in preceding years at a wide range of sites showed that Pirkka and Olli could produce green malt of high diastatic power (DP) when grown in Scotland but with very unsatisfactory yields. During 1970 the laboratory analyses for DP nitrogen content (N) and α-amylase activity (α) were completed and their inter-relations studied. The very restricted choice of highly contrasting varieties in these trials makes them unsuitable for studying relations between genetic effects, but some interesting conclusions are indicated about geographical effects, based on site means. Multiple regression shows that variation in DP can be largely explained in terms of N and α, which show little correlation with each other. This implies that β-amylase (which is supposed to be present in an inactive form in the mature grain) is related to N and that variation in α-amylase activity is more affected by the speed of *de novo* synthesis of the enzyme than by the total amount which can be produced.

Grain of Ymer from a fertiliser trials in 1969 was also studied for DP, N and α. Here again the source of variation was environmental, and again there was no significant correlation between N and α; both of these were correlated with DP but together explained much less of the variation in DP than in the above trials. As with the yields reported in the 1969-70 Report, main effects of nitrogenous fertiliser were large and, with one exception, were the only significant effects. The exception was a highly significant positive interaction of nitrogenous and potassic fertiliser effects on α-amylase activity.

When, in addition to environment effects, varietal effects are also operating, a small but statistically significant, positive correlation between N and α appears. Whether this is simply due to a threshold effect (N becoming limiting for α at the lowest levels of N) or something more complex, is a question needing more suitable genetic material to answer. The correlation is not helpful in breeding for high α-amylase and high yield (the latter usually implies a tendency to low N) but the present indications are that it is too low to be much hindrance. More worrying is the association, well known but difficult to quantify, of high α with low dormancy and therefore a risk of sprouting before harvest.

The "halo" test involves applying an extract of germinated grain to a small filter-paper disc on a starch-agar gel. After incubation and staining with iodine the DP of the grain is expressed as the diameter of the clear circle where the starch has been digested. The test was applied to two grains from each of 1,000 ears from a composite cross bulk in F_3. The mean halo diameter was 20·1 ± 0·03 mm. Micro-malting samples from the same bulk showed that this corresponded to 128 degrees Lintner for the DP of the green malt and 14·6 °L α-amylase activity. Selection of 100 ears in the high, mid and low ranges provided material to test the value of the halo test for selection. The mean diameters for the three classes were 21·6, 20·1 and 18·1 mm. respectively. Ear rows were sown in random order in the field, with Akka as control. At harvest five plants were taken at random from each row to continue selection in the high, mid and low ranges and also for micro-malting to measure response in terms of DP.

In developing screening techniques for diastatic power, capable of being used on single grains, ascending paper-chromatography has been used to display oligosaccharides as discrete spots. Glucose, maltose and maltotriose can be clearly separated and the sizes of their " spots " give a rough indication of their concentration; fructose and sucrose could also be identified if they occurred. The extracts used for other tests can be used in this one. Zymograms produced by electrophoresis in agar gel have been made more suitable for quantitative work by improving the uniformity of background staining.

A start has been made with studying the genetics of variation in iso-enzymes. Ymer and Olli differ in one α-amylase and one β-amylase in the endosperm and also in an esterase in the plumule of germinating grains. F_1 and F_2 determinations showed a single factor involved in each case and no evidence of linkage.

The control exercised by gibberellic acid (GA) over amylase activity has been further studied, using endosperms of Ymer barley. Although the most conspicuous effect of GA is to produce a single strong α-amylase band, adding calcium ions at the same time as GA produces two more α-amylases. By comparing results obtained from different parts of the endosperm with each other and with the patterns of bands obtained as germination of intact grains proceeds, it is concluded that GA is probably involved in the control of most of the α- and β-amylases. Its effects depend both on other chemical factors and on how long it has been since it reached the cells concerned.

The practical implication of this work is that in Ymer (and probably in some other varieties with characteristically low DP), GA is limiting during malting. Abscisic acid (ABA) acts as an antagonist of GA and might be expected to allow germination to proceed, if only slowly, in a variety with a greater production of natural GA, at a concentration which would just stop germination in Ymer and similar varieties. This is in fact so; a concentration of 5×10^{-4} molar ABA in an acetate buffer at pH5 allows Olli to germinate but stops Ymer. The practical value of this discrimination by ABA as a screen for high DP mutants is being tested. Grains of Ymer were treated with ethyl methane sulphonate and the M2 grains were treated with 10^{-4} molar ABA. The early germinating grains were planted in the greenhouse to produce M3 grain. A larger bulk of M2 grain awaits screening and a second M1 generation has been produced. Thanks are due to F. Hoffmann-La Roche & Co. for a gift of ABA, which does not seem to be commercially available.

The third main project with barley aims at producing a high-yielding variety for stock feeding. Information relevant to this project and to the high-diastase project should be obtained from a large diallel cross. F1 and F2 grains were obtained for a 14×14 set of crosses, but excessive dormancy associated with Glacier reduced this after sowing to a 13×13 set. Reciprocal crosses were available from 9 parents. The parents and each cross in F1 and F2 were represented by 10 plants ($5 + 5$ in the case of reciprocals), completely randomised in each of two blocks—a total of nearly 4,000 plants. The whole planting is to be repeated in 1971. With many variates to be measured, a formidable body of data will accumulate; good progress has been made with computer programs for analysing it and the file handling facilities of the Edinburgh Regional Computing Centre are well developed.

The variety-nitrogen trials started in 1969 were continued in 1970 at three sites and again produced useful information both about yield and about malting properties. The 1970 trials gave some indications that mildew was involved in differential yield responses to the three levels of nitrogenous fertiliser applied. The statistical analysis is not yet complete but it does appear that the well-known effect of nitrogen of increasing mildew reduces the response to nitrogen at sites and with varieties showing a high incidence of mildew.

Trials using the proprietary systemic fungicide, Milstem, to compare yields of Golden Promise, Ymer and Julia with and without control of mildew were continued by the station, by the Scottish Colleges of Agriculture and by certain seed firms. Overall statistical analysis of yields from the Station's trials at five sites showed that the effect of Milstem was positive but varied from site to site and from variety to variety. Golden Promise gave an average increase of 3·3 cwt/acre, and in two trials gave a response of over 6 cwt/acre to Milstem dressing. Ymer and Julia gave average increases of 1·3 and 1·0 cwt/acre respectively (1 cwt/acre = 126 kg/ha). The general picture was much the same with eight trials with bigger plots, run by the Colleges and others. These results indicate more serious losses from mildew in 1970 than in 1969, and the trials are to be continued for another year.

A dichotomous key using six easily observed binary characters divides the 950 barley accessions in the Station's museum into 28 of the potential 64 classes. Canonical analysis is being used to study the relationships between accessions. The two most numerous classes have been processed and a third is ready;

eight measurements are taken on ears and eight on grain. Ideally, one would like to establish a natural classification by some form of " clustering ". How nearly this can be approached will not be known until most of the classes have been studied. Within the large classes so far studied, some clusters can be recognised—*e.g.*, Western European, Turkish and Afghan—but many accessions evade clustering. This rather intensive study of the museum seems to be necessary if its full value for breeding work is to be realised.

Museum material grown in 1970 comprised new accessions, marker gene and translocation stocks, accessions needing replenishment, waxy-endosperm types, accessions suspected of having out-crossed and some wild species.

Canonical analysis was also tried as an aid to selection from a composite-cross bulk. From observations on a replicated trial with standard varieties and 69 single-plant progenies, standardised eigenvectors were obtained. These were applied to the observations from 900 unreplicated ear-rows adjoining the trial. There were five significant eigenvectors, and it is a measure of the intensity of selection needed that not one of the 900 fell within the limits defined by the extreme values of the standard varieties. By ignoring the least important vector, 52 progenies could be selected on this basis. Apart from any statistical analysis, an obvious defect of the composite-cross material was its excessive height. Evidently artificial selection will be needed to counter the natural tendency for tall genotypes to predominate.

Grasses. Good progress has been made with interspecific hybridisation between the mainly apomictic species *Poa pratensis* and *P. ampla*. From the pollinations made in 1968 some 60 seedlings were regarded as variants from the maternal parent, *P. ampla*, and so not the normal apomictically produced offspring. They were propagated vegetatively and planted in a replicated field trial with their putative parents. The presence of rhizomes led to 11 of them being classed as species hybrids. Canonical analysis of data collected in the field confirmed this diagnosis and also showed that another 12 individuals were intermediate between *P. ampla* and *P. pratensis*. The remainder were close to *P. ampla*. The hybrids were selfed, pollinated again by *P. pratensis* and intercrossed and seedlings from these pollinations have been raised for planting in the field in 1971. From a second series of pollinations of *P. ampla* by *P. pratensis*, a second trial of 80 possible hybrids was planted in 1970. The rhizomatous habit is not only useful as a marker but also agriculturally. In general, the hybrids are earlier in spring growth than the *P. pratensis* parents, though not as early as *P. ampla*. The prospects of finding good genotypes with early growth and a rhizomatous habit seems to be favourable. Stability under seed propagation will be the next problem.

Difficulties were met in setting up the Station's own service for determining *in vitro* digestibility (IVD). This in turn has hampered the work on cocksfoot, in particular the project aimed at improving the performance of Scotia cocksfoot without losing its high digestibility. As the difficulties were overcome the results have started to flow and a few hundred plants of interest agronomically have been determined as to IVD. These plants are available for more stringent selection in 1971.

The widely based cocksfoot composite cross is now into its third generation. A bulk was sown broadcast at Pentlandfield in 1970. The large, incomplete diallel, involving 18 of the populations which were incorporated in the composite, completed its first harvest year and several variates have been recorded. A computer program for the statistical analysis has been developed and tested.

The increasing trouble Scottish farmers are meeting with winter kill of Italian ryegrass has led to the Station starting a number of projects bearing on this problem. As a simple and direct approach 2,000 spaced plants of a range of cultivars of *Lolium multiflorum* were planted in autumn 1969 and heavily manured with nitrogenous fertiliser during 1970. The winter 1970–71 has been extremely mild and by the end of February no plants had been killed; however, clear differences in hardiness were evident and some 200 plants have been marked for propagation.

As a short-lived species, Italian ryegrass has attractions as a subject for studying grass breeding techniques. In a second project biometrical data are to be collected and analysed from a set of crosses in the design often called North Carolina I. To make the matings a set of polythene isolation chambers was constructed with capillary watering and ventilation by filtered air. Each member of a group of 69 plants was mated once with a member of a second group of 23. Good yields of seed were obtained and the chambers, which are housed in a polythene greenhouse, promise to be of lasting value.

A third possible approach to the hardiness problem is hybridisation of Italian with perennial ryegrass. In preparation for this, inbreeding has been started with diploid and tetraploid varieties of both species; 650 progenies were produced in 1970 and sown to continue the inbreeding in 1971.

Brassicas. In the breeding work with swedes, F_3 families of crosses of Pentland Harvester with several raan-resistant progenies were grown. With valuable—and gratefully acknowledged—co-operation from Mr K. Simpson and Major J. D. Callander, a site was found on the latter's Tynehead farm where it was judged that boron and pH could be adjusted to provide conditions for discriminating between resistance and susceptibility to raan. This careful preparatory work was largely defeated, not only by droughty conditions following sowing, giving a double emergence of seedlings and so uneven bulb sizes, but also by the fact that 1970 was a season in which very little raan occurred, even in Pentland Harvester. Selections have been made for selfing in 1971. With other swede crosses F_3 seed was produced and with still others F_2 selections were taken for selfing in 1971.

In 1968, swedes were extensively pollinated by radish pollen in the hope of producing completely homozygous maternal-type plants. Selfed progenies of maternals were grown in 1971 alongside the corresponding F_3 families. Segregation for colour characters was observed in both types of family, and the hypothesis that the maternal-type plants were all completely homozygous is rejected. With it goes the possible use of the phenomenon in swede breeding.

The same hypothesis was quite rigorously tested in kales. Here the progenies were derived by bud-selfing maternal-type plants resulting from pollinating *B. oleracea* by *B. campestris*. Pollinations were made within the families and also to lines homozygous for known self-incompatibility alleles. The compatibility of the pollinations was determined by fluorescence microscopy of stigma and style. According to the hypothesis each family should have been uniformly homozygous for a single S allele. In 6 out of 17 families adequately tested this was shown to be untrue, since compatible pollinations occurred within the families. One good genetic marker (hairy first leaf) was also shown to have been heterozygous when, according to the hypothesis, it should have been homozygous. Sadly we have to conclude that the method has no useful application in Brassica improvement. The question remains: what is the origin of the maternal-type plants? The German worker, Röbbelen, advanced the hypothesis that they arose by the doubling of a haploid cell in the embryo sac and reported that a marker, for which the maternal plant itself was heterozygous, segregated in the 1 : 1 ratio expected if the maternal-type derivatives were produced in this way. The results reported here rule out this explanation and also the genetically equivalent origin by fusion of two genetically identical haploid cells. Accidental self-fertilisation seems unlikely, since emasculation not followed by pollination produced no seeds. Development from a diploid cell without meiosis would have the consequence that all maternal-type plants derived from one parent would be genetically identical. The compatibility work described above showed that two maternal-type plants from a single parent had different genotypes, one being S_9S_{20} and the other $S_{20}S_{20}$; meiosis must have had some part to play in their origin. An hypothesis which would be consistent with Röbbelen's reported results and ours would be that the cell giving rise to the maternal-type offspring was diploid because of a failure of the second division of meiosis. The implication would then be that the S locus recombines with the centromere but that the locus used by Röbbelen did not; by this hypothesis, the tract of chromosome between the centromere and the most proximal chiasma would be homozygous.

Progeny from crossing curled kale and thousand head kale were tested against Canson kale in a replicated trial. They showed no advantage over the control in yield, digestibility or proportion of leaf and no further tests on this material are intended. Difficulties with pollination have held up projects concerned with biometrical studies and with diploid-tetraploid comparisons.

Co-operation between the three Colleges of Agriculture and the Station led to a uniform series of trials to study the possible utilisation of the original hexaploid *B. napocampestris* (NC). At each site NC was compared with rape under different agronomic managements. In the Station's own trials a further eight hexaploid NC lines were compared with rape. Their dry matter contents ranged from 9·6 to 10·2 per cent for NCs, from 12·5 to 14·5 per cent for rapes. The difference is presumed to be a result of the high polyploidy. Although seven NCs exceeded rape in fresh weight yield, all were lower in dry weight. It may be possible to retain the desirable character of NC at the tetraploid level, where the dry matter content would be higher. To test this *B. napocampestris* (aaaacc) has been crossed to *B. napus* (aacc) and, from the F_2, plants have been selected for selfing and cytological examination.

Work with synthetic rape, originally produced by crossing tetraploid *B. oleracea* and *B. campestris*, continued; F_2 plants gave moderate and variable sets of seed. F_3 families produced by selfing were observed in the field. Crossing synthetic with natural *B. napus* produced F_1s with moderate fertility, at least in isolation cages in the field.

Over 1,000 F_3 plants of *Raphanobrassica* have been raised out of season in the greenhouse. The fertility of F_2 plants ranged from 12 seeds per siliqua down to nil, the average being considerably higher than in F_1. New F_1 and F_2 generations have also been produced to expand the range of variation. Over 2,500 pollinations were made in one direction or the other between tetraploid *Raphanus sativus* and tetraploid *B. campestris* but only one suspected hybrid was obtained, with a few maternal-type plants. Pollen germination and growth were fairly good but very few ovules started development.

A small-scale trial comparing tetraploid turnips with the corresponding diploids showed the latter to have the advantage in both fresh weight and dry matter content.

A feasibility study of the use of triploid hybrids of *B. campestris* × *B. napus* was started by isolating together single plants of turnip and swede-rape in pollination cages. Enough seed was obtained from 11 turnips for a small-scale trial to determine the frequency of hybrids and their yields relative to turnip and rape. If the preliminary results are promising, *B. campestris* lines homozygous for different S alleles will be needed to make hybrids on a larger scale; the necessary inbreeding has been started.

2. THE SOCIETY AND THE STATION: AN HISTORICAL INTRODUCTION

R. J. L. Gallie

Foundation

Negotiations for Britain's entry into the European Economic Community have focused political attention once more on the place and purpose of agriculture, the largest single industry in the United Kingdom. The decisions taken in the months ahead, no matter what they be, will not only affect the industry as a whole but each component, agricultural research not excluded. The purpose of this historical note, however, is rather to look back to the origins of the Scottish Society for Research in Plant Breeding, leaving those who walk the corridors of power to determine its future. But, in entering the second half-century, it is not without interest that the Society was conceived at a time of national crisis—the First World War.

In 1914 the arable acreage of England, Wales and Scotland was about 14·3m. compared with 18·2m. some forty years earlier. Farming had gone over to a pastoral economy which, in terms of feeding the nation, fell far short of the output per acre of the agricultural industry in Germany. A Parliamentary paper of 1916, contrasting the output of the industries in both countries, revealed the perilous extent of the shortfall in the U.K. In 1916 the Government appointed an Agricultural Policy Sub-Committee of the Committee for Post-war Reconstruction, with the following terms of reference: "Having regard to the need of increasing home-grown food supplies in the interest of national security, to examine and report upon methods of such increase". Lord Selbourne, Chairman of the Committee, provided a conference in Edinburgh in 1917 with a western nations league table of national expenditure on agricultural research and education. The U.K. was well down the list, and France spent over three times as much as the U.K. At the same conference Dr E. J. Russell, Director of Rothamstead Experimental Station, Dr John H. Wilson of St Andrews University and others stimulated the interest of Scottish agriculturalists in the need for more research in Scotland. Though Scotland was not short of plant breeders in the nineteenth and early twentieth century, Simmonds reminds us that "these were practical men rather than scientists" and the need was to harness science to the plough. The establishment at the beginning of the century of the science of genetics, and the resulting influx of new plant varieties from Svalöf and elsewhere in

Europe, gave further impetus to the desire to establish a plant breeding station in Scotland.

In 1917 the Highland and Agricultural Society of Scotland appointed a delegation to meet the Secretary of the Board of Agriculture for Scotland " to discuss the desirability of setting up some authority (*a*) to decide what are and what are not new varieties of plants and also to grant certificates for such as, after careful trial, are recognised as new and improved varieties; and (*b*) to encourage the selecting and raising of new varieties ". The delegation was led by the late James Elder, Athelstaneford Mains, Drem, and the late Dr Charles Douglas, C.B., Auchlochan, Lesmahagow. The Board of Agriculture for Scotland agreed to proceed at once with the first of these projects and in the spring of 1918 a Government Plant Registration Station was set up. The second objective was deemed not immediately practicable and the establishment of a research station was therefore deferred. But not for long, for in 1918 discussions again took place with the Board which resulted in the Highland and Agricultural Society convening a conference in the same year with the object of establishing a Plant Breeding Station in Scotland. Representatives from the Scottish Chamber of Agriculture, the National Farmers' Union of Scotland and the Scottish Seed Trade Association attended, and the Chair was taken by the Secretary for Scotland, the Rt. Hon. Robert Munro, K.C., M.P. The need for setting up a research station was unanimously recognised; motions to establish and finance one were made without debate. In his address to the Meeting the Chairman intimated that, from public funds, the Government was prepared to subscribe to the inaugural fund one pound for each pound contributed by the public up to a reasonable limit. To allay the misgivings which seem to have existed in the minds of those present about the degree of control the Government might wish to exercise over the new organisation, the Secretary of the Board of Agriculture, Dr R. B. Greig (later Sir Robert B. Greig), said that " he wished to be allowed to remove what appeared to him to be a misapprehension as to the question of controlling a station such as was proposed. Dr Douglas and Mr Shields would bear him out when he said that there had not been any suggestion that the station should be controlled by the Board of Agriculture. It was far more important that it should be a national institution such as had been described by Dr Douglas than an annexe to the Board of Agriculture. This was much more a national business than a departmental one. It was of national importance, in order to produce what was required for the benefit of the people as well as for the benefit of the farmer, but it was of first importance that the farmer in Scotland should have a personal and definite link and deep interest in the proposal. Of course, he must modify the statement that the Board desired to have no control of this institution, because if the Board gave a proportion of the funds it was entitled to representation in proportion to these funds; but that was the only way in which there should be any kind of control by the Board of Agriculture, which was sufficiently weighted with burdens just now, and was glad to be relieved of some of them". It is interesting to note that one seed merchant present, who had intended to make it a condition of his substantial donation that the station should be in the hands of business men in the agricultural industry, waived this condition after receiving Dr Greig's assurance.

There must be many precedents for the mystical 50/50 ratio for sharing the cost of enterprises entered into jointly by the Government and the public. One of the earliest involving the Highland Society of Scotland is recorded by Haldane in his fascinating account of the great road building projects carried out by Thomas Telford in the Highlands at the beginning of the eighteenth century—a highly successful venture.

In the light of later developments it is perhaps worthy of mention that Government policy in relation to the new station was that it should be self-governing and, by means of Government assistance, should not be allowed to depend upon the accidents of annual subscriptions; to do otherwise was likely to bias the research programme unduly towards short-term work. It was felt too that, if the post of Director were to attract a man of high scientific attainment, he should not be tied by subscribers who might wish to see tangible results year after year, but should have freedom to go into the more fundamental aspects of the work.

Arising from the Conference in 1918 a Committee was formed for the purpose of raising finance. It consisted of the following members:—

10 from the Highland and Agricultural Society;
10 from the Scottish Chamber of Agriculture;
10 from the National Farmers' Union of Scotland;
10 from the Scottish Seed Trade Association;
1 from the West of Scotland Potato Trade Association;
1 from the Edinburgh and East of Scotland Potato Trade Association;
1 from the Perth and District Potato Trade Association;
1 from the Corn Millers' Association;
1 from the West of Scotland Wholesale Ryegrass Machiners' Association
1 from the National Association of Corn and Agricultural Merchants.

By 1920 the Committee was able to report that £21,000 had been received from firms, associations and persons, and shortly afterwards the fund was closed at £22,500. As promised, the Government subscribed a similar amount from the Agricultural Development Fund, bringing the inaugural fund up to £45,000. There followed the formal steps of giving the new organisation a name and drawing up rules. The name chosen was the Scottish Society for Research in Plant Breeding, and as such it became registered in 1921 as a specially authorised Society under the Friendly Societies Act, 1896. The Directors held their first meeting on 6th September 1920, and the first Office-bearers appointed were:—

Trustees:

The Rt. Hon. Robert Munro, K.C., M.P., *Secretary for Scotland.*
Charles Douglas, C.B., D.Sc., Auchlochan, Lesmahagow, *Chairman.*
James Elder, Athelstaneford Mains, Drem, *Vice-Chairman.*
David Bell, 15 Coburg Street, Leith.
J. F. McGill, 69 Kyle Street, Ayr.

Directors:

D. L. Bowe (Messrs J. H. Bowe & Sons), Dunbar.
Sir James Campbell, LL.D., 14 Douglas Crescent, Edinburgh.
William Cuthbertson, V.M.H. (Messrs Dobbie & Co.), Edinburgh.
J. Inglis Davidson, Saughton Mains, Corstorphine, Edinburgh.
J. W. Drummond (Messrs W. Drummond & Sons Ltd.), Stirling.
George A. Ferguson, Surradale, Elgin.
David Ferrie of Parbroath, Cupar, Fife.
Lord Forteviot, Dupplin Castle, Perth.
A. B. Fulton (Messrs Jas. Fulton, Jun.), 118 Queen Street, Glasgow.
James Gardner, South Hillington, Cardonald.
Sir Archibald Buchan Hepburn of Smeaton, Bt., 22 Lansdowne Crescent, Edinburgh.
J. H. Milne Home, Irvine House, Canonbie.
W. W. Hope, The Knowes, Prestonkirk.
John McCaig of Belmont, Stranraer.
J. T. McLaren, The Leuchold, Dalmeny.
A. T. McRobert (Aberdeen Line Co.), Aberdeen.
George G. Mercer, Southfield, Dalkeith.
Principal W. G. R. Paterson, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow.
G. B. Shields, Dolphinstone, Tranent.
Sir David Wilson of Carbeth, Bt., Killearn.

Nominated by the Board of Agriculture for Scotland:

Sir Robert B. Greig, M.C., LL.D.
T. Anderson, M.A., LL.B.
James Wood, O.B.E., M.A., B.Sc.

Under the rules the Secretary for Scotland was entrenched in the office of trustee.

Mr John Stirton, Secretary of the Highland and Agricultural Society, assumed the additional responsibility of Secretary of the new Society.

According to the Rules the objects of the Society were to promote agriculture, arboriculture or horticulture, and its operations in carrying out these objects were to be exclusively scientific and limited to experimental and other research for the improvement of plants and crops in Scotland and investigating conditions affecting their production.

To supervise the affairs of the Society the Board appointed three Standing Committees—Research, Finance and Management. The Research Committee had sub-committees for dealing with individual crop programmes.

The Station at Craigs House

While the Plant Breeding Station was to function as an independent research station, it appears that the sponsors intended it to operate in conjunction with the Government Registration and Seed Testing Station. The Plant Breeding Station was to produce, the Registration Station to evaluate, new plant varieties. As matters developed, the two Stations became neighbours at East Craigs, Corstorphine, for in 1920 the Society purchased the mansion-house of Craigs House along with thirty acres of land and later the Board of Agriculture for Scotland erected extensive modern premises on adjacent land. The Director of the Plant Registration and Seed Testing Station became a Government-nominated member of the Society's Board of Directors and, because of the close proximity of the Stations and a large common interest, there developed between them a valuable and harmonious association.

The Scottish Plant Breeding Station began operations at Corstorphine with a staff of two scientists; Mr Montagu Drummond, B.A., F.L.S., as Director of Research; and an assistant. Four years later Mr Drummond resigned to take the Chair of Botany at Glasgow University. The post of Director was filled by his assistant, Mr William Robb, N.D.A., F.R.S.E., who had, some years previously, been associated with the renowned plant breeder, Dr Wilson of St Andrews. With the assistance of the Board of Agriculture for Scotland, large collections of foreign oats and barleys were obtained which, along with a unique collection of potatoes raised by Dr Wilson and presented to the Society, provided material for the first programme.

Specialisation at that early stage in the life of the new station was naturally impracticable, but a beginning was made which embraced collecting and classifying suitable material, isolating strains and comparing their relative merits. The work was divided into four sections: cereals, herbage plants, potatoes and roots, with a sub-committee for each crop.

In 1929 the Empire Marketing Board, in response to an application, made a grant which enabled the Society to engage in investigations into virus diseases of potatoes; this led to the establishment of a second sub-station at Huntly, Aberdeenshire; and, later, to the erection of new laboratories and greenhouses at Craigs House. Income to maintain the work was also granted by the Empire Marketing Board, and when the Board was dissolved in 1934 the investigations continued, supported by funds administered by the Department of Agriculture for Scotland. The buildings at Huntly were dismantled and transferred to Ainville in 1936.

The founders had envisaged that the work of the Scottish Plant Breeding Station would have a practical aspect and would also be concerned with long-term investigations, more philosophical in character. It was their hope that, unfettered by financial considerations, the Director would enjoy wide scope in which to pursue his researches. But, in retrospect, financial stringency clearly exercised a limiting influence upon the development of the research programme in the first decade or so of the Society's existence. There was little correlation between the will and the means.

The Society had to depend upon four main sources of income: Government aid, income from investments, the sale of produce and subscriptions from members. In the first year the total income from these sources amounted to £3,500; a year later it was £3,700, of which the Government provided about a third. In 1923 there were 172 members, of whom 90 were life members; while in 1933 annual members numbered 216 and life members 127, in spite of appeals for new members. Sales of produce in 1923 brought in £178, and in 1933 £280—a small but useful increase. Income from investments was virtually static. Thus it was only natural for the Board to consider improving the Society's income by utilising a larger acreage for commercial seed production and by marketing schemes.

Multiplication and marketing of seeds, however, require commercial experience, to be expected, perhaps, among members of the Board but not among scientists. For this reason the Board examined but rejected as too speculative, the establishment of a Seed Company or Association similar to the organisation which, in Sweden, exploited the products of Svalöf. Instead, an arrangement was formulated which provided for the limited production of élite seed grown and inspected by the staff of the S.P.B.S. This seed was offered to members of the Society. There were obvious flaws in the production and distribution arrangement. They did not, for example, permit large-scale multiplication nor, consequently, a proper commercial assessment of the new varieties of plants.

1934 saw a change in the Government system of allocating grants which held promise of an expanded programme of research. But, by 1943, twenty-three years after its foundation, the Society's income was still only £6,898, of which the Government provided £5,400. It was not until after the Second

World War that the pace of development increased, so that by 1954 the annual income had reached £29,000.

Government aid having placed the Society's finances on a satisfactory footing, the Board in 1952 again tackled the problem of launching, to the best advantage, new varieties bred at the Station. This time an agency scheme was devised which provided for the appointment of official agents. These had to be members of the seed trade, preferably members of the Society. Agents were to be the sole recipients of élite seed stocks and were bound to multiply and distribute the produce of their crops under stated conditions and obligations. Weaknesses inherent in the agency scheme became apparent and the scheme was abandoned after a short life.

Accompanying a marketing scheme for grasses it was essential to have also a certification scheme. Such a scheme for Scotia strains of grasses was introduced in 1952 and lasted until the advent of the National Scheme for Comprehensive Certification of Herbage Seeds, to which Scotia Cocksfoot and Scotia Timothy were admitted in 1956.

Dr Douglas, who had been elected the Society's first Chairman in 1920, died in 1924 and was succeeded by Mr James Elder. Mr Elder remained in office until 1937 when, on his death, the office was filled by Sir John H. Milne Home, D.L., J.P. Though he continued in the office of Trustee until his death in 1963, Sir John resigned as Chairman in 1957 on grounds of age and health, and Sir J. D. Roberts, Bt., O.B.E., M.A., J.P., the present Chairman, took over the reins.

William Robb retired as Director of the S.P.B.S. in 1950 and was succeeded by J. W. Gregor, C.B.E., Ph.D., D.Sc., F.R.S.E., F.L.S., who had joined the staff in 1924. In 1951 the writer was appointed the Society's first full-time Secretary and Treasurer.

The move to Pentlandfield

An event occurred in 1954 which transformed the S.P.B.S. The Station moved from Craigs House, Corstorphine, to new laboratories and greenhouses at Pentlandfield on the Bush Estate near Roslin. The Government contributed about £100,000 to the cost and the Society £42,500.

While these many and important developments were taking place the Station was growing in scientific stature, and the Director and staff were forging valuable links with other bodies concerned with agricultural research. The Director of the Station had become a member of the Scottish Agricultural Improvement Council of the Department of Agriculture for Scotland and a number of other consultative bodies. Ties with the three principal Scottish Agricultural Colleges, the National Agricultural Advisory Service, the National

Institute of Agricultural Botany and other plant breeding institutes had been strengthened by staff in their quest for assistance and co-operation in conducting nationwide trials of new seedlings. Liaison between virologists at the Station and D.A.S. Scientific Services had contributed towards the formulation of the Department's seed potato certification schemes. Distinguished foreign scientists were visiting Pentlandfield and staff were in touch with research stations abroad. And the Agricultural Research Council, charged with responsibility for promoting and co-ordinating agricultural research throughout the U.K., had moved in as scientific advisers to the D.A.S.

The general role played by the Agricultural Research Council and its relationship with the S.P.B.S. are important developments worthy of elaboration. They are neatly described in an article contributed for the Council to the 1955 Annual Report:—

> " The Agricultural Research Council neither supports the Scottish Plant Breeding Station financially nor prescribes its activities, but is responsible for advising the Department of Agriculture for Scotland on the financial provision to be made for its maintenance and on other matters affecting its research programme and scientific staff. In order to discharge that responsibility the Council must have a detailed knowledge of the Station's programme, staff, facilities and achievements which can only be obtained by close and frequent contacts. Consequently the Council's relations with the Station are intimate though indirect.
>
> The Council's responsibility in this respect is part of its wider responsibility for co-ordinating State-aided agricultural research throughout Great Britain—a function which must not be confused with central direction of research which the Council does not attempt or believe in . . .".

> " For helpful relations with a Research Institute such as the Scottish Plant Breeding Station the first requirement is that the Agricultural Research Council must be fully and continuously informed about research in progress. It receives annual programmes and reports through the Department of Agriculture for Scotland, but does not rely on these alone. At intervals of not more than five years the Council appoints a small group of its members and other scientists to visit the Station and meet the Director and staff. This group acquaints itself thoroughly with the work going on in the various departments, discussing with each worker his particular problems and the direction that his work seems likely to take in the near future. It also invites the Director's views about the broad outlines of the programme in hand and the adequacy of staff and equipment to carry it out ".

Practical assistance in carrying out the research programme at the S.P.B.S., however, has also been provided by the A.R.C. When the Station moved to Pentlandfield at the end of 1954 the potato breeding sub-station, then at Boghall (to which it had moved from Ainville in 1939) was closed down so that, for the first time since 1926 the whole of the scientific staff came under one roof. But Pentlandfield, like Craigs House, was found to be an unhealthy site for raising potato seedlings. Thanks to the co-operation of the Animal Breeding Research Organisation—an A.R.C. establishment—a centre was set up at its Blythbank Farm, Peeblesshire, where seedlings could be grown under relatively healthy conditions.

Over the years the Society has been indebted to its members for providing land for experimental plots. Some twenty-four are presently scattered throughout the country enabling staff to make selections of plants grown in a wide range of environments.

One of the problems confronting the Board and the Director of the S.P.B.S. was the publication of reports on the research work in progress. For many years the Annual Report of the Board to members of the Society was also published in an abridged form; financial details were cut out. The abridged version, containing mainly the Director's account of the scientific work of the Station, was distributed to libraries, research establishments and individuals throughout the world. An exchange publication arrangement operated between the S.P.B.S. and a number of foreign stations. But, to members of the Society, largely practical men, the scientific content and language of the Annual Report obscured the practical implications of the work. And, also, the difficulty experienced by the staff in finding within a reasonable time a place for their papers in suitable scientific journals produced a measure of frustrations on their side. An attempt was made in 1957 to remove these frustrations by producing an 'Annual Report' which briefly described in popular terms the work of the Station, while publishing in parallel the 'Report' which became in 1962 the 'Record'. These two publications also contained scientific papers contributed by outside co-workers. In 1965 the Record ceased, leaving the way open again for a single publication, the Annual Report.

Reference has been made earlier to the financial support given by a commercial organisation for work on virus diseases of potatoes. It should also be recorded that from 1948 to 1963 there was carried out a project concerned with the elimination of bolting from sugar beet crops in the northern parts of the beet-growing area. It was financed by the Sugar Beet Research and Education Committee of Great Britain. For the record, too, it should here be mentioned that the Home-Grown Cereals Authority undertook in 1968 to support for three years a project on high diastase barley aimed at producing a variety suited to Scottish conditions.

In 1965 Dr Gregor retired after over forty years in the service of the

Society. He was acclaimed as a world authority in the field of genecology, which he defined as: "the study of hereditary structure and dynamics of biological populations". He was succeeded by the present Director, N. W. Simmonds, Sc.D., A.I.C.T.A., F.R.S.E., F.I.Biol., who came from the John Innes Institute, where he had been Head of the Department of Potato Genetics. He had established himself as an authority in the field of cytogenetics and evolution of crop plants.

With Dr Simmonds came the Commonwealth Potato Collection which he had maintained at the John Innes and which required the recruitment of more staff and the erection of new glasshouses.

An event of no small importance in the plant breeding world occurred in 1964 when the Plant Varieties and Seeds Act became law. This piece of legislation controlled the marketing of new varieties of plants and provided breeders with "Rights" in their new productions, the right to issue licences to growers and the right to claim royalties on their crops. One of the first potato varieties to be protected by the Act was Pentland Falcon (in 1966); since then Plant Breeders' Rights have been granted in 12 new varieties of potatoes bred at the Station and also in the oat Pentland Provender.

A natural consequence of the new Act was the need for an organisation to take from the shoulders of Government-aided plant breeding stations the task of licensing and collecting royalties from growers of "protected" plants. Financed by the Treasury, the National Seed Development Organisation was established in 1967 and charged with the job, not only of licensing growers and collecting royalties, but also of promoting and marketing in commercial fashion the products of the official plant-breeding stations. New varieties of plants bred at the S.P.B.S. now pass to the N.S.D.O. for exploitation. Thus, at last, the problem of launching the Station's varieties has been solved.

Members of the Board usually serve on crop research committees of their choice: Forages (covering cereals, brassicas and grasses), and Potatoes. Some members also serve on the Finance Committee. The Board, which meets at least four times a year, in addition to receiving administrative reports from the Director, also discusses reports submitted by Conveners of the various committees. But, possibly, the wide ranging discussions at Board meetings are the most valuable aspect of the Board's function.

The total staff complement at the S.P.B.S. is now over 100; the maintenance budget for 1971-72 is over £200,000; a new laboratory wing is currently being built at a cost of some £90,000, and glasshouse facilities are being extended. Virtually the whole of current and capital costs is met by the Department of Agriculture and Fisheries for Scotland. A 300-acre farm in East Lothian, the Murrays, was purchased last year by the D.A.F.S. for the use of the Station. In fifty years the Society and the Station have come a long way.

The mystical ratio mentioned earlier for sharing between Government and public the cost of launching a new venture has been succeeded by a new formula, born of experience, for carrying on the enterprise. Fifty years after its foundation, the S.S.R.P.B. is acknowledged as a successful expression of partnership between Government and industry. A Society having a membership, an elected Board drawn from the industry, reinforced by scientists and academics, together with scientific guidance from the A.R.C. and weighty financial support from Government constitutes a remarkably effective formula for maintaining an agricultural research programme. The Director of the S.P.B.S. has access to information about the needs of the industry, the opportunity for co-ordinating his researches through the A.R.C. and the financial means for pursuing his objectives from the D.A.F.S. Information, opportunity and means; to fuse these elements will remain an important task in the next fifty years.

3. RESEARCHES ON FORAGE CROPS AT THE SCOTTISH PLANT BREEDING STATION, 1921-1965

J. W. Gregor

Herbage plants and genecology

In the spring of 1924, when the herbage plant programme first got under way, the Swedish botanist Göte Turesson had only a short time before published a paper which was destined to have a marked influence upon the Station's approach to breeding problems, for it was in that paper that Turesson introduced the concept of the *ecotype* (a product of selection by environment) and also proposed that the term *genecology* be applied to the genetic study of the natural relationships between organisms and their habitats. It seemed, therefore, desirable to start off by examining what natural selection in general and ecotypic selection in particular had to offer the breeder before formulating any definite breeding programme.

From the results of a few preliminary observations it was evident that any serious genecological study of population dynamics would perforce require a quantitative approach. Moreover, it was clear that, for an investigation of the kind contemplated, an uncultivated, wild species with quantitative characters amenable to accurate measurement was likely to provide the most appropriate experimental material. Bearing this in mind a number of species were screened and of these the one thought to be the most suitable was the Sea Plantain (*Plantago maritima*). Here was a wind pollinated, self incompatible species with an extensive distribution split into a multitude of more or less isolated intra-breeding colonies or local breeding communities, covering a variety of habitats.

An assessment of some of the patterns of micro-evolutionary change within *Plantago maritima* of Britain was the initial objective. The first seed samples to be collected were taken from breeding communities scattered throughout a mosaic of differing habitats which, when subjectively arranged in ecological sequence, approximately corresponded to a gradient in soil salt content. On being cultivated in the Station's experimental garden these habitat population samples exhibited a parallel, though somewhat irregularly-regular, clinal gradient in respect of statistically significant genetic changes in plant size and growth-habit. Besides being recorded in numerical terms, growth-habit was also recorded with reference to five recognisable types on the continuous range of habit expression. From an analysis of these data it was evident that, while all five types were present in each habitat, the proportions in which they occurred changed with the environment. Such differences were, therefore, regarded as manifestations of the effects of *ecotypic selection*.

On the other hand, in the same series of samples changes in the proportions of a genetically controlled qualitative character, presence/absence of leaf spotting occurred purely at random and, in so far as this particular environmental gradient was concerned, had presumably no ecotypic significance. Such population differentiation was designated as *topotypic*.

Sea plantains are also to be found as a continuous, unfractionated population extending over a gradually changing series of habitats. One such continuous assemblage was sampled along a habitat gradient similar to the one already mentioned. On experimental examination a regular clinal type of ecotypic differentiation was discernible, but only samples from the extremities were sufficiently distinct to reach statistical significance. This type of micro-evolutionary change was later confirmed on a climatic (altitudinal) gradient when seed samples of the diploid race of *Festuca ovina sensu lato* collected at 200 ft. intervals from sea level to 3,689 ft. were grown at the Station.

Efforts were also made to assess the adaptive differences of individual genotypes and the intensity of selection between them. Natural clones of *Festuca rubra* and *Trifolium repens*, both strongly creeping species, were used and the distribution of individual genotypes mapped, which involved the recognition of individual clones, done by a combination of morphological and crossing techniques. In both species clones differing in spatial cover were found. The relatively few extensive clones in *F. rubra* were apparently able to tolerate a considerable range of micro-environments, while others had narrower ranges of tolerance. However, *T. repens* showed more convincingly that different genotypes within a population differ in their ecological tolerances.

Colonial development was being examined during the 1930s. From studies tracing the establishment of *Plantago maritima* immigrants from a common source into a series of vacant habitats, it was abundantly clear that, as far as the incidence of the qualitative leaf spot character was concerned, there were marked gene frequency differences between colonies. However, in the case of the polygenically controlled scape (stem and flower spike) length variation, all colonies exhibited very similar ranges of phenotypic expression, but within each colony phenotypic differences associated with irregularities in habitat conditions were observed. From one of these colonies the longest scape was pulled off each of its 82 reproductive plants. They were taken to the laboratory, measured and then divided into two equal lots: one containing the 41 longest and the other the 41 shorter scapes, the respective mean lengths in cm. being $23{\cdot}9 \pm 0{\cdot}47$ and $13{\cdot}3 \pm 0{\cdot}54$. This difference disappeared when plants were grown in the experimental garden from seed taken from the two fractions, giving values of 31·7 ± 0·59 and 32·3 ± 0·92 respectively. Obviously phenotypic plasticity of this kind is of genetic interest, for it could cushion genotypes against the full impact of environmental selection and by so doing militate against a too extreme ecotypic specialisation with consequent loss of population variability. And plasticity might, on that account, be itself susceptible to selection.

About this time the Department of Biology, Carnegie Institution of Washington, initiated a series of intercontinental trials with *Poa* clonal material aimed at gathering information concerning the phenotypic expressions of individual genotypes in contrasting environments. The Department's Director, Jens Clausen, invited the Plant Breeding Station to co-operate in the project: an invitation which was welcomed as this kind of investigation has considerable agricultural implications. The lines employed were particularly well suited to the project, for it was known that *Poa* apomicts carried a large store of genetic variability, some of which could remain unexpressed until such time as inactive genes became activated by a radical change of environment. For instance, one of the experimental lines which was considered to be moderately apomictic at Pullman, U.S.A., at Pentlandfield proved to be fully sexual. In reverse a line thought to be completely sexual at Pullman, at Pentlandfield appeard to be 66 per cent apomictic: thus showing that it required a change of environment to reveal the differences in sexuality potential of these lines.

Almost from the beginning of the plantain investigations the work with *Plantago maritima* was widened to cover a number of European and North American taxonomic species closely allied to *P. maritima*, thus entering a field of taxonomic investigation which has now assumed the status of what is virtually a new discipline—*Biosystematics*.

By the late 1930s the desire to facilitate the communication of the rapidly growing volume of research data bearing on matters such as patterns of micro-evolutionary change and processes by which these changes arise was reflected in the many attempts being made to assimilate micro-evolutionary information into orthodox nomenclatural taxonomy either by adding new categories or by redefining existing ones. This resulted in very considerable confusion. It seemed at first possible to record the plantain patterns of micro-variation in terms of ecotypes, but the concept of the ecotype as an ecological substitute for the taxonomic variety delimited by virtue of some degree of variational discontinuity, ruled this out as it was all too apparent that the trends of variation being studied were continuous and followed habitat gradients which seldom ran parallel for long; moreover different formative processes were involved. John Gilmour, then Assistant Director at Kew, came to the Station's aid at this point, and in 1939 he and the writer published a paper entitled 'Demes: a Suggested New Terminology', the essence of which is the construction of a series of category terms by the addition of one or more self-explanatory prefixes to the " neutral " suffix "——deme ". This suffix denoted any group of individuals of a specified taxon. For instance: *gamodeme*, a deme forming a more or less isolated intrabreeding community; *ecodeme*, a deme occupying any specified ecological habitat; and *topodeme*, a deme occupying any specified geographical area. The terminology was developed in 1954 by Gilmour and Jack Heslop-Harrison, subsequently Director of Kew.

Another communication problem arose about the same time, for with the rapid increase in the number of herbage cultivars coming on the market their naming and description had become a matter requiring serious consideration. In 1951 the Scottish Agricultural Improvement Council appointed a Group, the Convener of which was supplied by the Station, to " consider the problems of naming strains of herbage plants and to submit proposals regarding a system of nomenclature ". A point stressed in the Group's report was that the usefulness of such a system would depend largely on the formal descriptions of named units being linked to performance data. Fortunately, as it happened, no action had been taken by 1955, the year in which the International Union of Biological Sciences agreed to enlarge the Commission they had set up under their Division of Botany by the inclusion of agriculturalists and foresters. The new International Commission, to which a member of the Station's staff was appointed, then assumed responsibility for future editions of the International Code of Nomenclature for Cultivated Plants. The Code's Articles and Recommendations most effectively highlight the advances which have been made since 1933, when a paper from the Station was published entitled ' The ecotype concept in relation to the registration of crop plants '.

In 1945 at a meeting in St Andrew's House it had been decided that, as far as Scotland was concerned, the task of providing herbage cultivars with botanical descriptions would be the responsibility of the Department's Scientific Services Laboratory, and that the testing of the performance of cultivars and potential cultivars in different environments could best be done by the three Agricultural Colleges. The following year saw a further notable advance, for it was in that year that herbage plant descriptions became the subject of a co-operative effort on the part of the Department of Agriculture for Scotland and the National Institute of Agricultural Botany. Since then descriptions have assumed an added importance as Article 39 of the Code stipulates that after 1st January 1959 descriptions are necessary and must be associated with cultivar names.

During the war years the need to upgrade Scotland's marginal arable and rough grazings was regarded as urgent. Reseeding was considered to be one of the most practical ways of achieving quick results. Since the Station was already engaged with certain aspects of hill pasture improvement it was natural that it should become involved with reseeding experimentation.

Previously it had been observed that, when vegetations of extremely contrasting nutritional types were grazed as complements, herbage utilisation was more efficient than when either was grazed alone. Furthermore, such complementary use made it possible to take full advantage of the responses of herbage grasses to intensive manuring, particularly their phenomenal responses to applied nitrogen. In 1944 the Station acquired appropriate field facilities at two centres—one in Midlothian, the other in Western Ross—for the development on a field scale of the complementary principle, where for five years the investigation was conducted with encouraging results. At the request of the Agricultural Research Council these grassland studies were then transferred to the Hill Farm Research Committee's programme at Lephinmore, Argyll, in order to assess the effects upon the health of livestock of such intensive cultivation of grass under a system of complementary usage.

The Station now turned its attention to examining the role of the relatively rich vegetations of areas naturally "flushed" by base-rich water. The first step was to examine the ecological distribution of genetic variation within a few of the major components of these "flush" communities. As a method of expanding existing flushed areas by irrigation the Station had experimented with polythene pipes and had studied the resulting changes in soil mineral content with a view to making good deficiencies by adding fertilisers to the water supply. By 1965 plans had been made to initiate such a programme, with the intention of establishing and maintaining, at low cost, small islands of relatively high quality herbage within larger areas of untreated rough grazing.

Throughout the whole of the period under review population samples of cocksfoot, timothy and perennial ryegrass were being added at intervals to the Station's collection of material from uncultivated and long rotation habitats within the British Isles.

As a general rule "wild" and "semi-wild" ancestors of food-crop plants are unable to compete economically with their commercial relatives. Because herbage grasses seemed to provide one of the few exceptions to this rule the Station's grass programme was from the very beginning primarily aimed at assessing naturally selected products as potential cultivars. A start was made by collecting population samples of cocksfoot and perennial ryegrasses from exposed sea-cliff and sheltered inland habitats in northern Scotland. A few of the ryegrass samples from the cliffs were then separately seeded in isolation and sown in upland reseeding trials. Over a period of years their yields of leaf dry matter were as high as most of the control cultivars of similar maturity type and they withstood trampling by livestock better than any. However, the picture was very different when the same "wild" populations were grown at a lower altitude and intensively manured for complementary purposes: yields were now well below those of the cultivar controls. On the other hand, a good example of a "semi-wild" population's ability to respond to intensive treatment in a manner superior to its cultivar controls is 'Scotia' perennial ryegrass. When compared with some of the cultivars then available the relatively high degree of gene balance resulting from long continued adaptive selection and, often, superiority for particular agronomic purposes of many of these "wild" and "semi-wild" populations suggested that, rather than embarking on a programme primarily designed to produce "bred" cultivars, attention should instead be focused on naturally selected products as potential cultivars.

From among the cocksfoot samples one from a small clearing in an oak-wood in central Perthshire was chosen for multiplication because of its broad thin leaves and smooth flower stems. Extensive field tests under conditions of sheep grazing proved its palatability to be high as cocksfoots go, and subsequent *in vitro* digestibility tests were very satisfactory. In 1945 this stock was marketed as a sheep-pasture cultivar and given the name 'Scotia' cocksfoot.

Two years later the cultivar 'Scotia' timothy, a late-flowering hexaploid, was introduced. A year earlier a high-yielding diploid population of timothy which had undergone both grazing and hay trials was released to test the market, but it never became popular and was not given a name.

The "wild" perennial ryegrass populations collected in Scotland were without exception of the late type. It was, therefore, of particular interest to the Station when in 1946 Frank Horne, Director of the National Institute of Agricultural Botany, reported that arable grasslands in South-West England originally sown with local strains were still to be found in a number of localities and some of them were reputed to contain populations of early ryegrass. With Horne's guidance the Station collected 73 local population samples from a variety of habitats in Devon, Cornwall and the Scilly Isles. One unit of this collection was later put on the market under the cultivar name of 'Scotia' perennial ryegrass.

At the same time as these localised indigenous stocks of perennial ryegrass appeared to be threatened with extinction, the Stirlingshire "land race" of timothy was also in danger of being lost as a result of the introduction of exotic stocks. Seed growing in that district is a comparatively recent venture, dating from the beginning of the century, and is confined to estuarine clays at elevations of from 35 ft. to about 50 ft. above sea level under a rainfall of approximately 40 in. As a possible means of preserving the best elements of this regional race a scheme of certification was mooted, but in a letter to the Grassland Committee of the Scottish Agricultural Improvement Council from a member of the Seed Trade it was stressed that it would be advisable, before initiating a scheme of this kind, to carry out an examination of the stocks in the area. Subsequently, at the request of the Grassland Committee, and with the active co-operation of the West of Scotland Agricultural College and James Gray & Coy. (Stirling) Ltd., samples of individual grower's stocks were collected and forwarded to the Plant Breeding Station for botanical examination and comparison. In due course a certification scheme was inaugurated, and this regional race of timothy is now marketed as a medium-early cultivar known as 'Scots' timothy.

The opinion is sometimes expressed that from the point of view of convenience there are already far too many herbage cultivars on the market. This may be so, but when looking to the future it is well to remember that there is a certain merit in numbers. This is so because, despite the limited genetic basis of the individual cultivar, those collectively available to agriculture constitute a sizeable and valuable gene pool conserved by virtue of the fact that it is maintained for use. Where it is possible, as it often is in the lowlands, to create conditions of comparative agro-ecological uniformity over large areas, it may be that relatively few broadly adapted cultivars could suffice to meet all practical objectives. However, the trend towards a reduction in cultivar numbers is less likely to extend to upland and other marginal arable districts of Britain where, in all possibility, the need for a good range of cultivars will persist and so incidentally contribute to the preservation of genetic variation.

Oats

In the Society's first Annual Report, published in 1922, mention is made of the receipt of a collection of oats which included a number of unfixed selections gifted by the representatives of the late J. H. Wilson of St Andrews. It is clear that at that time the Station's intention was to obtain improved varieties of the 'Potato', 'Sandy' and 'Tam Finlay' types, suggesting that from the beginning the organisers of the breeding programme had the poorer agricultural districts of Scotland very much in mind.

Wilson's collection made possible an immediate start on a project designed to produce *pure lines* of the types considered to have at least potential value in Scotland's stock-raising districts and, in this connection, it is noteworthy that, over the years, the yield and quality of the straw received no less attention than the yield and quality of the grain. It was largely because of the importance of the oat crop for animal feeding, both then and since, that when a rearrangement of the Station's activities was made in 1964 the oat programme was included under the general heading of Forage Crops. By 1926 many 'Potato', 'Sandy' and 'Tam Finlay' hybrids had been obtained and twenty-six selections of 'Potato' and 'Sandy' types were breeding true. Moreover, two selections from 'Tam Finlay' crosses which were also breeding true were chosen for field trial on account of their leafiness and free tillering habit in the hope that they might be useful as components of silage mixtures. Though neither of them fulfilled this hope on a commercial scale, one of them was found to make an excellent grazing nurse-crop for establishing grass swards under the direct reseeding programme.

Liability to lodge was a serious defect of many otherwise most promising selections from 'Castleton Potato' hybrids. However, a few had relatively short straw and one of these ('Castleton Potato' × 'Besler's Prolific') was multiplied and, after extensive field tests, was found to withstand lodging better than any other of this series of selections and also to give satisfactory grain yields. This selection was released in 1930 under the cultivar name 'Elder'. Two years later a selection from the cross 'Sandy' with a popular horse-corn variety, 'Leader', was released and named 'Bell', a cultivar having many of the characteristics of 'Sandy'; a moderately good yield of grain, a large yield of good quality straw and suitability for poorer soils and late districts. It soon became extensively used in the districts where these conditions prevail.

About now it was noted that it was the lower yielding varieties which were favoured for milling, and an effort was made to discover how far in one variety the best milling quality could be associated with a capacity for high grain yield. Some selections from the cross 'Potato' × 'Record' had particularly thin husked grain, a character favoured by millers, and in 1934 an early ripening selection with a low proportion of husk and fibre, straw of good fodder quality and relatively resistant to lodging was named 'Early Miller' and duly marketed.

In 1949 'Craigs Afterlea' was named but not put into commerce until 1951. An outstanding feature of this cultivar bred from ('Castleton Potato' × 'Yielder') × 'Elder' was its resistance to lodging, and on that account it was regarded as being particularly suitable for growing after lea in which there had been a strong stand of clover. Very much a special purpose type, it was recommended for soil of average fertility. Then in 1952 another oat of similar origin, 'Castleton Potato' × 'Yielder', which had over a number of years given consistently good results at high elevations in Aberdeenshire was introduced under the name 'Albyn Donside'.

Up until now initial selections of hybrid material had been made on the basis of appearance at Corstorphine alone, but for some time past it had been felt that this procedure might be wasteful in so far as some lines which did not reach the desired standard at the Station were automatically discarded but might well have been selected had they been seen in other districts of Scotland. Following discussions with the North and West Colleges, two additional selection centres were eventually established in the spring of 1953—one in Inverness-shire, the other in Argyll. As a beginning one hundred and twenty-eight lines of unfixed F_3 and F_4 generation hybrids were sown at each of these centres as well as at the Station. Selections made at these centres were grown at their respective centres until they appeared to be breeding true and then were multiplied at the Station to provide sufficient seed for the replicated trials, which were again carried out at the centres. One of the selections made at the Argyll centre, when tested at that centre, proved to be superior in yield to all the controls though inferior at the Station. This selection was named ' Albyn Bard ' and introduced in 1956 for areas of high rainfall and low fertility in the West of Scotland.

In the same year the laboratory testing for resistance of oat selections to stem eelworm (*Ditylenchus dipsaci*) started. Inoculation experiments showed that at least two types of resistance were involved: (1) a tolerant reaction in which the plants, while becoming dilated at their bases, could support large numbers of eelworm without being seriously retarded; and (2) an inhibitory reaction in which, though severely stunted initially, the plants subsequently grew with no other external symptoms. The species *Avena ludoviciana* and selections made from crosses between *A. ludoviciana* and various *A. sativa* types when tested appeared to possess another form of resistance where no stunting or dilation occurred and in infected field plots showed no signs of attack. By the early 1960s several thousand resistant seedlings were available for multiplication and ultimate field trial.

High-yielding barley cultivars were by now progressively replacing oats over much of the more fertile land, with marginal land assuming an ever-increasing proportion of Scotland's oat acreage. It was, therefore, most appropriate that the Station's last introduction during the period of this review was ' Shearer ', another cultivar suitable for growing in upland and late districts.

Swedes and other brassicas

At the time the swede programme started in 1922 there were a number of " varieties " in cultivation of similar appearance bearing different names, as well as a number of different seedsmen's stocks having the same name. Indeed, when stocks of ' Best-of-all ' were compared in 1926 the modal shape varied from oval in a stock sold in England to flat-globe in one sold in Aberdeenshire. In the circumstances, therefore, it is not surprising that, when formulating the initial breeding programme, particular emphasis was placed on reducing the existing disorder and on producing cultivars of greater uniformity. Although as a rule the swede is self-compatible, a considerable amount of cross-fertilisation was found to occur in the field, and this raised the question of whether with a plant of this kind a pure line technique, as used in cereal breeding, could achieve uniformity without loss of vigour. To obtain a reliable answer to this question was obviously going to take some time because of the swede's biennial nature and the fact that the produce of a single bagged plant amounted to no more than 28 grammes of seed.

By the fourth generation of selfing, the indications were that lines obtained by repeated selfing were no less productive and considerably more uniform than their parental cultivars. But the effects of different plant numbers, in the yield trial plots, made some comparisons decidedly suspect so, after co-variance methods became available, data from all earlier trials were re-examined and re-worked. When the Station moved to Pentlandfield some lines were in the fifteenth generation of selfing and, after covariance adjustments, a few of these were still giving yields not significantly different from their respective source cultivars.

During the course of the inbreeding investigations a continuous search for club-root resistance went on; but selfing, unfortunately, did not lead to the fixation of any resistance factors which it was hoped might be carried by the swede. The next task was to compare inbred lines derived from crosses between different types of swede. From among the many lines examined some dozen were chosen for intensive study, but by this time they had become more or less fixed and consequently any defects they happened to show could no longer be eliminated by selection. In attempts to overcome this difficulty it was found that by the mass seeding of a large number of plants which had been carefully selected from different lines to conform to a given phenotype, it was possible to accumulate genes for desired characters without sacrifice of uniformity.

In 1962 the Station introduced the cultivar 'Pentland Harvester', which was regarded as being particularly suitable for mechanical harvesting on account of its good hold of the ground and its uniform bulb shape and erect growth habit.

Kales were first specifically mentioned in the Scottish Agricultural Returns in 1938. About this time the apparent decline in the popularity of the swede crop directed attention to the leafy brassicas belonging to the cabbage tribe and to *Brassica napus*, which included the fodder rapes. However, in order to avoid contaminating the broccoli strains, which were being multiplied during the war years, these operations were suspended for a time and only resumed when field facilities were again available. The aim then was to seek new forms of fodder brassicas while continuing with the swede but on a less exclusive scale than hitherto.

As a start an examination of the variation within three Asiatic species was undertaken with the object of finding a source of leaf characteristics which might be introduced into European crops, such as the fodder rapes and hungry-gap kale. Next, a larger range of brassica material was obtained from various parts of the world. Of particular interest were the 10-chromosome species *Brassica campestris sensu lato*, the 9-chromosome *B. oleracea*, and the natural amphidiploid ($10 + 9 = 19$) *B. napus* to which the fodder rapes belong. *B. campestris* ssp. *nipposinica* was remarkable in that it produced very numerous leaves arising from a basal rosette, some plants having finely divided leaves and, when seeds were sown broadcast, the resulting stand resembled a grass sward.

Autotetraploids were now being used in increasing numbers, and several thousand attempted interspecific crosses between *Brassica oleracea* and *B. campestris* had been made at this level, because crossing between tetraploids was reputed to be easier than between diploids. However, such crosses were still difficult to obtain. In order to produce the amphidiploid hexaploid *napocampestris*, F_1 seedlings from the cross *B. campestris* with *B. napus* were treated with colchicine, but this initial synthesis lacked variability and provided little scope for future selection of desirable agronomic characters. Efforts were then made to obtain a greater range of leafy varieties by producing a number of populations with the same genomic formula but of different genetic constitutions. Of all the combinations the one that seemed most promising was where ssp. *nipposinica* had been a parent, and in a field trial this amphidiploid gave a dry-matter yield 30 per cent above the mean of eight commercial rape cultivars in early January—an increase mainly due to numerous and well-developed side shoots.

Another interesting member of the *campestris* group was *Brassica tournefortii*, alleged to be immune to club-root. However, even at relatively low spore concentrations of the local race of *Plasmodiophora brassicae* it, in common with some other members of *B. campestris*, including ssp. *nipposinica*, proved highly susceptible to infection. An exception was ssp. *rapifera* 'Gelria', which remained free of the disease. F_2 hybrids between 'Gelria' and *nipposinica* showed continuous segregation which suggests that resistance is polygenic. Tests of F_3 individuals showed that, in so far as this particular race of *Plasmodiophora* was concerned, the leafiness of *nipposinica* could be combined with the resistance of 'Gelria'. In a further search for sources of resistance, seedlings of fodder radish, *Raphanus sativus*, were treated with colchicine to give auto-tetraploids with the intention of using them in crosses with tetraploids of fodder rape, *Brassica napus*, in the hope of obtaining amphidiploids which might possess the disease immunity of *Raphanus*.

Conclusions

The aim of the Station as stated at the time of its foundation was: "To conduct investigations calculated to yield information of scientific interest, and especially information bearing upon the general problems of crop improvement", crop improvement covering the production of "new and improved varieties of direct value to agriculture".

Because of the importance to the Scottish economy of the relatively large acreage of arable land verging upon the " marginal " and of the very extensive areas of uncultivated natural grazings, the forage crops programme, not surprisingly, was biassed from the beginning in favour of these stock raising territories. The oat programme which largely concentrated on the production of cultivars adapted to a variety of agro-ecological conditions within marginal districts exemplifies this trend; so also does the study of the complementary principle in grassland farming which sought a practical method of exploiting the cropping potentialities of indigenous rough grazings. Among other matters related to crop improvement which, though not directly concerned with the actual introduction of new cultivars, have received attention at the Station during the period of this review were: the processes governing intra-specific ecotypic fractionation and micro-evolutionary change; terminology applicable to micro-evolutionary units; national and international aspects of herbage cultivar performance testing, description and nomenclature. These last items obviously are essential to complete plant breeding objectives; on the other hand, the genecological-micro-evolutionary investigations are contributing to the basic information required for intelligent collection of the raw materials of plant breeding.

Before the end of the review period the Plant Varieties and Seeds Act (1964) came into force, an Act which provides for the granting of proprietory rights to persons who breed or discover new plant cultivars. The probability, and indeed the hope, at that time was that the bulk of new cultivars would ultimately come from commercial organisations, and that the Station's role would almost inevitably be restricted to satisfying special-purpose needs of low royalty value and to acquiring " information of scientific interest, and especially information bearing upon the general problems of crop improvement ". Most recent information suggests that, broadly speaking, this is the pattern that is emerging.

4. RESEARCHES ON POTATOES AT THE SCOTTISH PLANT BREEDING STATION

W. Black

Introduction

When the Scottish Plant Breeding Station was established fifty years ago, relatively little information was available regarding the genetics and cytology of the potato, and the potentialities of both wild and cultivated species in Central and South America had never been seriously investigated. Although the breeding of new varieties had been vigorously pursued, mainly by private breeders, since the middle of last century much of it was essentially of an empirical nature. Accordingly, the aims of the Society from its inception were twofold: firstly, to carry out investigations calculated to yield scientific information concerning potatoes and potato breeding; and, secondly, to produce new and improved varieties of direct value to agriculture.

In the early years investigations were mostly concerned with the inheritance of characters, such as pigmentation in flowers and tubers, shape of tubers, depth of eyes and colour of flesh. These studies provided useful information and demonstrated the complexity of the hereditary constitution of commercial potato varieties as a whole. But it soon became clear that resistance to the many diseases and pests that attack the crop must form the basis of future work.

Wart disease

At that time, thanks to the activities of the Potato Synonym Committee and to the Potato Inspection Scheme of the Department of Agriculture for Scotland, potato growing in Scotland was in a highly organised state, varieties were accurately described and synonyms were practically non-existent. It was thus possible to assess accurately the merits and demerits of the varieties most widely grown and to determine the characters most urgently in need of attention. Immunity towards wart disease, as a result of legislation, had become an essential quality for new varieties, and breeding experiments were conducted to determine the nature of this immunity and its mode of inheritance. It transpired that the so-called " immune " varieties were, in fact, field immune (*i.e.*, hypersensitive) to the races of *Synchytrium endobioticum* present in this country. The character was inherited in dominant fashion (though there are genetical and pathological complications) and could readily be transmitted from generation to generation. Fortunately the variability of the fungus is relatively low and the chances of a build-up of aggressive races appear remote. Nevertheless, a number of new aggressive races have been found elsewhere, particularly in Eastern Canada and Central Europe, and if such races occurred in this country all our "immune" commercial varieties would perforce be classified as "susceptible". The risk, however, is not regarded as serious, though it undoubtedly does exist. Apart from wart disease the most severe losses at that time were considered to be due to blight and to virus diseases.

Blight

The search for blight-resistant varieties had been in progress in this country since the disastrous epidemics of 1845-46, but it was not until 1909 that resistance was demonstrated in wild species by the late Dr Salaman at Cambridge. About the same time the late Dr Wilson in St Andrews employed the Mexican species *S. demissum* in breeding experiments, and derivatives of that material were presented to the Society. In the course of subsequent field trials it was observed that certain selections bred from Dr Wilson's seedlings remained free from blight, while adjoining plots of ordinary varieties succumbed to the disease. These selections provided the initial parent plants for the work on blight resistance which followed. A few years later, however, a new race of blight appeared which was capable of attacking all Dr Wilson's seedlings, although the wild species from which they had been bred was completely resistant. It was thus necessary to start afresh by hybridising *S. demissum* and selecting in subsequent back-cross generations for resistance to the new as well as the original race of the parasite. This work started in 1932, but it was found that progenies bred only from *S. demissum* and *S. tuberosum* gave segregation ratios which bore little resemblance to standard Mendelian ratios, due to the different chromosome numbers of the species and the irregularities in their behaviour. In order to overcome this difficulty *S. demissum*, which is hexaploid, was crossed with the diploid species *S. phureja* and a fertile tetraploid hybrid obtained. This hybrid in turn was crossed with *S. tuberosum* and the triple hybrids which resulted were back-crossed. Repeated back-crossing to *S. tuberosum* varieties then followed. Chromosome behaviour in these plants was normal and the segregation ratios obtained were comparable with Mendelian expectations.

As these experiments progressed, and as more races of the parasite were isolated, it became possible to distinguish the different genotypes produced. The ultimate outcome of these studies was the formulation (in collaboration with Dutch and American potato colleagues) of a scheme which provided a genetical basis for the classification of races of the fungus and the relationships so illustrated afforded a means of calculating the segregation ratios to be expected from the mating of any pair of genotypes in the series when infected with any race or group of races of the parasite. It has since been adopted as the international system for the nomenclature of races of blight and of genes controlling hypersensitivity in *S. demissum* derivatives.

The results obtained from the first four R genes and the sixteen different combinations of them showed that this form of resistance—*viz.*, hypersensitivity—could only be of temporary value. Specialised races to match each gene combination were quick to appear. Further breeding experiments revealed that *S. demissum* is well supplied with R genes, and it became possible to differentiate ten of them under laboratory conditions. But *P. infestans* proved to be equally well endowed with variability, because all ten R genes eventually succumbed to the matching races of the pathogen. These results were confirmed under natural conditions in the Toluca Valley, Mexico, where test facilities were provided by Dr J. S. Niederhauser of the Rockefeller Foundation. Thus the R genes which induce only a hypersensitive response to infection with particular races of the fungus failed to provide a permanent solution to the blight problem.

Varieties bred from *S. demissum* and dependent mainly upon R genes for resistance to blight are Craigs Snow White, Pentland Ace, Pentland Beauty, Pentland Dell, Pentland Falcon, Pentland Hawk, Pentland Ivory, Pentland Kappa and Pentland Squire. Of these, Craigs Snow White and Pentland Ace have gone out of cultivation; while Pentland Kappa was withdrawn because of the unsatisfactory nature of its reaction to wart disease. Pentland Beauty is a popular early maturing garden variety, yielding attractive tubers of excellent table quality. Its shape and colour make it a frequent exhibit at horticultural shows. Pentland Dell is an early maincrop variety and has built up to a substantial acreage mainly at the expense of Majestic, which it usually outyields. Its attractively shaped tubers show fewer irregularities from growth cracking than Majestic. It is now an established variety in some of the ware growing areas of England and, although it has been affected by a specialised race of blight, seems likely to have a secure place in potato production.

The more recently named varieties, such as Pentland Hawk, Pentland Ivory and Pentland Squire, show several valuable qualities, but they have not yet had time to prove their true economic worth in commercial cultivation.

In the course of the above experiments, however, it was observed that the different genotypes were not all equally susceptible to the matching races. Likewise, some colonies of the wild species *S. demissum* not only survive but flourish in the extreme conditions of the high valleys of Mexico. Clearly another form of resistance—*viz.*, " field resistance " or " horizontal resistance " —was in operation. When this became appreciated in the early 'fifties a change of emphasis in the breeding work from R gene hypersensitivity to field resistance was made, and laboratory tests were developed to facilitate selection for field resistance using races of the fungus with the widest host range available. The effects of any R genes present in the parent plants were thus neutralised and seedlings were selected initially on the basis of inherent field resistance. They were classified into five groups according to the numbers and sizes of lesions and the amount of damage incurred—*viz.*, group 1, highly resistant; group 2, fairly resistant; group 3, slightly resistant; group 4, normally susceptible; and group 5, very susceptible.

As the work progressed it became apparent that field resistance in hybrid derivatives of the wild species *S. demissum* is controlled by many different genetic factors and inherited in polygenic fashion. It is a complex character representing the combined effect of genetic factors controlling (1) the resistance of the plant to infection, (2) the rate of spread through the tissues after infection has taken place, (3) the time required to initiate sporulation, and (4) the number of spores eventually produced. It became apparent that, in the course of hybridisation and back-crossing to commercial varieties to improve yield and other economic qualities, these factors had become dispersed with consequent reduction in degree of resistance. By inter-crossing appropriate selections, particularly selections from different breeding lines, resistance factors can be reassembled and field resistance built up in varieties of economic standard to a level high enough to make protective spraying unnecessary.

Field resistant varieties have, thus far, had their principal successes overseas, and this is a convenient point at which to turn aside and review briefly the Station's contribution to potato improvement in a somewhat wider context.

The first field resistant variety to meet with success was Roslin Eburu, which proved to be adapted to the shorter day length conditions of East Africa and is now the most widely grown variety in that part of the world. Under British conditions it is too late in maturing. A seedling bred from Roslin Eburu, and named Roslin Castle, has moderate field resistance and matures as an early maincrop. It was introduced in Britain following promising results in official trials. Other field resistant varieties now named and coming into commercial production are Pentland Marble (Britain), Pentland Raven (Britain), Kufri Jyoti (India), Kufri Moti (India), Roslin Bvumbwe (Malawi), Roslin Tsangano (Malawi), and Kenya Akiba (Kenya). Pentland Marble, as the name implies, is a special purpose variety suitable for the canning industry. It is early in maturing and produces many small tubers of canning size, which remain unbroken during processing. Pentland Raven yields attractive tubers of high dry matter content which appear to have potential for the crisp industry. Grants of Rights were obtained for these two varieties in 1970.

In India the two varieties Kufri Jyoti (4495) and Kufri Moti (4514) were selected from tuber samples supplied from Pentlandfield. The former has given good results both in the hills and in the plains of northern India where its blight resistance, classified as Group 2 in Mexico, is an important feature. Kufri Moti is adapted to the environmental conditions of the Nilgiri Hills in southern India. Two other promising blight resistant selections (4542 and 4546) are at the pre-release stage and are expected to be named soon. Yet two more, Kufri Naveen and Kufri Jeevan, were bred at the Central Potato Research Institute, Simla, using parents supplied by the Station. They were both classified as Group 1 for blight resistance in Mexico and are adapted to the Assam region.

In Malawi, Roslin Bvumbwe (3751(5)) and Roslin Tsangano (3035 ab(5)) have found favour because of their adaptability to local conditions and their field resistance to blight. They require no protective spraying and are now the main commercial varieties for the trust land producers in that country. Another blight resistant selection reported as showing exceptional promise is in the final stage of trial.

Kenya Akiba, mentioned above, in addition to its high degree of resistance to blight, also possesses some resistance to bacterial wilt (*Pseudomonas solanacearum*). Several other seedlings with similar qualities have been selected in Kenya from Pentlandfield material and are being multiplied for extended trials. Blight and bacterial wilt are the two most important diseases affecting potato crops in East Africa and a project promoted by the British Overseas Development Administration was launched in July 1970 to expand research on potatoes at the National Agricultural Laboratories in Nairobi and help establish the potato in East Africa as a major food crop. The initial approach to the problem is to raise as many seedlings as possible from different crosses known to combine resistance to both blight and wilt, and to screen for resistance to both diseases. This will provide a range of types for selection for commercial purposes and also broaden the genetic base for inter-crossing to intensify the resistance qualities. Resistance to blight was derived mainly from *S. demissum*, while resistance to bacterial wilt is a feature of the diploid species *S. phureja*. Consumer qualities will also be investigated as will resistance to viruses and to any other diseases of special significance in Kenya.

Virus diseases

In the earlier phases of the work on potato viruses the prime concern was with the identification of virus diseases infecting potato stocks, with their mode of spread in the field, and with the identification of varieties showing resistance to them. Possibly because of the widespread nature of virus diseases in potatoes, breeding for tolerance was at first thought to have the greatest promise of success, but was soon rejected when the inadvisability of breeding "carrier varieties" became evident. Commercial varieties were, in fact, soon found to be well endowed with dominant field-immunities to the field strains of virus X (X and B) and to the A and C strains of virus Y. A search for resistance to the more destructive strains of Y naturally followed. Fortunately, about this time an Australian seedling which had the required resistance to virus Y (inherited from the American variety Katahdin) was received for use as a parent. The resistance is now present in a number of the Station's varieties and has proved very useful (*e.g.*, in Pentland Crown); however, a still wider spectrum of resistance to X and Y viruses was thought to be desirable.

Progress in this direction was made when sources of comprehensive (*i.e.*, non-specific) hypersensitivity, comprehensive extreme resistance or immunity to both viruses and comprehensive resistance to infection to virus Y were discovered as a result of screening exotic Solanum species from the Commonwealth Potato Collection. Thus, *Solanum acaule* and several clones of the Andigena group provided useful dominant X-resistances of the desired types, now much used in potato breeding. For Y-resistance, several useful hypersensitivities were found in *S. microdontum*, *S. chacoense* and *S. demissum*; and the Phureja group of cultivated diploids yielded a polygenic resistance to infection. However, the most promising Y- resistance of all seems to be a comprehensive immunity derived from the Mexican tetraploid species, *S. stoloniferum*. Several of these resistances are now in advanced breeding stocks.

Resistance to potato leaf roll virus is, unlike most resistances to the mosaic viruses, polygenic. It was initially identified in field trials in the varieties Shamrock, Imperia and South Esk. Later it was found also in other cultivated varieties and, in higher degree, in hybrid derivatives of *S. chacoense*, *S. acaule* and *S. demissum*. The resistance was found to be difficult to assess and, predictably, all too easily dissipated by outbreeding. However, by introducing leaf roll resistance at the early stages, and by careful selection thereafter, the character has been preserved and enhanced in breeding stocks which may also carry comprehensive resistance to one or both of the mosaic viruses. Over the years the commercial qualities of the lines have been improved while preserving the virus resistance by screening both in the greenhouse and in field trials under conditions of intensive natural infection. Many seedlings now in hand are sufficiently promising to undergo appraisal by commercial standards.

Eelworm

The potato cyst eelworm, *Heterodera rostochiensis*, has for many years caused serious losses to the potato crop in some of the best potato growing areas in the country. No means of combating the pest by breeding methods was known until 1951, when Ellenby at Newcastle discovered that eelworm resistant forms did exist in the Commonwealth Potato Collection. The potentialities of this material were fully appreciated by the Agricultural Research Council and arrangements were made to initiate an intensive breeding programme. Seeds of four self-fertilised eelworm resistant clones of subsp. *andigena* were obtained from Cambridge in 1952, and selected plants raised from them were crossed with commercial varieties. Further breeding, essentially by back-crossing to commercial varieties and inter-crossing resisters, was carried out and tests for resistance were made by growing the seedlings in eelworm infested soil and examining the roots for cyst formation.

The results of this work showed that several clones of subsp. *andigena* possessed a major dominant gene which prevented normal cyst formation. It was also found that resistant plants stimulated the emergence of larvae in the same manner as susceptibles and that the invading larvae were subsequently inhibited in the roots at various stages of development prior to cyst formation. Under favourable conditions some resistant plants even showed an occasional poorly developed cyst, suggesting that inhibition, although adequate for practical purposes, was not always absolute. Probably the only danger that could be associated with such cysts is that incomplete inhibition may be the means of selecting out specialised races of eelworm.

In 1956 a comparison of eelworm samples from different sites in the Edinburgh area revealed the existence of a population that was adapted to seedlings which had proved resistant to other populations. Apparently more than one pathotype was present in nature. An extended survey was therefore made and soil samples from fifteen different counties in Scotland, together with samples from East Anglia, were examined. The results showed that 10 per cent of the samples contained cysts of aggressive populations.

An examination of various wild species from the Commonwealth Potato Collection showed that *S. multidissectum* possessed a gene for resistance different from that found in subsp. *andigena*, C.P.C. 1673. While derivatives of C.P.C. 1673 were resistant to pathotype A but susceptible to pathotype B, derivatives of *S. multidissectum* were susceptible to pathotype A but resistant to pathotype B. Hybrids possessing the genes from both species proved resistant, as might be expected, to both pathotype A and pathotype B, but another race was found, pathotype E, to which this combination of genes was susceptible. A further examination of wild species, however, showed that *S. vernei* was resistant to all three eelworm populations, and breeding experiments with this species were intensified with encouraging results. Apparently the resistance in *S. vernei* is controlled by a polygenic system and seedlings bred from it by the back-cross/inter-cross approach possess not only resistance to all known pathotypes of the eelworm but also attractive commercial qualities. At the moment *S. vernei* resistance seems to offer the best prospects for overcoming the eelworm problem in the future.

Meanwhile three selections of subsp. *andigena* origin have shown promise as economic types and have been named. The first one, Pentland Javelin, received commendation in the Merit Trials in 1967 and Grant of Rights in 1968. The second, Pentland Lustre, followed suit a year later. The third seedling, named Pentland Meteor, received Grant of Rights in 1970. All three varieties are resistant to pathotype A of the potato cyst eelworm and are likely to prove valuable on land contaminated by that race.

General breeding

In addition to the three special breeding programmes dealing with blight resistance, virus resistance and eelworm resistance, a general breeding programme to produce improved varieties of *S. tuberosum* has always received some attention. In the choice of parent varieties, emphasis was usually placed on yield, size and shape of tubers and consumer quality. Of special interest were wart immune varieties to replace the existing wart susceptible types.

From this programme a series of varieties emerged—*viz.*, The Alness, Craigs Defiance, Craigs Royal and its mutant Red Craigs Royal, Craigs Alliance, Pentland Crown, Pentland Envoy and Pentland Glory. Three of those—*viz.*, The Alness, Craigs Defiance and Pentland Envoy—have gone out of cultivation in Britain.

One of the more successful varieties—Craigs Royal—was named in 1947. It built up rapidly to become the most widely grown second early variety in the country. Later it was gradually replaced by its red-tubered mutant, Red Craigs Royal, which still maintains its popularity. It is an excellent table potato, which tends to bulk early and is often harvested as a first early. It was recommended for general use by the National Institute of Agricultural Botany and also has some value in the processing industry.

Craigs Alliance is a first early variety which was recommended for general use by the National Institute of Agricultural Botany, but it has difficulty in competing with Red Craigs Royal and its acreage has been limited. Another first early, Pentland Glory, is a good cropper and resistant to virus Y, but it has proved to be rather too susceptible to common scab to gain wide popularity.

At the present time the most widely grown variety bred at the Station is Pentland Crown, which was named in 1958. In 1970 it surpassed Majestic and became the leading variety in Great Britain. It matures as an early maincrop, producing heavy crops of tubers which rarely show growth abnormalities. One of its parents was a virus resistant selection bred by the virus research workers in the Station for use in the general breeding programme; the other was a virus resistant selection of Australian/American origin.

Pentland Crown has proved to be significantly resistant to leaf roll and virus Y, and its increasing popularity in ware growing districts of England has, no doubt, been enhanced by the less frequent need for seed replacement. Its quality for domestic purposes is excellent and it has also proved suitable for some processing uses. In addition to its recommendation by the National Institute of Agricultural Botany for general use, it appears to have possibilities for cultivation overseas, particularly in the Mediterranean area. Pentland Crown has been described as the best early maincrop potato bred in Britain since 1911, when Findlay introduced the famous variety Majestic.

To sum up, the number of potato varieties bred at the Station and subsequently named has reached a total of 34. Some of the earlier introductions showed promise for a time, then passed out of cultivation. The more successful varieties named prior to 1965 have been Craigs Royal and its mutant Red Craigs Royal, Pentland Beauty, Pentland Crown and Pentland Dell in this country, and Roslin Eburu in East Africa.

The 15 varieties named during the last five years are still in early stages of development and have not had time to prove their true commercial value. What the position will be after another five years is uncertain, but their performances in tests so far observed must induce a considerable amount of optimism.

5. RECENT DEVELOPMENTS AND FUTURE TRENDS

N. W. Simmonds

General

The Scottish Plant Breeding Station is, in current jargon, an R. and D. establishment: it does research and development. None of the research done at the Station is undertaken because it would be nice to know the answer to a question; it is all done because, if successful, the answer would bear, often directly, sometimes obliquely, upon plant breeding. The R. part of the R. and D. is therefore all applied research. Development is customarily defined as the application of established knowledge and techniques to short-term practical objectives; so plant breeding is development work. There is no sharp line between applied research and development, nor indeed between applied and fundamental work: one grades into the next. With this qualification the ratio of R. to D. at the Scottish Plant Breeding Station is about 50 : 50. It is sometimes argued that Stations such as this should devote themselves to "benefiting agriculture" by sticking to practical matters, leaving the research to others. There are two good reasons to reject this argument.

First, research and development are good for each other; research stimulates development and vice versa, and often, by the nature of the situation, in wholly unexpected ways. Pentland Crown, as one example, owes its existence to the significant accident that virus research and potato breeding were going on in the same laboratory. Second, the long-term health of plant breeding depends on relevant research, and no one has yet invented a better means of sustaining that research than an institute: industry, understandably, lacks the long-term commitment of interest that is necessary and universities are devoted to other things. The conclusion, which has been stated before but deserves to be stated again, is simple: a Station such as this *must* maintain a dynamic balance between R. and D. if, in the long term, a lively and productive plant breeding is to be achieved. The founders of the Scottish Society for Research in Plant Breeding made the point very well fifty years ago.

It is a piece of currently accepted conventional wisdom that agricultural R. and D. is only slowly and with difficulty applied to farming practice. Like much conventional wisdom this is a half-truth; the product of plant breeding R. and D., the new variety, is effectively and smoothly transferred to the farm as quickly as biological limitations and the essential trials and regulations permit. That not all new varieties are successful does not affect the fact that opportunity to succeed comes quickly and easily. The same is broadly true of two other important areas of R. and D.—namely, in the introduction of new materials (such as chemicals and medicaments) and new equipment; if the product is available and good it has the opportunity of rapid adoption. The point may seem obvious, but it is worth making because failure to recognise it is at the root of many of the numerous current lamentations about the slowness of application of R. and D. to practice.

Plant variety rights and commercial breeding

In our 46th Annual Report (1966-67) it was argued that British plant breeding was rather backward (as evidenced by the dominance of foreign-bred varieties), but that the Plant Varieties and Seeds Act (1964) could be expected to encourage commercial plant breeding and, ultimately, to promote effective competition to foreign breeders. Four years later it is evident that commercial plant breeding has indeed been encouraged but that it is yet too soon for it to have had a major impact; several major crops (and minor ones too) are still dominated by foreign varieties. Five years hence we may hope to see many British commercially bred varieties on our recommended lists (and on foreign lists, too). This is not mere chauvinism: the best varieties for a place ought usually, on biological principles, to be those bred in that place. British plant breeding (whether official or commercial), given an adequate scale of operation, *ought* to have more to offer to British farming than foreign breeding.

Having said all this we must note that commercial breeding is likely to have certain characteristics and effects which will have to be taken into account in discussing the future of plant breeding in this country. First, commercial breeders will, in general, aim to maximise profits, so they will concentrate on breeding rather than on research and on major crops (hence large acreages and large royalties) or on high-value crops having expensive seed (such as vegetables). Second, their breeding activities will, for obvious reasons, often be linked economically to seed production. Third, the commercial breeders will naturally wish to maintain a rapid turnover of varieties and this must tend to lead to pressures to lengthen recommended lists. Fourth, the commercial breeders will favour high royalty rates on and rapid marketing of new varieties. And, fifth, there may perhaps be a tendency to adopt " gimmick " breeding for promotional reasons; in particular, " hybrid " has become a vogue-word and, whatever their merits in some situations, there is no reason to think that " hybrids " are a panacea; also, seed is expensive.

Commercial breeding and the official stations

In 1969-70 the Agricultural Research Council reviewed its policy with regard to support of plant breeding R. and D. in the State-aided institutes. These include three stations wholly devoted to plant breeding and six others partly devoted to it. A policy statement issued by the Council in February 1970 was printed in our last Annual Report (**49**, pp. 6-7) and need not be reprinted here. Essentially, the Council: (1) welcomed the expansion of total effort devoted to plant breeding; (2) favoured collaboration between commercial and State-aided breeders; (3) saw no reason to change its policy of maintaining a reasonable balance between research and practical breeding; but (4) recognised that a changing situation will necessarily call for the changes of direction and emphasis in the programmes of the Institutes.

Let us take these four points in order. The first is of great importance because success is not only a matter of competence, it is also a matter of scale. The greater the total effort, the quicker will the long dominion of foreign varieties come to an end and the better served will be British farming. The second point is both accepted current ideology and practical good sense. Effective collaboration should lead to economical deployment of resources and sometimes to the opportunity to exploit a promising line of work more quickly and on a larger scale than would otherwise have been possible. Discussions have taken place as to what practical form such collaboration might take and, though there would be certain practical problems, there is no doubt that much could and should be achieved. No doubt there will be considerable developments in the next few years. The validity of the third point has already been argued for in the earlier part of this article and is not in any doubt. An institute must be free, as the ARC said, " to develop improved techniques and to establish their validity by the tests of practical breeding ".

The fourth point is perhaps the most contentious. All programmes change with time as projects succeed or fail or have to be reorientated. The question is: what effect will or should the existence of commercial plant breeding have on the programmes of the institutes? The commercial breeders have argued that a State-aided breeding programme aimed at the same objectives as their own would represent " unfair competition ". But competition is not necessarily harmful; indeed, as the ARC said, it may well be the reverse. Nor is it clear just what is " unfair "; the public pays for the State-aided institutes and (by way of the NSDO) the public profits. The NSDO's success is our success. This does not mean that the institutes should work in direct competition with commercial breeders all along the line. That would be foolish, wasteful and not at all productive of the desired co-operation. It does mean that direct competition should be accepted when it is in the public interest—for example, when the total commercial effort on an important breeding objective was small or concentrated in only one firm. If, by contrast, the total effort were large and well spread it could then be in the best interests both of overall efficiency and of the institute itself to opt out of a competitive situation: " if you can't beat 'em, leave 'em to get on with it " seems to be a sensible philosophy. This is presumably the sort of adjustment that the ARC had in mind when it wrote of the need for flexible policies and selective programmes.

The tendency—which may well take years to become a visible trend—will thus be towards a combination of breeding of the specialised varieties destined for moderate (rather than large) acreages and a shifting of the balance of R. and D. towards the R. end of the range. Such a trend would be regretted by some but there is no doubt that, in conjunction with a vigorous commercial plant breeding devoted primarily to varieties aimed at large acreages, this sort of pattern would provide a reasonably efficient way of employing the resources of the State-aided institutes. Essentially the same argument was put forward in our *Annual Report*, **46** (1966–67) and it still seems reasonable. It is satisfactory that it should be compatible with published ARC policy on the matter.

Breeding objectives of the future

Let us imagine a situation in which the changes foreseen in preceding paragraphs had, in fact, taken place. We should then have an expanded plant breeding effort in which a large and vigorous commercial sector concentrated on the varieties destined for large acreages and those with expensive seed. The State-aided stations would sometimes have the same objectives as commercial breeders and thus be in competition with them; more often they would have chosen different objectives, aiming to fill specialised ecological or technological niches with varieties that, though valuable to farmers and processors, offered no promise of large breeding profits. A large part of the work of the State-aided stations would be applied genetics aimed (as it is now of course) at the advancement of future plant breeding techniques. A regular dialogue between the stations and the commercial breeders would help to ensure that ideas as to worthy research projects flowed one way and research results and breeding materials the other. Given a system such as this, working smoothly, there is every reason to expect a lively and productive plant breeding effort well able to meet foreign competition; perhaps we might even see British varieties grown in continental Europe (a welcome trend which may, indeed, already be starting).

The last paragraph distinguished, by implication, between the large-scale unspecialised variety and the small-scale specialised one. The distinction is already significant and is likely to become very important indeed. There are two aspects of specialisation—ecological and technological. The first has long been recognised in a general sort of way but can hardly be said to have been consciously exploited. Our trials systems for new varieties are regularly replicated over sites and seasons in the expectation that ecological adaptation to site will be revealed; there is nothing one can do about seasons. In practice any information that might emerge about adaptation is largely ignored and results used primarily to reveal those varieties of wide adaptation which will do well almost anywhere. So the "great" varieties (such as Majestic and Proctor) are, by definition, the widely adapted ones. But Proctor is not much use in Scotland, so even great varieties have their limits. In principle, we ought to be able to do better by recognising ecological differences and breeding for adaptation to them than by seeking widely adapted varieties. But this turns out to be extraordinarily difficult, and it would certainly demand a much more refined trials system than we have at present. The difficulties lie in the uncontrollable effects of seasons and seasonal interactions, in our ignorance of the physiology of adaptation and in our inability to select trial sites on a rational basis. There is now some interest in this set of problems, however, and better understanding may follow. Meanwhile, when some specific ecological factor limiting production in a given area can be recognised, it is usually possible to do something about it. The selection by the SPBS of blight resistant potatoes for the South-West of England and of oats for the machair are examples. Resultant varieties may be of considerable value to local agriculture, but the breeding of these (since acreages will be small) would not be of interest to the commercial breeders.

The other kind of specialisation is technological: it has increased apace since the war and must clearly go much farther yet. Barleys for malting and peas for canning are two long-established examples; processing potatoes are more recent; barleys for whisky making are only just beginning. The specialised varieties needed may sometimes be of wider utility, but it seems reasonable to assume that crops will generally be grown on limited acreages for very definite purposes. Once again, therefore, the specialised variety will tend to be of little interest to the commercial breeder, however valuable it may be technologically. As an example, Pentland Marble may be highly successful, but it is not likely to reach even 1 per cent of the U.K. potato acreage and royalties from it will be, at best, derisory. It is very unlikely that any commercial organisation would find the breeding of this or any other processing potato worth-while. No one processing potato is likely to exceed (or even to attain) 10 per cent of the acreage in the next fifteen years; Record in recent years has been in the range 5-7 per cent.

These arguments lead to the conclusion that it is in the specialised varieties, whether ecologically or technologically specialised, that the State-aided stations will find their principal breeding objectives in future years. The trend in that direction may not be rapid but it seems inevitable.

Future research objectives

We saw above that there is a need to keep a reasonable working balance between R. and D., between applied genetics and plant breeding. There is no less a need to keep a balance between different kinds of research. For our purposes four kinds of research objective can usefully be recognised. They are outlined in the following paragraphs with examples from the work of the Scottish Plant Breeding Station. Equally good examples could, of course, have been drawn from the programmes of the other breeding institutes.

First, there is the project that seeks to make a radical change in the genetical structure of a crop, to the extent even of constructing a new crop species. The Station's work on Raphanobrassica is a good example of this; if successful we should have a new crop species having the general agricultural characters of rape but with less woody stems and better disease resistance. Poa hybrids, though based on somewhat different genetical principles, would, if successful, represent nearly as fundamental a change as Raphanobrassica. In potatoes the Andigena programme, which seeks greatly to widen the genetic base of the crop, is of the same character, though less radical in intent than the Raphanobrassica or Poa projects.

Second, there is the project that seeks to improve breeding methodology. Much biometrical-genetic research comes in this category. At the Station current projects on potatoes, barleys, brassicas and grasses are of this kind. They are designed to provide answers to questions such as these: what parents should be used? What crossing pattern should be adopted? What is the most efficient method of selection? Sometimes it is sensible to ask questions of this kind, not of the crop itself but of some suitable analogue such as a different plant in a growth chamber or a computer. Again, there is reason to think that hybrid ryegrasses, swedes or triploid brassicas might have advantages over conventional varieties; to develop means of making hybrids efficiently will require a good deal of enabling research, now being initiated.

Third, there is the project that provides background information; here objectives are, almost by definition, rather imprecisely formulated. Examples are provided by the work of the Station, spread over many years, on potato viruses, blight and eelworms; ultimately all had important impacts on the breeding programme as well as advancing our general knowledge of the biology of the pathogen. Similarly, work on diploid potatoes, on the biochemical genetics of barley diastase, on the classification of the barley collection and on certain aspects of barley mildew is being carried on in the expectation that some of the results are virtually certain to bear, ultimately, upon breeding problems.

And, fourth, there is the project aimed at providing a technique or a piece of equipment ancillary to plant breeding, sometimes technique-and-equipment in one. Examples are the Scottish Plot Seeder, polythene houses, grass-pollinating chambers, oat stem eelworm injection equipment, the diastase halo test, the detached leaflet blight test, tests for latent tuber diseases and so on; a full list would be a long one.

Conclusions

The general conclusion that emerges from this discussion is that several balances must be struck simultaneously: between R. and D., between different kinds of research objective, between different crops, between general and specialised varieties, and between commercial and State-aided breeding None of these balances will be achieved fortuitously, and to maintain a reasonable equilibrium in the whole system will demand unremitting effort. Given this the prospects are excellent; between them, breeders and research workers in commercial and State-aided organisations should be able to end the long dominion of foreign varieties or, more positively, to provide British agriculture with a sustained flow of home-produced varieties of an excellence that the high technical competence of that agriculture deserves. The Scottish Plant Breeding Station is entering its second fifty years at an exciting time.

6. VARIETIES BRED BY THE STATION

The following varieties are on the market:—

Oats	Albyn Empress Bell	Shearer Pentland Provender*
Barley	Craigs Triumph	
Bean	Albyn	
Swede	Pentland Harvester	
Grasses	Scotia Cocksfoot Scotia Perennial Ryegrass	Scotia Timothy
Potatoes	Craigs Alliance Pentland Beauty Pentland Dell Pentland Glory* Pentland Ivory* Pentland Lustre* Pentland Meteor* Pentland Marble* Roslin Eburu	Craigs Royal Pentland Crown Pentland Falcon* Pentland Hawk* Pentland Javelin* Pentland Squire* Pentland Raven* Roslin Castle* Roslin Riviera

Varieties marked * have been granted Plant Breeders' 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. Application for licences should be made to the Executive Officer, NSDO Ltd., The Granaries, White House Lane, Cambridge.

The commercial development of the three Scotia grasses is also in the hands of the National Seed Development Organisation. Elite stocks of the oat Bell are in the hands of Messrs Macfarlan, Shearer & Co., Greenock.

7. COLLABORATORS

The list of collaborators in the work of the Station includes farmers, landowners, colleges and official stations, who have provided field facilities; and workers in university, official and industrial laboratories, who have provided valuable scientific help. We hope the following lists are complete; to all collaborators, named or (perchance) unnamed, we offer our best thanks.

(*a*) *Official bodies:*

Animal Breeding Research Organisation, Edinburgh.
Animal Diseases Research Association, Edinburgh.
Department of Agriculture and Fisheries for Scotland, Scientific Services, Edinburgh.
Edinburgh Regional Computing Centre.
Forestry Commission, Research Branch, Edinburgh.
Fruit and Vegetable Preservation Research Association, Chipping Campden.
Grassland Research Institute, Hurley.
Home-Grown Cereals Authority, London.
John Innes Institute, Norwich.
National Agricultural Advisory Service (Gleadthorpe, Terrington and Ely E.H.F. and Rosewarne E.H.S.).
National Institute of Agricultural Botany, Cambridge.
National Institute of Agricultural Engineering (Scottish Station), Edinburgh.
National Seed Development Organisation, Cambridge.
National Vegetable Research Station, Warwick.
Plant Breeding Institute, Cambridge.
Potato Marketing Board, London.
Rowett Research Institute, Aberdeen.
Scottish Horticultural Research Institute, Dundee.
States of Jersey, Department of Agriculture.
Welsh Plant Breeding Station, Aberystwyth.

(*b*) *Universities and Colleges:*

A.R.C. Unit of Statistics, University of Edinburgh.
Department of Brewing and Biochemistry, Heriot-Watt University, Edinburgh.
Edinburgh School of Agriculture.
Edinburgh University, Departments of Botany and Chemistry.
North of Scotland College of Agriculture, Aberdeen.
School of Agricultural Sciences, University of Leeds.
West of Scotland Agricultural College, Glasgow.

(*c*) *Industrial Collaborators:*

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Ross Foods Ltd., North Walsham, Norfolk.
Rothwell Plant Breeders Ltd., Caistor, Lincs.
Scottish Agricultural Industries Ltd., Edinburgh.

(*d*) *Individual:*

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T. Dale, Auldhame, North Berwick, East Lothian.
R. Dykes, Myles Farm, Tranent, East Lothian.
J. S. Graham, Queenston Bank, North Berwick, East Lothian.
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Strathallan Growers, Ruthvenvale Mills, Auchterarder.
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Sir JAMES DENBY ROBERTS, Bt., O.B.E., M.A., J.P., Strathallan Castle, Auchterarder
ROBERT L. SCARLETT, C.B.E., C.D.A., S.H.M., V.M.H., Sweethope, Musselburgh

Chairman of Directors

Sir JAMES DENBY ROBERTS, Bt., O.B.E., M.A., J.P., Strathallan Castle, Auchterarder

Vice-Chairman

JOHN ARBUCKLE, O.B.E., Logie, Newburgh, Fife

Ordinary Directors

1968

H. F. D. ELDER (William Dods & Son), Haddington
W. H. M. GILL, Rosskeen, Invergordon, Ross-shire
A. HOWIE, B.Sc.(Agric.), N.D.A., N.D.D., North of Scotland College of Agriculture, 581 King Street, Aberdeen AB9 1UD
Sir DAVID LOWE, C.B.E., D.Sc., F.R.S.E., F.R.Ag.S., S.H.M., Elvingston, Gladsmuir, East Lothian
A. GORDON PORTER, J.P., East Scryne, Carnoustie, Angus
.... Vacancy

1969

JOHN ARBUCKLE, O.B.E., Logie, Newburgh, Fife
GEORGE CLAPPERTON, Sheriffhall Mains, Dalkeith
H. P. DONALD, Ph.D., D.Sc., F.R.S.E., Animal Breeding Research Organisation, King's Buildings, West Mains Road, Edinburgh EH9 3JQ
J. W. GRANT, B.Sc., North of Scotland College of Agriculture, Drummondhill, Stratherrick Road, Inverness
A. K. M. MEIKLEJOHN, B.Sc., Edinburgh School of Agriculture, West Mains Road, Edinburgh EH9 3JG
E. F. SHERRIFF (Sheriff & Sons Ltd.), Burleigh Mead, Great North Road, Hatfield, Herts.

1970

A. MANTON BAXTER (Baxter & Guion Ltd.), Midland Road, Peterborough PE3 6DQ
J. G. M. BREMNER, O.St.J., M.A., D.Phil., M.I.Chem.E., F.R.I.C., (S.A.I. Ltd.), 124 Salamander Street, Edinburgh EH6 7LA
J. LESLIE DAWSON, B.Sc., (S.A.I. Ltd.) West Mains of Ingliston, Newbridge, Midlothian
J. E. RENNIE, C.B.E., Greendykes, Macmerry, East Lothian
J. STEWART, Dalquharran, Dailly, by Girvan
G. A. STORRAR, M.C., B.Sc., J.P., Rossie, Auchtermuchty

Directors Co-opted

ROBERT ALLISON, Turnhouse, Corstorphine, Edinburgh 12
G. B. R. GRAY, Smeaton, East Linton, East Lothian
JOHN WATSON (McGill & Smith Ltd.), 67 Kyle Street, Ayr

Directors moninated by the Secretary of State for Scotland

Professor ROBERT BROWN, D.Sc., F.R.S., 15a Corrennie Drive, Edinburgh EH10 6EG
M. A. H. TINCKER, M.A., D.Sc., F.L.S., F.R.S.E., Arbeadie House, 44 Station Road, Banchory
D. W. WILLIAMS, M.Sc., Ph.D., Scientific Services, East Craigs, Corstorphine, Edinburgh EH12 8NJ
Sir MAURICE YONGE, C.B.E., D.Sc., F.R.S., P.R.S.E., 13 Cumin Place, Edinburgh EH9 2JX

Standing Committee—Finance

Sir JAMES DENBY ROBERTS, Bt., *Convener*
R. ALLISON
JOHN ARBUCKLE
W. A. BIGGAR
J. G. M. BREMNER
ROBERT BROWN
H. F. D. ELDER
G. B. R. GRAY
JAMES GRAY
Sir DAVID LOWE
ROBERT L. SCARLETT
M. A. H. TINCKER

Research Committees

Forage Crops

H. F. D. ELDER, *Convener*
J. G. M. BREMNER
G. CLAPPERTON
J. L. DAWSON
H. P. DONALD
J. W. GRANT
G. B. R. GRAY
JAMES GRAY
A. HOWIE
Sir DAVID LOWE
A. K. M. MEIKLEJOHN
Sir JAMES DENBY ROBERTS, Bt.
J. STEWART
J. WATSON

Potatoes

J. ARBUCKLE, *Convener*
R. ALLISON
A. MANTON BAXTER
H. P. DONALD
W. H. M. GILL
Sir DAVID LOWE
A. GORDON PORTER
J. E. RENNIE
Sir JAMES DENBY ROBERTS, Bt.
E. F. SHERRIFF
G. A. STORRAR
J. WATSON
D. W. WILLIAMS

Election of Directors

In accordance with the rules of the Society the following members of the Board retire at this time:—

H. F. D. ELDER (Wm. Dods & Son), Haddington.
W. H. M. GILL, Rosskeen, Invergordon, Ross-shire.
A. HOWIE, B.Sc.(Agric.), N.D.A., N.D.D., North of Scotland College of Agriculture, 581 King Street, Aberdeen.
Sir DAVID LOWE, C.B.E., D.Sc., F.R.Ag.S., Elvingston, Gladsmuir, East Lothian.
A. GORDON PORTER, J.P., East Scryne, Carnoustie, Angus.

To fill the existing vacancies the Board recommends election of the following:—

ROBERT ALLISON, Turnhouse, Corstorphine, Edinburgh 12.
JAMES D. G. DAVIDSON, M.V.O., M.I.Ex., Royal Highland and Agricultural Society, Ingliston, Newbridge, Midlothian.
G. B. R. GRAY, Smeaton, East Linton, East Lothian.
Mrs B. A. GORDON, B.Sc.(Agric.), Rosefarm, Cromarty.
M. JOUGHIN, Wester Manbeen, Elgin, Morayshire.
J. WATSON (McGill & Smith), 67 Kyle Street, Ayr.

Meetings

An Extraordinary General Meeting, followed by a General Meeting, of members was held at Pentlandfield on 23rd July 1970.

The Board met four times: on 23rd July 1970; 12th November 1970; 15th April 1971; and 4th June 1971. The Finance Committee met on 4th June 1971.

Research Committee Meetings were held as follows: Potatoes on 9th October 1970, and Forage Crops on 29th October 1970.

10. ADMINISTRATION

Finance

The abstract of audited accounts set out on pages 81-88 reveals the Society's financial position at 31st March 1971. The cost of the research programme at the Scottish Plant Breeding Station was met by a maintenance grant of £190,550 from D.A.F.S. In addition, the Department provided a grant of £2,500·29 for re-surfacing roads at the Murrays Farm.

The Secretary of State for Scotland acquired the Murrays Farm in East Lothian for the use of the S.P.B.S. and expenditure of £9,624·79 was incurred in operating the farm since its acquisition in November 1970.

Equipment of a capital nature costing £6,346·38 was purchased by means of a corresponding Government grant.

Capital works, comprising the completion of two farm cottages, continuing construction of a new laboratory wing and two glasshouses at Pentlandfield were also financed by means of a D.A.F.S. grant of £64,486·32 and £1,216·65 from invested funds.

The Home-Grown Cereals Authority provided a grant of £3,087·34 in support of a barley breeding programme.

Membership

At 31st March 1971 the total membership was 311, comprising 110 life members and 201 annual members. Fifteen new members were elected during the year and 36 died or resigned.

Board of Directors

Mr W. Andrew Biggar, O.B.E., M.C., B.Sc., F.R.Ag.S., regretfully relinquished the office of Vice-Chairman of the Society on his appointment as a member of the Agricultural Research Council. The Board unanimously elected Mr J. Arbuckle, O.B.E., to the office of Vice-Chairman.

The Board warmly welcomed, on election for the first time, Dr J. G. M. Bremner, O.St.J., M.A., D.Phil., M.I.Chem.E., F.R.I.C., Mr J. E. Rennie, C.B.E., and Mr J. Stewart.

The Board warmly congratulated Sir Maurice Yonge, C.B.E., D.Sc., F.R.S., P.R.S.E., on his election as President of the Royal Society of Edinburgh.

Amendment of Rules

Following is the Minute of a Special General Meeting of the Society:—

" A Special General Meeting of Members of the Scottish Society for Research in Plant Breeding was held at the Scottish Plant Breeding Station, Pentlandfield, Roslin, Midlothian, on Thursday, 23rd July 1970, at 2 P.M., for the purpose of considering and, if thought fit, passing the following Resolution:—

> That a complete amendment of the Rules of the Society be made by the adoption of the draft Rules which accompanied the Notice convening this meeting in substitution for the existing Rules of the Society and that the amendment of Rules be registered with the Registrar of Friendly Societies.

Presiding was the Chairman of Directors, Sir James Denby Roberts, Bt., O.B.E., M.A., J.P., Strathallan Castle, Auchterarder, Perthshire.

On the Motion of Sir James D. Roberts, Bt., seconded by James Gray, Esq., O.B.E., T.D., Stirling, the meeting unanimously passed the above-mentioned Resolution.

There being no further business the meeting was concluded."

Staff

The following new appointments were made during the year:—

Scientific Officers	J. H. W. Holden, B.Sc., Ph.D. (Head, Potatoes).
	S. Gowers, B.Sc. (Forages).
Experimental Officers	I. M. Chapman, B.Sc. (Forages).
	Mrs G. Macdonald, H.N.C., L.I.B. (Potatoes).
	M. S. Phillips, B.Sc. (Forages).
	Miss C. L. Snell, M.Sc. (Forages).
	Miss C. J. Williamson, B.Sc. (Forages).
Assistants	G. L. Bleazard.
	Mrs M. S. Cochrane.
	Mrs I. Davidson.
	D. A. Hamilton.

	Miss D. Hanning.
	D. J. Liston.
	A. A. Mitchell (temporary).
	Mrs A. R. V. Ross.
	Miss C. Stuart.
	G. E. L. Swan.
Technical	G. Stevens.
Administration	Mrs E. McNeill. Miss S. M. Taylor.

The following resignations took effect:—

Miss E. M. C. Baillie.
D. C. Bignell (temporary).
F. G. Cook, B.Sc.
Miss R. Jackson.
M. Macaulay.
Mrs M. D. Montgomery.
Miss M. I. Munro.
Mrs D. C. Murray.
Miss H. Pollock.
Mrs A. T. Turner.
J. T. Walker, B.Sc., Ph.D., A.K.C.

Members of staff made two visits abroad during the year with the aid of grants from the ARC for the purpose. In September-October 1970 Dr McNaughton visited private and State plant breeding stations in Holland to acquaint himself with work being carried out there on brassica crops. Mr Fyfe visited barley workers in Sweden (Svalöf and Weibullsholm) and Denmark (Carlsberg Brewery Laboratory, Copenhagen) in October 1970.

Members of staff attended a number of scientific meetings in the United Kingdom, and gave four lectures or seminars to various audiences in meetings or at universities. Dr Dunnett organised an exhibit on potato breeding at the Plant Variety Rights Office Exhibition in London, 13-17 July 1970. The Director and Mr J. L. Fyfe lectured in Edinburgh University, the former to the fourth year Botany Class, the latter to the Diploma Class in Genetics. Mr Fyfe examined for final honours B.Sc. and M.Sc. in Agricultural Botany at Aberystwyth, and the Director completed his three-year term of duty as external examiner to the Birmingham University M.Sc. course in Applied Genetics. Miss I. K. Munro and Miss A. R. Hutchison acted as tutors for a course on field botany run by the Scottish Field Studies Association in July 1970.

The Director gave seven lectures to various audiences in research stations and universities during the year. In January 1971 he gave a brief account of the work of the Station in an interview on the Grampian Television farming programme. In August-September 1970 he visited the Rubber Research Institute of Malaya for ten days, and in November-December 1970 the West Indies Central Sugar Cane Breeding Station in Barbados for two weeks in his capacity as consultant in plant breeding matters to the two organisations. He continued to serve on several committees within or directly connected with the work of the Agricultural Research Service. During the year he was appointed Chairman of the Research Councils Users Committee of the Edinburgh Regional Computing Centre; this Committee represents the views of users in four Research Councils (ARC, MRC, NERC, SRC) collectively to the Centre. At the same time, and arising out of Chairmanship of the Users Committee, the Director also became a member of three other Committees concerned with computing—namely, the Computer Consultative Council, the ARC Advisory Committee on Computing and the Executive Committee of the ERCC.

The Station received many visitors during the year: among them parties of students, farmers and advisers, as well as individual scientists and technologists from home and abroad. We were pleased to see them all.

11. PUBLICATIONS

BANKS, W., GREENWOOD, C. T., and WALKER, J. T. (1970). Studies on the Starches of Barley Genotypes: The Waxy Starch. *Die Stärke*, **22**, 149-152.

BLACK, W. (1970). The Nature and Inheritance of Field Resistance to Late Blight (*Phytophthora infestans*) in Potatoes. *Am. Potato J.*, **47**, 279-287.

COCKERHAM, G. (1970). Genetical Studies on Resistance to Potato Viruses X and Y. *Heredity*, **25**, 309-348.

MACARTHUR, A. W. (1970). Fifty Years of Potato Breeding at the Scottish Plant Breeding Station. *J. Nat. Ass. Seed Potato Merchants*, **10**, 1-12.

12. ABSTRACT OF ACCOUNTS

ABSTRACT OF ACCOUNTS

For Year ended 31st March 1971

INCOME

1970		
£233	Dividends and Interest	£36·11
431	Sales of Produce and Stock on Hand	543·55
106	Sale of Van	..
73	Subscriptions—Annual	67·25
	Note.—Annual Subscriptions amounting to £12·60 are in arrear	
137	Rent of Cottages	143·19
£980	*Total Ordinary Income*	£790·10
	Grant received from the Department of Agriculture and Fisheries for Scotland—	
145,500	Maintenance	190,550·00
..	The Murrays—Farm Road improvement	2,500·29
£146,480	*Total Income*	£193,840·39
	Balance at 1st April 1970—	
	Department of Agriculture and Fisheries for Scotland—	
9,185	Maintenance Grant	7,564·39
£155,665		£201,404·78

EXPENDITURE

1970			
	Salaries:—		
£72,419	Scientific and Technical Staff	£91,452·75	
8,173	Administrative and Clerical Staff	9,694·87	
1,576	Pension Supplementation	1,589·53	
£82,168			£102,737·15
7,457	Superannuation Contribution		8,000·49
15,553	Wages		21,177·15
4,315	National Insurance and Graduated Contributions		5,622·84
6,694	Apparatus and Equipment		10,537·55
5,794	Chemicals and Materials		7,391·93
2,319	Travelling and Subsistence		2,860·61
2,937	Rates		2,992·30
5,464	Power, Heat and Light		7,147·51
562	Library Books and Periodicals		691·09
721	Printing and Binding		875·37
1,760	Stationery, Postages, Telephone and Office Expenses		2,125·16
1,908	Vehicles—Purchase £160·00; Maintenance 1,765·37		1,925·37
232	Audit and Legal Expenses		250·00
1,260	Property Repairs and Improvements		1,613·06
347	Trial Centres		271·00
1,233	Edinburgh Centre of Rural Economy—Contribution towards upkeep		2,418·60
914	Repairs, Servicing and Upkeep		1,560·69
451	Seed Testing, Plant Variety Trial Fees		822·50
138	Transport		213·90
1,271	Land Improvement		..
931	Advertising		1,094·17
495	Furniture		679·56
527	Miscellaneous		282·41
1,944	Property Alterations (covered yard)		..
706	Rentals		981·44
..	The Murrays—Net Cost		9,624·79
	Improvement to Road (by D.A.F.S. Grant)		2,500·29
£148,101	*Total Ordinary Expenditure*		£196,396·93
	Balance at 31st March 1971—		
	Department of Agriculture and Fisheries for Scotland—		
7,564	Maintenance Grant		5,007·85
£155,665			£201,404·78

BALANCE SHEET

as at 31st March 1971

I. Funds:—		
Balance at 31st March 1970	£257,261·67	
Grant received from D.A.F.S. Capital—Works	64,486·32	
Equipment	6,346·38	£328,094·37
II. Current Liabilities:—		
Accounts outstanding due by Society	£3,336·31	
Subscriptions paid in advance	13·00	
Department of Agriculture and Fisheries for Scotland—		
Balance of Maintenance Grant	5,007·85	
,, Capital Grant	15,047·81	23,404·97
		£351,499·34

	Cost	Amounts charged to Revenue	Net
I. Fixed Assets:—			
Heritable Property	£298,947·20	}	£327,521·30
Capital Equipment	28,574·10	}	
Implements and Tools	19,411·28	£19,411·28	..
Vehicles	4,839·06	4,839·06	..
Laboratory Apparatus	25,098·13	25,098·13	..
Furniture and Fittings	8,253·63	8,253·63	..
Library Books	6,517·00	6,517·00	..
	£391,640·40	£64,119·10	£327,521·30

II. Current Assets:—		
Stocks on Hand as valued by Directors	£28·95	
Accounts outstanding due to Society	882·60	
H.G.C.A. Grant due to Society	762·84	
Cash and Bank Balance	22,303·65	23,978·04
		£351,499·34

Edinburgh, *25th May, 1971*.—The undersigned, having had access to all the Boo[illegible]nts of the Society, and having examined the foregoing Statement of Accounts and verified the same with the Accounts and Vouchers relating thereto, now sign the [illegible]nd to be correct, duly vouched, and in accordance with law.

16 Alva Street.

Messrs BROWN, MACDONALD & FLEMING, *Auditors.*

J. D. ROBERTS, *Convener, Finance Committee.*

LIFE MEMBERSHIP SUBSCRIPTIONS AND DONATIONS ACCOUNT

Dividends and Interest	£683·42
Profit on Sale of Investments	382·50
Malayan Rubber	375·00
Donations	55·00
Life Subscriptions	160·00
Balance at 1st April 1970	10,150·19
	£11,806·11

W. J. REID AND JAMES MUNRO BEQUESTS

Dividends and Interest	£119·54
Balance at 1st April 1970	1,910·37
	£2,029·91

DR. WILSON MEMORIAL FUND

Dividends and Interest	£26·45
Balance at 1st April 1970	532·37
	£558·82

HOME GROWN CEREALS AUTHORITY

Grant received	£3,087·34
Balance due to Society at 31st March 1971	762·84
	£3,850·18

Hospitality		£88·50
50th Anniversary Celebrations		483·11
Insurance		7·25
Balance at 31st March 1971, consisting of:—		
Investments (see Appendix), at Cost	£9,366·49	
Recoverable Income Tax	263·83	
Cash in Bank—Current Account	862·26	
Savings Account	734·67	
		11,227·25
		£11,806·11

Balance at 31st March 1971, consisting of:—		
Investments (see Appendix), at Cost	£1,699·14	
Recoverable Income Tax	48·05	
Cash in Bank—Current Account	214·66	
Savings Account	68·06	
		£2,029·91
		£2,029·91

Balance at 31st March 1971, consisting of:—		
Investments (see Appendix), at Cost	£464·01	
Recoverable Income Tax	9·31	
Cash in Bank—Current Account	29·10	
Deposit Account	55·00	
Savings Account	1·40	
		£558·82
		£558·82

Balance brought forward from previous year	£645·98
Salaries	2,750·93
Superannuation Contribution	238·90
National Insurance and Graduated Contributions	154·12
Apparatus and Equipment	60·25
	£3,850·18

APPENDIX

LIST OF INVESTMENTS

Life Membership Subscriptions and Donations Funds

Nominal Value		*Market Value at 31/3/71*
£710·00	Claverhouse Investment Trust Ltd. 1,420 Ordinary 50p shares	£781
264·00	Courage, Barclay & Simonds 1,056 Ordinary 25p shares	1,056
416·40	6½% Funding Stock 1985-87	333
82·75	Guardian Royal Exchange Association 331 Ordinary 25p shares	649
345·00	Imperial Chemical Industries Ordinary £1 Stock Units	863
247·50	National Commercial Banking Group Ltd. 990 Ordinary 25p shares	1,188
86·25	Shell Transport & Trading Co. Ltd. 345 Ordinary 25p shares	1,173
1,153·00	Stirling County Council 7¾% Redeemable Stock 1977-79	1,061
2,359·35	Treasury 8¾% Loan 1997	2,253
760·00	Treasury 8½% Loan 1980-82	771
		£10,128

W. J. Reid and James Munro Bequests

£1,359·29	6½% Funding Stock 1985-87	£1,088
80·00	Imperial Chemical Industries Ordinary £1 Stock Units	200
208·00	Stirling County Council 7¾% Redeemable Stock 1977-79	191
		£1,479

Dr Wilson Memorial Fund

£276·60	6½% Funding Stock 1985-87	£221
26·75	Guardian Royal Exchange Assurance 107 Ordinary 25p shares	210
		£431

13. 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.
Food Research Institute	Colney Lane, Norwich NOR 70F
Letcombe Laboratory	Letcombe Regis, Wantage, Berks.
Meat Research Institute	Langford, Bristol BS18 7DY
Poultry Research Centre	King's Buildings, West Mains Road, Edinburgh EH9 3JS
Weed Research Organisation	Begbroke Hill, Sandy Lane, Yarnton, Oxford OX5 1PF

State-aided Institutes in England and Wales:

Animal Virus Research Institute	Pirbright, Woking, Surrey
East Malling Research Station	East Malling, Maidstone, Kent
Glasshouse Crops Research Institute	Worthing Road, Rustington, Little-hampton, Sussex
Grassland Research Institute	Hurley, Maidenhead, Berks. SL6 5LR
Houghton Poultry Research Station	Houghton, Huntingdon PE17 2DA
John Innes Institute	Colney Lane, Norwich NOR 70F
Long Ashton Research Station	Long Ashton, Bristol BS18 9AF
National Institute of Agricultural Engineering	Wrest Park, Silsoe, Beds.
National Institute for Research in Dairying	Shinfield, Reading, Berks. RG2 9AT
National Vegetable Research Station	Wellesbourne, Warwick
Plant Breeding Institute	Maris Lane, Trumpington, Cambridge CB2 2LQ
Rothamsted Experimental Station	Harpenden, Herts.
Welsh Plant Breeding Station	Plas Gogerddan, Aberystwyth, Cardi-ganshire SY23 3EB
Wye College, Department of Hop Research	Ashford, Kent

State-aided Institutes in Scotland:

Animal Diseases Research Association . .	Moredun Institute, 408 Gilmerton Road, Edinburgh EH17 7JH
Hannah Dairy Research Institute . . .	Kirkhill, Ayr
Hill Farming Research Organisation . .	29 Lauder Road, Edinburgh EH9 2JQ
Macaulay Institute for Soil Research . .	Craigiebuckler, Aberdeen AB9 2QJ
National Institute of Agricultural Engineering (Scottish Station)	Bush Estate, Penicuik, Midlothian
Rowett Research Institute	Bucksburn, Aberdeen AB2 9SB
Scottish Horticultural Research Institute. .	Invergowrie, Dundee DD2 5DA
Scottish Plant Breeding Station . . .	Pentlandfield, Roslin, Midlothian

A note on the Scottish Plant Breeding Station

The Scottish Society for Research in Plant Breeding was founded in 1920 with the aims of conducting scientific investigations into plant breeding and of breeding plants for Scottish agriculture. Membership of the Society is open to any interested person whether farmer, merchant, scientist or other, in or out of Scotland. Management of the Society is vested in a Board of Directors which is elected partly by the members and partly nominated by the Secretary of State for Scotland. The principal activity of the Society is to look after the affairs of the S.P.B.S. The Station was for thirty-three years at Craigs House, Corstorphine, and moved to new premises on the Bush Estate of the Edinburgh Centre of Rural Economy in 1954. The Society met a third of the cost of the new laboratories but the recurrent expenses of running the Station were, from an early stage, greater than the Society could bear and nowadays nearly the whole cost is met from public funds granted by the Department of Agriculture and Fisheries for Scotland under scientific advice from the Agricultural Research Council.

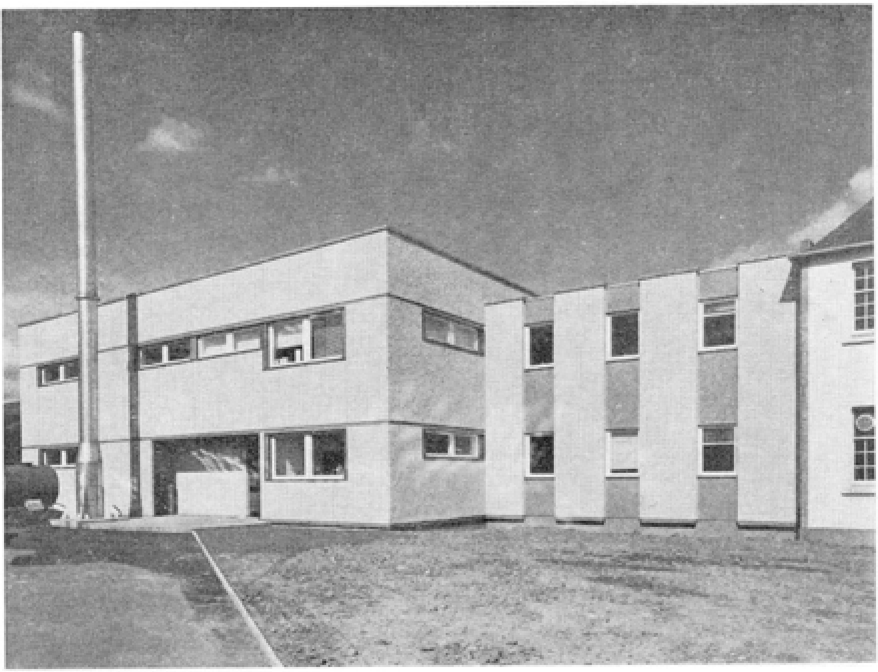
Interested persons are invited to submit the sub-adjacent membership form. Members receive the Annual Report and are eligible to participate in the affairs of the Society.

Address: Scottish Plant Breeding Station, Pentlandfield, ROSLIN, Midlothian, Scotland.

Telephone: 031-445 2171.

Location: See map on back cover.

Printed by William Blackwood & Sons Ltd., Edinburgh



TWO VIEWS OF THE NEW WEST WING

(Photos: John Porteous)