SCOTTISH PLANT BREEDING STATION
PENTLANDFIELD, ROSLIN, MIDLOTHIAN
EH25 9RF

REPORT

TO THE

ANNUAL GENERAL MEETING

OF

THE SCOTTISH SOCIETY FOR RESEARCH

IN PLANT BREEDING

22nd JULY 1976

BY THE

BOARD OF DIRECTORS

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1. REPORT BY THE DIRECTOR

General

The new east wing of the laboratory came into service in March 1976, several months late, due to delays in delivery of critical supplies. The architects were Messrs Moira and Moira. The building, which, at first acquaintance, seems very satisfactory, fulfils several rather disparate functions. The ground floor contains controlled-environment chambers for work on potato tuber diseases, potato pathology working space and four offices. The first floor provides a common room (part of which lies in the old east end of the building) and a general purpose room (see below). A storage shed at Pentlandfield was completed during the year and a shed at the Murrays is scheduled for completion in May 1976.

The Station received a Visiting Group in the autumn of 1975. Its report is awaited. The Group consisted of: Professor P. W. Brian, F.R.S., Professor J. L. Jinks, F.R.S., Professor R. C. F. Macer; Mr D. D. S. Craib was unfortunately unable to attend, due to illness. The Group was assisted by members of DAFS and ARC Headquarters.

During the year, the ARC initiated discussions on " rationalisation " with the intention of identifying areas of work in which overlaps between institutes could be eliminated, thus allowing selective strengthening of other areas. Plant breeding was chosen as the first field for review. The outcome is not yet settled, no decisions having been taken, but it looks as though the result for SPBS will be a natural concentration on the three areas where the work is already strongest, namely, potatoes, Brassicas and cereals. It has been officially emphasised all along that any changes of programmes called forth will proceed, not hastily, but deliberately and with full consideration of staff interests.

Several significant organisational changes were made during the year. Hierarchical staff structures for the two departments were adopted, apparently to general satisfaction. They will improve the general process of communication, as will also, of course, the use of the new common room as a place where all staff can, for the first time, gather for the tea break and at lunch. And the new general purpose room permits regular staff meetings and seminars in comfortable surroundings, as well as bringing the Board to meet at Pentlandfield without pre-empting the use of the library.

It is not normal practice to anticipate in this general introduction the detailed report which follows but, this time, an exception seems to be indicated. *Raphanobrassica* (project 10), in trials for the first time, gives excellent promise of providing a high yielding, disease-resistant, palatable substitute for rape.

Like the only other example of a new crop plant species synthesised *de novo* (Triticale, wheat-rye), *Raphanobrassica* combines the merits of its parents, in this case radish and kale. It is exciting very wide interest and the next few years should see notable developments. It is not often that new crops are invented.

The fifth SSRPB lecture was given by Professor R. L. Wain, C.B.E., Ph.D., D.Sc., F.R.I.C., F.R.S., on 10th April 1975 to a highly appreciative audience. Professor Wain is Honorary Director of the ARC Systemic Fungicides Unit at Wye College; his title was: "Some development in research on plant growth and plant disease control". The sixth lecture will be given by Dr J. W. B. King, Ph.D., F.R.S.E., Director of the ARC Animal Breeding Research Organisation, under the title: "The prospects for animal breeding". A summary of it appears elsewhere in this report.

Forage Crop Investigations

ARC Project 1: Barley genetics

Genetical and systematic studies in support of barley breeding programmes, including breeding methods and classification of collection.

(Workers: A. M. Hayter, R. P. Ellis, R. J. Giles)

The analysis of data from the F_1 and F_2 generations of a diallel cross has been completed for the characters ear number, grain number per ear, 1,000-corn weight and straw length. As four of the thirteen parents were six-row varieties and therefore genetically rather distinct, separate analyses were conducted on the two-row subset. A high level of dominance was detected in the F_1 for all characters and the dominance effects were mainly directional and positive. Apparent over-dominance due to non-allelic interaction was found in the F_1 of crosses between two-row and six-row parents for 1,000-corn weight.

Selection has resulted in the accumulation of dominant genes with increasing effect on the morphological components of yield. It is concluded that further shortening of the straw would probably be possible but perhaps at the expense of yield.

Genotypic correlation coefficients were computed and indicated that further genetic improvements for yield should be possible within the two-row genotypes. Narrow-sense heritability estimates from the two-row parent half-diallel indicated that selection would be most effective for 1,000-corn weight and uncertain for ear-number and grain number per ear.

Considerable experience has now been obtained with broadly based composite cross populations which did not contain male sterility and which were exposed only to natural selection. They have yielded nothing of value so far but the principle remains attractive. In future, new composites will be constructed from fewer parents, will contain male sterility and will be exposed to artificial selection.

The multivariate technique called canonical analysis has been used to select parents for the malting quality programme. This technique simplifies the handling of complex data and a series of trials is planned over several years.

We have been collaborating with the Plant Breeding Institute and the Welsh Plant Breeding Station in making arrangements for the preparation of a computer-based barley data bank. A working descriptor schedule has been agreed and the coding of varietal descriptions has begun; however, implementation has been delayed due to recent modification in the TAXIR program which will be used for the manipulation of the bank. In preparation for inclusion into the bank, the whole barley collection has been renumbered using the allocation made to SPBS of one-third of the bank's item numbers. This has provided the opportunity to overhaul the numbering sequence but has also generated a considerable amount of work.

The barley collection has about 1,700 entries, 1,300 of which were grown at Pentlandfield in 1975. This sowing provided an opportunity for updating existing descriptions and composing new ones.

ARC Project 2: Barley biochemistry

Biochemical genetics of diastatic enzymes in relation to barley breeding; mutagenesis.

(Workers: M. J. Allison, J. S. Swanston)

Abscisic acid (ABA)-resistant lines of Maris Mink produced by means of a mutation with biochemical screening system, have now reached the M5 generation. Micromalting tests on M4 progeny (from unreplicated progeny rows) have shown that five ABA-resistant lines have diastatic activities intermediate between that of Maris Mink and a high diastase control. One line, mutant 23, had a high alpha-amylase activity (about 70 per cent of that of Conquest) and showed the erectoides growth habit. Observation of the early growth of mutant 23 during current multiplication in New Zealand supports the suggestion that it is a double dwarf. In addition to its enzyme properties, this mutant may thus also serve as a source of dwarfing genes for the breeding programme.

An investigation into whether some combinations of isozymes of beta-

amylase (see *Annual Report* **53**, 7, 1974) and those of alpha-amylase are better than others at degrading starch is currently in progress. Preliminary results from F4 progeny homozygous for amylase zymotypes indicate that there is an effect on beta-amylase associated with the appropriate locus but that this effect is too small to warrant the use of isozyme typing as a sole criterion in selection for diastatic activity.

There are at least two forms of beta-amylase in the resting grains of barley, a water-extractable "free" active form and a bound form which can be converted to an active form by the proteolytic enzyme, papain. In surveys of barleys it has been shown by Canadian workers (and confirmed by us) that total (that is, free *plus* bound) beta-amylase in the resting grain correlates highly with diastatic activity in the malt. From a cross between Akka (very high free but low bound beta-amylase activity) and Freebar (very high bound, but low free activity), about 10 per cent of the F4 progeny have exceptionally high beta-amylase activity in the resting grain. The possibility of using this method to synthesise parental lines with very high diastase is under further investigation.

ARC Project 3: Barley breeding

Breeding spring barley varieties for Scotland with specific objectives: feed, malting, including high diastase and high amylose types for whisky.

(Workers: A. M. Hayter, R. P. Ellis, J. E. Bradshaw)

All our breeding programmes can be said to have the objective of combining high yield and reliable disease resistance with one or more special features. In the case of the feed barley programme, high grain nitrogen is one such special feature. The most advanced material was in F_6 trial in 1975; yields were disappointing, probably due to an attack of yellow rust. However, the F_5 selections yielded well and did not show undue disease susceptibility.

Similar problems of yellow rust susceptibility were encountered in the 1975 F_6 trial of high diastase lines derived from the cross Akka × Midas; they are not susceptible to existing mildew races but need further improvement in relation to *Rhynchosporium*, yellow rust and brown rust.

The results of 1975 malting trials on high amylose isogenic lines confirmed the earlier conclusion (*Annual Report*, **54**, 9, 1975): high amylose starch is more resistant to degradation by amylases than is normal starch. Unless some novel enzyme system capable of degrading high amylose starch can be found, there is no point in pursuing this character any further.

The malting quality programme aims to improve barley for use by malt

whisky distillers and by brewers. Low contents of grain nitrogen and beta-glucan, high hot water extract and high levels of hydrolytic enzymes are all desirable characters in malting barley. The existing facilities for micro-malting have been supplemented by the addition of equipment for measuring beta-glucan. Investigations, carried out in collaboration with the Chemistry Laboratory, have been set up to evaluate the use of rapid small-scale tests for assessing malting quality in early generations. The most advanced breeding material for this programme stems from a series of crosses made at the Plant Breeding Institute. F_3 populations were selected in Scotland in 1975, are currently being grown in New Zealand and twenty will be in F_5 trials in 1976.

In comparison with oats and wheat, barley is relatively intolerant of low soil pH. The cost of maintaining a high soil pH could be reduced if the crop's tolerance could be increased. To this end, acid-tolerant varieties and other materials with desirable agronomic characters were crossed to lines containing male sterility genes. A composite cross population will be constructed and sown on acid soil in 1976.

In last year's report we noted a need for increased attention to barley diseases. The 1975 season was the first in which the potential seriousness of yellow rust epidemics in Scotland became obvious to us. The Eucarpia Integrated Control Trial was grown for a third year, in co-operation with the East of Scotland College of Agriculture. The arrangement for the screening of breeding material and potential parents for resistance to *Rhynchosporium* was continued at the Welsh Plant Breeding Station. A similar screening nursery was also set up at the Murrays and a larger one is planned for 1976.

The area devoted to barley trials will increase again in 1976, partly in reflection of collaborative trials carried out with the PBI and the WPBS and an increased flow of New Zealand grown material. Thanks to help from the Department of Scientific and Industrial Research, 3,900 lines are being grown at Gore, South Island; they are currently being selected by A. M. Hayter and the survivors will be returned to the SPBS for sowing in April 1976.

ARC Project 4: Oat breeding

Breeding spring oats for Scotland, including eelworm resistance and varieties for marginal areas.

(Workers: D. Cameron, M. S. Phillips)

The three oats (Aa 748 Arkle, Aa 749 Leven and Aa 752 Etive (proposed names)) which were entered for National List Trials and Plant Variety Rights in 1974 performed well in official and Station trials, Etive, selected in Argyll,

had the highest yield (109 per cent of Astor) at the Murrays and in Germany; Arkle was the best in France, with a yield of 110 per cent of Maris Oberon.

A selection for upland use, Aa 754, in trial in Inverness, gave a yield of 100 per cent of Astor, while Shearer's yield was 80 per cent. The maturity of Aa 754 was between that of Astor and Shearer. It will be included in trials in Inverness and Aberdeenshire before a final decision on its future is made in 1976.

It will be recalled from previous Annual Reports that the oat breeding programme is based on composite cross populations constructed annually since 1965 and grown at three centres (in Argyll, Inverness and East Lothian). Seven promising selections from the first (1965) composite have been entered for final Station trials in 1976. One of these, Aa 758, gave yields of 116 per cent of Astor over four sites and was comparable in maturity. Another, Aa 760, had similar yield and maturity and, in addition, had very good resistance to lodging. Selections from the 1966 to 1969 composites have entered Station trials this year.

Natural crossing in oat composites was found to be between 2·4 per cent and 4·0 per cent. Although this is not so high as in the barley composites (*Annual Report*, **54**, 7, 1975) these estimates are still surprisingly high.

Laboratory testing for resistance to oat stem eelworm (*Ditylenchus dipsaci*) has finished and 334 selected lines are being multiplied for trial in 1977. Three advanced lines (E 1141, E 1142 and E 1391) will enter final Station trials in 1976. They have outyielded Astor in breeders' trials and have suitable height and maturity for lowland cultivation.

ARC Project 5: Hybrid swedes

Methods of exploitation of known heterosis

(Worker: S. Gowers)

The work upon self-incompatibility in swedes continued but, due to poor pollinating conditions, no further work could be done on cross-checking unknown *S*-alleles. The most advanced lines are now at the fourth backcross and will be selfed to produce homozygous *S*-allele lines.

Two trials were carried out this year to examine combining abilities. A 10 × 10 partial diallel was transplanted at the Murrays and a smaller trial was drilled at Boghall with any hybrids of which there was sufficient seed. The Murrays trial contained twenty-nine hybrids and nine parents in two replications. In dry matter yield, the best hybrid, APZ × BW, was 21 per cent above its higher yielding parent (Bangholm Wilby, BW) and 17 per cent higher than Bangholm Ruta Otofte (BR), the highest yielding parent; differences, however, were non-significant. Unfortunately there was in-

sufficient seed for inclusion of WD × PH, which had done best in the previous trial.

In the Boghall trial, eight parents and eight hybrids were sown in four replicates and another ten hybrids were included in two replicates. APZ × BW was the highest in the former group, giving 40 per cent higher yield than BW itself, but it was not significantly higher than BR. In the latter group, BS × WS was the highest yielding, giving 12 per cent more than BR, and the difference was marginally significant. At the Murrays, however, this line had only equalled BR. Although high levels of heterosis have again been demonstrated, as yet no combination showing significant advance over Bangholm Ruta Otofte has been found.

ARC Project 6: Swede breeding

New swede varieties adapted to mechanical cultivation.

(Workers: S. Gowers, Isabel K. Munro)

An experiment is being made to investigate the results of inbreeding within normal swede varieties. From twenty open-pollinated families of Scotia, six were selected for high yield characters. Plants from these families were selfed and the seed was sown in a trial at Boghall. Of thirty-three families tested, the lowest yield of dry matter was 22 per cent below Scotia and the highest was 23 per cent above (LSD = 15 per cent). If these results hold for later generations and other varieties, they would have important implications for swede breeding methods, whether by line or by F_1 hybrids. The study will be continued.

Work is now in hand to produce clubroot resistant varieties of swede. As it is hoped that sufficient *S*-alleles have already been obtained in *B. napus*, the turnip-swede backcross programme has been diverted completely to clubroot breeding. Three lines derived by selfing 38-chromosome plants have been tested this year. All three produced some plants which appeared to be resistant to one of the most virulent strains of clubroot tested at the Station. Selected plants will now be pollinated to fix the resistance and also crossed to existing cultivars to produce high-yielding clubroot-resistant lines.

Inbred lines involving Pentland Harvester were selfed and selected lines multiplied at the F_5 level. Trials of other materials were unsuccessful (see Murrays report) but yielded selections and data on establishment, raan and mildew resistance. A trial of thirty-five cultivars at Pentlandfield revealed large differences in mildew attack; selections were made from the five most resistant cultivars.

ARC Project 8: Kale improvement

Study of kale breeding systems with object of developing grazing types with a wide genetic base.

(Worker: G. R. Mackay)

Qualitative analyses of the 1973 polycross trial were completed by the chemistry laboratory. Statistical analyses of the data confirmed significant differences in yield of digestible dry matter between the single plant progenies, sixty-seven of which proved significantly higher than the Maris Kestrel control. Individuals of the twenty highest yielding families were selected from the observation plots and transplanted to an isolation cage. One hundred and forty of these individuals set sufficient seed for replicated trial and these single-plant progenies plus controls will be sown this spring.

Additional plants were sampled from the five highest yielding families and were seeded in isolation cages; the bulked seed produced from each of these has been passed to the Trials Unit for assessment as pre-varietal stocks, at two sites. Although still very heterogenous, it is hoped that these larger scale trials will provide an indication as to whether the very encouraging results from breeding trials represent a real improvement under conditions closer to those of agricultural practice.

The first generation of progenies from the reciprocal recurrent selection programme (*Annual Report*, **54**, 14, 1975) were harvested in December. Growth was poor and statistical analysis of fresh weight and dry matter yields failed to detect significant differences between progenies (coefficient of variation 25 per cent). Samples have been passed to the Chemistry Laboratory for qualitative analysis to provide criteria for selection.

A range of cultivars representing six botanical varieties of *B. oleracea* were sampled throughout the 1975 growing season, from cotyledon to mature plant stage. These are now being analysed by the Chemistry Laboratory for S methyl-cysteine sulphoxide (SMCO), the haemolytic factor, and thiocyanate levels; the results will provide guidance for selection against these toxic compounds in kale breeding programmes.

ARC Project 9: Brassica wide crosses

Exploitation of polyploid interspecific crosses as possible rape-substitutes or as new forage species, including artificial *napus* (4x) and triploid (aac) hybrids.

(Workers: I. H. McNaughton, G. R. Mackay, Carol L. Snell)

Modified embryo culture techniques for making the very difficult cross between *Brassica oleracea* and *B. campestris* proved successful and the yield of

hybrid plants rose to 7·5 per 100 pollinations. The way is therefore open to the resynthesis of *Brassica napus* on a wide scale. Successful crosses were made at both diploid and tetraploid levels. The combinations were chosen primarily to test techniques but some would appear to have immediate agronomic potential and are being multiplied with this in view.

Before this very recent success with embryo culture, attempts were made to introgress edible stem characters into *B. napus* from *B. oleracea* by direct crossing methods. A single allotriploid hybrid (2n = 28, acc) was obtained from 2x *B. campestris* (a leafy stubble-turnip) × 4x *B. oleracea* (marrow-stem kale). This hybrid was inter-crossed with various forms of rape; sixty-one seeds resulted from over 1,000 pollinations. Plants raised ranged in chromosome number from 2n = 32 to 2n = 46. Five plants were obtained with 2n = 37 which, on selfing, should give a one in four chance of 2n = 38 progeny, *i.e.*, semi-synthetic *B. napus* with, it is hoped, high stem edibility from the kale.

Selected F_3 families, derived from artificial rapes × Nevin rape were compared in a trial with leading British and continental rapes. The former were notable for their rapid growth in the establishment phase, an important consideration in rape as a pioneer crop.

Several marrow-stem kale lines, homozygous for strong *S*-alleles, were colchicine treated with a view to producing new artificial *B. napus* forms by isolating self-incompatible 4x *B. oleracea* with 4x *B. campestris*. In view of the development of a successful embryo culture technique, this method of hybrid production becomes outmoded.

Two leafy 4x *B. campestris* sub-species hybrids, developed as prospective parents for artificial *B. napus* work, appear promising on their own account. These hybrids, Appin (approved name) and Ballater (provisional) (previously CA57 and CA50 respectively), have completed the two years of DUS trials. The former has outyielded cultivars of giant rape, stubble-turnip and fodder radish in a mid-August sown trial conducted by GRI, Hurley. This facility to perform well from late sowing suggests that Appin will be a strong competitor to stubble-turnips as a catch crop. Commercial release should be in 1977. For brief descriptions of Appin and Ballater, see Appendix to this project report.

Test crossing and analysis of incompatibility relationships amongst the *B. campestris* *S*-allele stocks continued and further useful information regarding the dominance relationships between alleles was obtained. Seed production from these weak, inbred stocks remains a problem. Of twenty-five *S*-allele homozygotes isolated during the course of this work, only thirteen remain as extant lines. Samples of all the remaining stocks were sown in autumn 1975 and a concerted effort, in co-operation with the Pure Stocks Unit, will be made in 1976 to maximise seed production. Further studies on *S*-allele

relationships will be given a secondary priority for, unless seed can be produced in sufficient quantity, the production of aac hybrids on a field scale, using turnips as parents, will not be feasible.

Test crossing and the back-crossing of self-incompatible (s.i.) rapes to their recurrent parents (self-compatible (s.c.) cultivars) continued very successfully. Twenty-six s.i. lines are now available and sufficient seed was produced by hand pollination to enable agronomic assessment by replicated field trials in 1976. It is quite likely that the field scale production of interspecies hybrids will ultimately be achieved using these s.i. rapes as seed parents and turnips as pollen donors rather than *vice versa*, as originally planned.

A start has been made in isolating *S*-allele homozygotes from the s.i. rape stocks; progenies produced by bud-selfing s.i. individuals have been sown for this purpose. The allotetraploid status of *B. napus* may complicate the isolation of *S*-homozygotes. However, *S*-alleles from *B. campestris* have been successfully transferred by crossing and back-crossing. The " semi-artificial " rapes thus produced are effectively diploid with respect to their *S* loci and this promises to be a most useful technique.

Four putative F_1 hybrid turnips were produced from *S*-allele homozygotes in insect cages in 1974. By sowing out of season, these have been successfully " annualised " and were set up in insect cages with rape cultivar pollen donors. Coincidence of flowering was good and there is sufficient seed for replicated trials in 1976. Cytological examination of samples is in hand and it is hoped that this material will provide useful information on the field scale production and performance of aac hybrids. Additional turnip F_1s are available for use this season.

Appendix: Appin and Ballater are both leafy tetraploid ($2n = 4x = 40$) forms of *B. campestris*. Leaves arise from near ground level and there is little or no bulb-formation. Foliage is more persistent than in stubble-turnips, *i.e.*, there is less premature senescence. On present evidence, they may be sown early or late and, if early, will give regrowth after first cutting or grazing. Appin has performed well from late sowing in comparison with stubble-turnips.

Appin: (CA 57) Derived from a hybrid between *B. campestris* ssp. *nipposinica* (an oriental salad vegetable) and ssp. *rapifera*, Tigra stubble-turnip. Leaves are less dissected than those of Ballater, dentate-serrate rather than laciniate. The rootstock may form a " semi-bulb ", depending upon time of sowing and spacing.

Ballater: (CA 50) Derived from a hybrid between *B. campestris* ssp. *nipposinica* and ssp. *rapifera*, Bruce turnip. Finely dissected, almost laciniate, leaves arise from a many-headed rootstock.

ARC Project 10: Raphanobrassica

Intergeneric allopolyploids as new forage species, with clubroot resistance, to substitute for or supplement rape.

(Worker: I. H. McNaughton)

A *Raphanobrassica* population, derived from a multiplication carried out in New Zealand, was tested at four sites in replicated, drilled experiments with two sowing dates. Sites were the Murrays, Cockle Park (by courtesy of Newcastle upon Tyne University Farm), managed by SPBS Trials Unit and Beverley and High Mowthorpe (North Humberside) supervised by ADAS.

From an early July sowing, dry matter yield increases of 31·3, 28·4, 12·8 and 25·8 per cent over giant rape (Cv. Lair) and 50·4, 36·9, 29·3 and 44·4 per cent over Nevin rape were recorded for the four sites respectively. Results, not yet statistically analysed, also suggest an increase in crude protein content of *Raphanobrassica* over rape, probably in reflection of its leafiness.

From an early August sowing, *Raphanobrassica* was outyielded by Ponda stubble-turnip and by Appin (SPBS turnip-rape, see Project 9). Results suggest that *Raphanobrassica* should be considered a competitor to rape, at the time that crop is normally sown, rather than as a late sown catch crop. Utilisation by sheep of discard *Raphanobrassica* plants, from the above trials, was reported by NIAB and ADAS to be good.

Seed fertility of *Raphanobrassica*, previously a major obstacle to progress, showed considerable improvement in 1975. Individual F_5 plants yielded up to a maximum of 60g seed and one family of twenty-five plants averaged 25g per plant. But there remains considerable variation within and between families. From a large number of siliquae sampled, 84 per cent of the seed set came from the lower, dehiscible sections, suggesting no real problems of seed extraction, such as are encountered with radish. A single siliqua was found with eighteen seeds, almost the full potential for *Raphanobrassica*.

Raphanobrassicas included in 1975 trials were based on thousand-head kale as the *Brassica* parent. More recent hybrids have been based on marrow-stem kale. As before, F_1 plants were highly sterile; they were crossed with F_4s of thousand-head parentage which were at a reasonable level of fertility. The progeny of these crosses showed enhanced fertility, suggesting that, once a line of high fertility has been developed, it can be used to introgress fertility into sterile, early generation material.

Resistance of some *Raphanobrassica* families to virulent races of *Plasmodiophora* was again shown in glasshouse tests. Resistance to *Erysiphe* (powdery mildew) was clearly demonstrated at several locations and in laboratory tests carried out by NIAB, Cambridge. A few plants showing hypersensitive reactions in the field were noted at Cambridge.

Progenies of *R. sativus* (fodder radish, an annual) × *R. maritimus* (sea radish, a biennial-perennial), back-crossed to *R. sativus*, were observed as transplants. The establishment of a leafy, biennial radish, as an improved parent in *Raphanobrassica* synthesis is in prospect. This material is being developed at both diploid and tetraploid chromosome levels. Some susceptibility to *Plasmodiophora* was shown by *R. maritimus*.

The analogous amphidiploid (genome formula aarr) is extremely difficult to obtain by direct crossing of the parent species, *B. campestris* (aa) and *R. sativus* (rr). An alternative method of producing it was therefore tried. *B. napocampestris* (aaaacc) was crossed with tetraploid *R. sativus* (rrrr) in the hope of obtaining aarrc hybrids which, on selfing or sib-mating, should result in aarr plants by the elimination of an unpaired c genome. Several hundred pollinations produced only one seed; its hybridity has not yet been ascertained.

Facilities for *Plasmodiophora* testing have been extended so that 3,200 plants may be screened at one time. Investigations into race identification have involved the use of the recently agreed fifteen ECD (European) differential hosts, five each from *B. campestris*, *B. napus* and *B. oleracea*. *Plasmodiophora* populations, obtained from ten widely spread locations in the UK showed similar, virulent infection patterns, several coding out identically on the test differentials.

Cultivars of rapes and swedes, the latter reputed to possess resistance, proved very susceptible in almost every test. Nevin rape, which possesses resistance to five out of seven races previously identified in the UK by other workers, proved susceptible to eight out of the above ten populations. Dutch stubble-turnip cultivars, generally considered highly resistant, proved partly susceptible to several races or aggregates of races.

Two *B. campestris* lines, used as differential hosts, proved virtually immune to these virulent populations of *Plasmodiophora*. It should be possible to transfer this high degree of resistance from *B. campestris* to *B. napus* either by backcrossing through the sesquidiploid (aac) or by resynthesis of *napus*, as described above.

Entry into official trials of the late-flowering fodder radish mentioned in the last *Annual Report* (**54**, 17, 1975) was delayed because of difficulties with seed production. These difficulties have been resolved and the variety resubmitted for trial this year. The name Crail has been approved.

ARC Project 12: Winter kill in ryegrass

Selection against winter kill in ryegrass.

(Worker: F. J. W. England)

The joint investigations with the Welsh Plant Breeding Station and the Plant Breeding Institute, Cambridge (*Annual Report*, **54**, 18, 1975) have been

completed and the results are in course of publication. The remaining Station effort is concentrated on the production of winter-hardy, persistent cultivars of Italian ryegrass. Selected material is in three progeny testing trials, all sown in 1974, two at the Murrays and one at Pentlandfield. Most of the progenies gave satisfactory yields in 1975 and will be assessed for winter resistance in early 1976. At the time of writing, there has been very little severe weather and no signs of winter damage are apparent.

An isolation plot of an Italian ryegrass synthetic based on genotypes selected from the North Carolina I experiment (described in previous annual reports) was sown at the Murrays to give pre-basic seed in 1976.

ARC Project 13: Cocksfoot breeding

Selection of nutritive and high yielding derivatives of Scotia cocksfoot.

(Worker: F. J. W. England)

Forty-nine selected genotypes were clonally multiplied and planted in a sixteen-replication polycross. It was hoped to produce seed in 1975 but wet weather so delayed planting that flowering was uneven and sparse and it was thought better to leave the material to produce polycross seed in 1976.

ARC Project 14: Poa breeding

Interspecific hybrids of *Poa pratensis* as perennial, rhizomatous grasses for hill land.

(Worker: Cynthia J. Williamson)

There are 270 hybrid progenies currently being assessed for field performance as spaced plants and in rows in two separate trials. In the first trial, planted in 1974, thirty-four of the more uniform progenies and thirteen of the original parental lines were harvested four times in 1975. At the first harvest, rows of ten plants were cut ten to twelve days after ear emergence and sampled for IVD. Eleven hybrids yielded more than the best parent and twenty-one yielded more than the mean of all parents over four harvests. The mean DOMD was 69·0 per cent for hybrids and 69·7 per cent for parents.

A second trial including 107 hybrid populations was sown in a greenhouse in March and planted out in the field in July 1975. Individual seedling fresh weights were recorded seventy-five days after sowing and used as the basis on which 50 per cent of the more vigorous seedlings in each family were

selected for the field trial. Ninety-two per cent of the hybrids had a higher mean fresh weight per family than the overall mean for three *P. pratensis* cultivars.

Data from field trials completed in 1974 were analysed by various methods to find the best means of discriminating between apomictic and sexual progenies. Both univariate and multivariate (*e.g.*, principal component) techniques were tried. The results broadly confirmed field experience, that variability could be used as a measure of apomixis, and that occasional sexual progeny occurred in predominantly apomictic families.

One of the problems associated with the use of *P. pratensis* in the British Isles is slow field establishment. Improved knowledge of conditions for germination and of factors affecting seedling development is evidently needed as a basis for improved selection.

The germination of six hybrid progenies is being examined under different temperature and lighting regimes. So far, results indicate that light inhibits germination at low temperatures (4-15°C); in continuous dark, alternating temperatures and higher temperatures (15-25°C) both promoted germination. Tests are continuing in 1976. A preliminary pot-trial on the establishment of nine populations from three *Poa* species has just been completed and results are being analysed. There appear to be marked differences between *P. pratensis* biotypes, as well as between species, in germination, dry matter yields, tiller numbers and rhizome production.

ARC Project 28: Exploration Unit

Explore unfamiliar crops for breeding potential in Scotland: wheat, beans, oilseed rape, maize, white clover.

(Workers: R. N. H. Whitehouse, I. M. Chapman, M. S. Phillips)

In the maintenance of a winter wheat composite 2-chloroethylphosphonic acid (Ethrel) was originally used to produce male sterility and hence outcrossing. This proved unsatisfactory and cytoplasmic male-sterile lines were introduced into the programme. This latter method now commands the greater effort. Seed set has been very good and the amount of hybrid seed produced is in excess of that which can be conveniently handled. The pollen parents are carefully chosen, new lines being introduced and others being left out, as required, each year.

Selection for earliness in the spring bean (*Vicia faba*) composite appears to have been effective. The material has been grown on with additional selection for earliness and seed size. Material exhibiting determinate growth habit and non-shattering pods will be introduced.

A bean trial was run at the Murrays for the Plant Breeding Institute. Yields were moderately high, averaging 4·5 t/ha (36 cwt/a). Breeders' lines were disappointing and the old SPBS variety Albyn gave the highest yield (5·3 t/ha, 42 cwt/a).

A winter oil-seed rape trial was grown at Ayton, Berwickshire, with very satisfactory results. The two best varieties Norde and Victor yielded over 3·5 t/ha (28 cwt/a). A spring trial at Ormiston, East Lothian, brairded excellently but later suffered severely from drought. Yields were 50 per cent down on 1974. The variety Cresus again gave the best yield, at 1·9 t/ha (15 cwt/a).

The collection of 1,400 white clover plants was scored for early growth in the spring of 1975. Eighty plants were selected and, along with controls, are being grown in replicated plots in the Pentland Hills (House O'Muir Farm) and at Pentlandfield. Several new accessions to the collection were added in 1975. Of note were a number of *Trifolium* spp. from Peru, samples of *T. ambiguum* supplied from Australia and the Welsh Plant Breeding Station and a collection of *T. repens* from Snowdonia.

During the past three years, three small forage maize trials have been carried out, in 1973 at Pentlandfield and in 1974 and 1975 at the Murrays. It is generally considered that a minimum of 2,100 Ontario heat units is required, between sowing and harvest, for the satisfactory growth of forage maize; this level was only approached in 1975 (2,060 Ontario units). In 1975, dry matter yields ranged from 7·2 to 10·0 t/ha. The minimum economic yield of forage maize is about 8·5 t/ha. This minimum was not approached in 1973-74 except by sowing under polythene sheets to promote rapid germination and early growth. Starting plants in this fashion produced yields of 9·5-11·0 t/ha in 1974. Breeding for quick germination and early growth at low temperatures is already being practised at the PBI and it is not considered worth pursuing any further work on maize at the SPBS.

Potato Investigations

ARC Project 16: Potato breeding

New varieties (early and maincrop) for ware and processing (crisps, chips, dehydration, canning).

(Workers: J. M. Dunnett, Rosalind M. Ford, A. A. McFarlane, A. W. Macarthur, C. J. Torrance, T. M. W. Davidson)

Most aspects of potato breeding were again adversely influenced by the restrictions imposed on glasshouse work and field trials due to potato spindle

tuber virus. The programme of screening the breeding material continued and was further complicated by the requirement of the quarantine authorities that we carry out a " passaging " procedure of all potato sap samples in tomato before the definitive final test carried out by them. This work effectively tied up a glasshouse and a scientist for the whole of the growing season. Of the clones tested, only two have given indications of possible infection and the results of check tests are awaited. Whether or not these clones are infected, it is again clear that the frequency of infection is very low and that sap transmissibility of the virus under our conditions is poor, a deduction already drawn from the very low frequency of infection on the Commonwealth Potato Collection.

Attempts to grow PSTV-free clones in isolation on land adjoining the Sourhope hill farm of the Hill Farming Research Organisation were frustrated by drainage problems; thanks are due to Mr James Black, of Drochil Castle, who offered alternative land at short notice. Despite late planting (29th May), yields were good. The new potato store at Sourhope was used for the first time during the winter and proved highly satisfactory. From this year on, the Drochil Castle plots will grow unscreened material and the Sourhope store will be used for the produce of the Drochil Castle plots and for any unscreened material of the PBI, Cambridge. Since, from the 1976 season, the acreage of " cleared " material will be greater than that of the " uncleared ", the former will be grown and stored " at home " at Blythbank.

We record the addition of Pentland Squire to the National List in Spain, which country has been making large and apparently yet unsatisfied demands on the limited seed supplies of this variety. The National Institute of Agricultural Botany recently announced the addition of Pentland Javelin to the Recommended List.

Arrangements have been made with Dr E. Allen of the University College of Wales, Aberystwyth, for collaboration in our first-early breeding programme. The intention is to multiply and acclimatise stocks in Radnorshire for the planting of field trials in the following year at the College's Farm, Trefloyne, Pembrokeshire, and elsewhere. We expect, as a result, to get a better assessment of earliness and to simplify the production of sufficient " physiologically mature " seed for the planting of replicated trials.

Of the early clones in trial, 8906(11) outyielded Home Guard and Epicure at all centres. It is a by-product of the maincrop programme, has *S. vernei* in its parentage, and possesses a notable degree of resistance to potato cyst eelworm pathotypes A and E.

In the maincrop breeding programme, two of the regional trials suffered from exceptional weather. Yields were very low at Gleadthorpe as a result of defoliation by a hailstorm; and at Terrington as a result of drought. However, growth at Mepal and the Murrays was good. Three of the most

promising clones, 8818(18), 8890(42) and 8911(15) are of particular interest. They are the most advanced material in the eelworm resistance programme based on the pathotype non-specific resistance of *S. vernei*. They also contain the Andigena gene, H_1 for resistance to pathotype A, and have acceptable yield and tuber quality characters. They will be re-trialled.

A trial was carried out, in collaboration with ADAS (East Midlands) to test the effectiveness of *vernei* resistance in the field, with and without application of nematicide. The site, near Skegness, was infested with pathotype E and, probably to a lesser degree, with B. The table gives estimates (from pot tests) of susceptibilities of the ten clones and four controls and of the multiplication rate of the field population on the different clones in plots which were not treated with nematicide.

Variety	*Pot tests. Relative susceptibility (% of controls).* A	E	*Field trial. Multiplication factor.*
8806(25) (H_1)	—	24	2·0
8859(1) (H_1)	—	24	2·3
8906(22)	19	31	2·0
8899(9) (H_1)	—	33	0·7
8911(15) (H_1)	—	48	5·6
8823(8) (H_1)	—	50	6·4
8897(72)	46	58	7·8
8844(10)	37	72	15·6
8911(16) (H_1)	—	73	8·4
8805(4)	39	82	16·4
King Edward	100	100	20·7
Majestic	100	100	16·1
Maris Piper (H_1)	—	100	9·4
Record	100	100	9·0

There is a clear (and encouraging) correlation between the two measures of eelworm resistance. The less-than-expected multiplication on Maris Piper and Record is interesting. The H_1 gene completely masks ex-*vernei* resistance to pathotype A, which cannot then be assessed.

Clone 7495(6), provisionally entered for National List Trials in 1974, was tested under commercial conditions in 1975 by Golden Wonder Crisps Ltd., who reported enthusiastically on its high dry matter content, high tuber yield, excellent crisp colour and low fat absorption.

The programme for the breeding of high dry matter varieties for processing purposes, which was begun in 1970 reached a landmark in 1975 when the nuclei of the surviving clones of the first crosses were tuber-indexed and transferred to Blythbank for the multiplication of virus-free stocks. In contrast to the conventional Tuberosum breeding programme (which remains at Blythbank), it has been the policy to grow and select this material at the

Murrays, where more realistic estimates of dry matter content can be made. However, despite frequent spraying with systemic aphicides, the epidemic of potato virus leaf-roll, which has affected eastern Scotland in the past three years, resulted in a loss through roguing of about 30 per cent of the material in 1975. Losses from this cause were also serious in 1974. New and more rigorous spraying routines are being adopted but, since these cannot be effective against incoming viruliferous aphids, the future of this programme at the Murrays is in some doubt.

Further crosses were made between high dry matter and gangrene-resistant parents to generate another wave of potential processing varieties. Crosses were also made in other groups of material: between virus-resistant parents, between Tuberosum and Neo-Tuberosum clones and between various clones with pathotype non-specific resistance to PCE derived from *S. vernei*.

The development of an artificially stimulated blight epidemic at Blythbank enabled selection for blight resistance to be practised on the younger material there.

The single-plant harvester performed very well at the Murrays and completed the harvest of some fourteen thousand single plants in nine working days. The customary planting of alternating Arran Victory plants between the singles was omitted in part of the area without detriment to the separation of tubers at harvest and with obvious benefit to the performance of the experimental material. We conclude that we may safely dispense with the Arran Victory separators in future.

ARC Project 18: Potato economic genetics

Biometrical genetics of economic characters in potatoes with the objective of defining improved breeding plans.

(Worker: R. J. Killick)

The six-parent half-diallel cross grown during 1974 and described in last year's annual report was scored and analysed. The characters used and the sources of genetical variation were: (*a*) yield—specific combining ability (s.c.a.); (*b*) number of tubers—general combining ability (g.c.a.); (*c*) average weight of tubers—g.c.a. and s.c.a.; (*d*) proportion of cracked tubers—s.c.a.; (*e*) specific gravity—g.c.a.; (*f*) texture of steamed tubers—s.c.a.; (*g*) after-cooking discoloration—s.c.a.; (*h*) maturity—g.c.a. Genetic variation could not be detected for the proportion of diseased tubers. The material was regrown at the Murrays during 1975, with clonal replication, in order to confirm these results. However, leaf-roll infection was so severe that the experiment had to be abandoned.

Tubers from a 2 × 15 North Carolina experiment II crossing scheme

were retained from glasshouse-grown plants for multiplication in 1976. The experiment will be grown in 1977 and should provide further information on the relative importance of general and specific combining abilities in the control of some economically important characters. This will enable decisions on the choice of parents to be made on a more objective basis than has been possible in the past.

ARC Project 19: Potato blight

Mechanisms of field resistance and variability of the pathogen.

(Worker: Jean F. Malcolmson)

Another, and much larger, trial of the effect of time of planting on the expression of field resistance confirmed earlier findings (*Annual Report*, **54**, 26, 1975). Averaged over all 37 clones, size and frequency of lesions on stems and leaves and rate of tuber infection were all higher in older plants. From the potato breeding point of view, it is clear that field resistance scores can only be made in relation to controls planted at the same place and time.

Tests under epidemic conditions in the field, confirming results obtained previously in the laboratory, indicated that field resistance in the haulm is not necessarily associated with resistance in the tubers. Generally, fewer tubers were blighted in clones with resistant haulm (graded 6-9) than in those with susceptible haulm (graded 1-5). However, in unsprayed plots, ten out of thirty-three top-resistant clones had more than 5 per cent of blighted tubers and in another trial of top-resisters, 24 per cent of forty-two clones reached that level of tuber infection.

In the extreme, one clone which maintained the highest top-resistance grading (9) until harvest had 21 per cent of blighted tubers. It is probable that this severe tuber infection came from neighbouring plots with infected foliage and that substantial blocks of this clone would be much less affected in the tubers. The example, however, serves to emphasise the importance of tuber resistance in any clone in which foliage resistance is less than total (but might yet be good enough to obviate the need for spraying).

In the field it was noted that the considerable foliage resistance of Corrie and clone 7683a (12) (a prospective entrant for National List Trials) was matched by good tuber resistance.

Virus-free stocks of the international field resistance standards (Alpha, Bintje, Eigenheimer, Majestic, Record, Libertas and Pimpernel) and a few R-gene differentials, were established, ready for multiplication. In glasshouse tests with the standards, it was noted that they differed more in rate of deterioration due to blight than in final resistance grading.

Further information on somatic recombination in the fungus was obtained.

Mixtures of single isolates of four races of the fungus were inoculated on tubers and re-isolates were determined as to specificity. Two trials, using the same isolates on leaves and differing only as to temperature of incubation, were also carried out. In one leaf trial the expected recombinant specificities emerged; in the other leaf trial and in the tuber experiment, race O predominated even though absent from the original mixture. Evidently, loss of specificity is possible as well as recombination.

ARC Project 20: Commonwealth Potato Collection

Introduction, quarantine, maintenance and distribution of the Collection.

(Worker: D. R. Glendinning)

With certain provisos concerning lines which were dealt with before the test-procedure was fully developed, screening of the Commonwealth Potato Collection for Potato Spindle Tuber (PSTV) is now complete and distribution is free of restrictions. In all, there have been four positive findings in about 1,200 seed-lines, in addition to the original two in imported clones. Introduction of new material was suspended during the screening programme; how soon this can be recommenced is uncertain as the quarantine authorities are extensively involved in testing other (non-Collection) material.

A computer program has been written to facilitate Collection maintenance procedures.

An account of the strategy of maintenance and distribution of the Collection from its establishment in 1939 has been prepared for a conference in Peru in March 1976. Although distribution in recent years has been impeded by PSTV considerations, since the Collection came to Scotland in 1967 approximately 2,700 seed-samples have been sent out, about 850 of them in Britain and the remainder to sixteen countries. We seek to meet all reasonable requests. We believe ours to be the only Collection that has been fully screened for PSTV and thus the only one that can be freely drawn upon by countries wishing to exclude that disease.

ARC Project 21: South American tetraploids

Studies and exploitation of the Andigena Group (Neo-Tuberosum) as material for potato breeding.

(Worker: D. R. Glendinning)

It now seems very unlikely that potato spindle-tuber virus (PSTV) occurs in the main Neo-Tuberosum population. Following last year's screening in which eight hundred plants involved in eight satisfactory tests revealed no

PSTV, two other tests being spoiled by virus Y infection, approximately 1,200 plants were screened in 1975 and again no PSTV was found. These plants were the parents of seed to be sown in 1976, while those tested in 1974 were parents of the 1975 seedlings. Thus the only remaining uncertainty is that associated with the spoiled tests in 1974.

Establishment of the revised programme outlined in the 1972-73 report has been delayed by the PSTV problem and the leafroll epidemic at the Murrays mentioned last year. Together they have prevented use of Blythbank for exposure of Neo-Tuberosum to blight, have impeded assessment of clones as potential parents for purposive interbreeding or for further exploration of the range of variability of Neo-Tuberosum, and have caused the loss of many clones before much could be found out about them. Crossing of Neo-Tuberosum onto PSTV-cleared Andigena from the Commonwealth Potato Collection has proceeded but the resultant seed from the 1973 and 1974 crosses has been stored pending clearance of the Neo-Tuberosum pollen-parents for PSTV. The 1975 crosses utilised pollen from screened Neo-Tuberosum material.

Twenty-three Neo-Tuberosum clones individually tested for PSTV in 1974 to permit their use in the Tuberosum breeding programme (ARC Project 16) were inter-pollinated and the resultant progenies were raised in a screened polythene greenhouse in 1975 in preparation for planting at Blythbank in 1976. These will be exposed to blight and clones selected from them can subsequently be maintained there in relatively leafroll-free conditions while under assessment at the Murrays.

Eleven Neo-Tuberosum parents were used in the commercial breeding programme in 1975. As usual they were chosen primarily on the basis of the attractiveness of their tubers but tests showed one of them to have comprehensive resistance to virus Y and an exceptionally high specific gravity. There was also evidence, from a planting at Archerfield, that a number of them were exceptionally scab-resistant.

ARC Project 22: Dihaploids and diploids

Studies of the potential of South American diploids and Tuberosum-dihaploids for potato breeding.

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

The production of dihaploid potatoes with a high level of " field " resistance to late blight is meeting with some success: sixty-six dihaploids were obtained from last season's pollinations of material supplied by Dr Malcolmson and, of these, twenty-six proved very resistant in leaflet tests. Tests for resistance of tubers to blight infection require that dihaploid clones be multiplied in the field; of only four clones so far tested, two possessed resistance. Difficulties have

been encountered in the production of dihaploids from eelworm-resistant stocks based on *S. vernei*. Both flowering and seed-set were poor in many of the potential tetraploid parents and only eight dihaploids were obtained. The 1975 crosses promise a greater output of dihaploids; through judicious choice of parents based on the previous year's experience, seed-yield has been more than doubled. An improved method of screening for eelworm resistance is being developed so that relatively less vigorous, yet potentially valuable, dihaploids can be adequately tested.

The next stage in utilisation of disease resistant dihaploids requires their chromosome number to be doubled, thus returning to the tetraploid level. Trials were made with five female-fertile dihaploid clones, using Dionne's colchicine method to bring about vegetative doubling. After treatment, cuttings were obtained from three of the dihaploids and all but two out of thirty-three plants established gave counts of forty-eight chromosomes in root tip squashes. Further multiplication and screening will, however, be needed to eliminate ploidy chimaeras (plants with tissues containing a mixture of chromosome numbers).

The testing of the Phureja/Stenotomum diploid mass-selection populations to clear them of any suspicion of PSTV infection is now a matter of priority. In 1975 the two seed-producing sub-populations, comprising 1,170 tuber grown plants, were screened in the field and found free of infection. Bulk seed samples harvested from these will be raised in an insect-proof polythene house next season ready for transfer to Blythbank. Since plants with PVY infection were unsuitable for PSTV testing and had to be eliminated before PSTV samples were collected, an opportunity was taken to check the efficiency of visual roguing for PVY against laboratory inoculation tests. Despite the unusual phenotypes of many diploid potatoes, the results showed that visual roguing had been, if anything, too stringent.

Encouraging results have been obtained with both gangrene and scab resistance trials of material at the diploid level. An improved gangrene test procedure was used to investigate thirteen élite clones: three were rated resistant, six intermediate and four susceptible, paralleling the variation in a group of Tuberosum cultivars used as controls. Of twelve élite clones submitted for scab trials, all but one Phureja were rated as equal, or superior, to the best Tuberosum controls. These results tend to confirm the impression of high resistance gained from smaller trials in 1974.

Investigation of progenies from crosses between tetraploid cultivars and diploid élite clones (as pollen parents) has shown that the production of tetraploid hybrids is influenced both by choice of seed and pollen parents and also by environmental conditions during the crossing period. The cultivars Maris Piper and Pentland Dell are particularly suitable for 4x hybrid production from tetraploid × diploid crosses.

ARC Project 23: Aspects of potato cyst eelworm biology

Host-parasite relationships in potatoes carrying *vernei* field resistance.

(Worker: J. M. S. Forrest)

The aim of this project is to determine how resistance derived from *S. vernei* operates. It is known that the clones of *S. vernei* used as parents have a less active root diffusate; fewer larvae penetrate the roots and their subsequent development is poor. There is thus a high level of non-pathotype-specific resistance in *S. vernei* itself. Tuberosum clones carrying *vernei* resistance vary widely in the degree of resistance they show; the problem is to determine which component or components are responsible for this variation.

From September onwards the hatching activity of rooted sprouts of control varieties and some ex-*vernei* clones of varying resistance was tested on *H. pallida*; some of the latter had much lower hatching activities than the controls but it remains to be seen whether this pattern will persist through the whole season.

ARC Project 24: Potato virus resistances

Resistances to viruses (X, Y, leafroll and PMTV and TRV spraings) in the breeding programme.

(Workers: T. M. W. Davidson, Ruth M. Solomon)

Two sister clones, G5691(7) and G5691(9), the former with particularly good tuber shape and quality, the latter with good crisping quality and both resistant to viruses X and Y, were included in Regional Trials in 1975. Both suffered some leafroll infection (from the Murrays, 1974) and will be trialled again in 1976, using Blythbank seed.

Appreciation of the economic value of leafroll resistance is, it seems, becoming more widespread. Under the sponsorship of the International Potato Centre in Peru, breeding for resistance is being promoted in South America and elsewhere to allow potatoes to be grown in areas where the disease limits cultivation. On request from the Centre, tuber samples with leafroll resistance were sent to Peru, Chile, Mexico and to two places in Brazil. True seed from resistant parents was supplied on request to Peru, Israel and the USA (Cornell).

Tuber samples of clones exposed to natural infection with leafroll virus (and virus Y) at Long Ashton in 1974 were grown at Pentlandfield and scored for infection. The control varieties Pentland Crown and Majestic had become 12 per cent and 50 per cent infected respectively. This showed that infection had been low at Long Ashton, too low to do more than indicate the presence

of clones with resistance at least as good as that of Pentland Crown. Of 250 lines from the virus-resistance programme and 100 from the main breeding programme, 126 and eight respectively were in this category. The 1975 infection plot was also grown at Long Ashton; due to rain at planting followed by drought, growth was not good but the aphid vector was more abundant than in 1974 so a better infection rate may be expected.

Twenty thousand seedlings derived from PSTV-tested parents were grown on after surviving the routine screening for resistance to viruses X and Y. Seventy advanced clones were screened for resistance to viruses X, A, B, C and Y and others for X and Y only (projects 16 and 24). A large programme of indexing was undertaken to ensure the health of material being transferred from the Murrays to Blythbank.

A trial was grown on infested soil to estimate the relative resistances of about 100 advanced clones to mop top virus. Although there was little evidence of corky scab (*Spongospora subterranea*), the vector of the disease, a very good level of infection was achieved. Arran Pilot controls were evenly infected, showing an average of 50 per cent spraing. Only two of the clones tested were as susceptible as the control and fifteen had no spraing. An uncut sample from each has been kept to observe the incidence of haulm symptoms in 1976.

A small trial on land infected with tobacco rattle virus encountered severe drought and very little spraing was evident in the susceptible controls. Ideally, irrigation should be available to provide good feeding conditions for the eelworm vector. A suitable site has been found for the 1976 trial. Breeding from clones of proven resistance to TRV spraing was initiated in 1972 and some promising material is in the early stages of selection.

ARC Project 25: Potato cyst eelworm resistance

Resistance to PCE in breeding programme, especially field resistance from *vernei*.

(Worker: J. M. S. Forrest)

Between April and September 1975, 326 clones were tested for resistance to pathotype A of *H. rostochiensis* and 239 of these also against pathotype E of *H. pallida*. The plants were grown in clay pots containing infested soil at a concentration of 40 eggs/g. The pots were sunk in sand beds and watered intermittently from above and below to produce the strong root systems essential for good eelworm tests. Plants were scored by counting the numbers of cysts visible on the root ball through a perforated copper mask. Six to eight control plants of Pentland Crown were included on each bench. Three

replicates per clone were used for detecting H_1 (Andigena) resistance. The youngest and most advanced ex-*vernei* clones were replicated four and six times respectively in tests against both A and E.

Interest centred chiefly on the resistance of the ex-*vernei* material to pathotype E. Cyst numbers among clones at an earlier stage of selection varied from 4 per cent to 100 per cent of those on Pentland Crown. The most resistant plants were in the (F_3 *vernei* × Tuberosum) × Tuberosum group where eighteen clones lay in the 4 per cent to 20 per cent range. The most advanced material was not so resistant (24 per cent to 100 per cent) but, even so, promises markedly to reduce the rate of eelworm multiplication (see Project 16).

It has been the practice at this Station to grow plants in clay pots buried in sand in order to achieve a more natural root growth and pattern of cyst development, and to estimate cyst frequency by counting those on the surface of the root ball. Some workers believe that this method overestimates resistance but have used plastic pots which are thought, at this Station, to be unsatisfactory for the purpose. A trial of clay *versus* plastic pots will be made this year. Meanwhile it may be noted that our test is highly repeatable. Twenty-five clones were scored by three different investigators over the last four years. For each year the clones were ranked according to resistance and a comparison of the rankings in different years was made, using Spearman's rank correlation coefficient. In every comparison there was a highly significant correlation ($p < 0{\cdot}001$).

ARC Project 26: Potato blight resistance

Resistance to blight in breeding programme.

(Workers: Jean F. Malcolmson, Helen E. Stewart)

A satisfactory level of resistance to blight, confirming laboratory tests, was noted in twenty-nine advanced selections (seventh year of selection and later) grown under epidemic blight conditions at Blythbank. At the stage when Record was graded 6 for resistance, fourteen of the selections were graded 6 or better. One month later, when the commercial controls (Record, Pentland Crown, Pentland Hawk, Maris Piper and Maris Peer) had deteriorated to grade 1, six of the clones were graded 6 and three were graded 5, 4 and 3 respectively. At that time cv. Corrie was also graded 6.

In laboratory tests of the foliage of selections in the third, fourth and fifth years of selection, 33 per cent, 24 per cent and 8 per cent respectively were graded 6 or better. In tests of the tubers of these clones 21 per cent had resistance superior to that of Pentland Crown. Similar resistance was noted in

nine out of thirty-one clones from the virus resistance breeding programme and four of eighteen dihaploid and diploid clones. Twenty-six dihaploids derived from resistant tetraploid parents all showed a high level of resistance.

In place of leaflet tests (not now possible because of PSTV restrictions), samples of seedlings from the families later to be raised from true seed were screened and discarded. Considerable resistance was evident in families derived from recently developed blight resistant parents and from Neo-Tuberosum parents × established resisters. The results were used to guide selection of families for the main sowing.

ARC 27: Potato tuber disease resistance

Resistance to tuber diseases (wart, scab, gangrene skin spot, blackleg) in breeding programme.

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

The installation of eight tuber storage cabinets with accurate control of temperature and relative humidity has facilitated the routine screening programme this year and should facilitate experiments on optimum storage conditions for the development of tuber-borne diseases. The need for these facilities is underlined by the failure of the test for skin spot (*Oospora pustulans*) in 1974/75, due to lack of adequate control of the moisture level of the tubers after inoculation.

The test plots at Archerfield continued in use as a stringent test for resistance to common scab, but poor yields (due to drought) and within-plot variation resulted in some under-estimation of disease intensity. However, scab scores on four advanced seedlings in the regional trial at Gleadthorpe EHF agreed well with assessments from Archerfield in a previous year. Attempts to develop a reliable greenhouse test for scab resistance continue.

The standard cornmeal-sand method of inoculation was used for routine tests of 895 clones for resistance to gangrene (*Phoma exigua* var. *foveata*). For ease of comparison between years, scores have been expressed as an index relating to the mean score of twelve standard reference clones covering a wide range of reaction. On this scale Roslin Castle (resistant) scored 2 and Majestic and Dunbar Standard (susceptible) 15 and 18 respectively. Approximately 33 per cent of M2 clones, 50 per cent of M3 and M4 selections and 82 per cent of high specific gravity (HSG) selections had an index of 5 or less. The latter material derives mainly from crosses with Pentland Ivory and Roslin Castle, both of which are themselves resistant.

Filter paper discs soaked in a suitable nutrient solution were stuck to cellulose tape and strung above-ground on canes in potato plots; the discs

recovered the fungus throughout September and October, with a peak in mid-October. Baits were exposed for seven days. Baits buried in soil close to potato tubers became colonised much less readily. The role played by airborne propagules of the fungus in the development of gangrene is not yet clear.

Chemistry Laboratory

(Workers: M. J. Allison, I. A. Cowe, R. B. W. Williamson)

The routine workload was roughly the same as in previous years. Routine determinations were made of: *in vitro* digestibility (1,890 samples of ryegrasses, Poas and Brassicas); kjeldahl nitrogen (2,650 samples, mainly of barley, the remainder of Brassicas and oats); diastatic power and alpha-amylase (2,600 barley samples); and insoluble carbohydrates (826 samples of barley flour).

Most of the development work has been concerned with establishing techniques for measuring toxic factors in Brassicas. An amino acid derivative, S-methyl-cysteine sulphoxide (SMCO), is converted in the rumen to a substance causing haemolytic anaemia in kale-fed ruminants. Since SMCO has a low isoelectric point, it can be separated from free amino acids by electrophoresis or ion-exchange chromatography. Electrophoretic separation on glass fibre paper was successful in isolating SMCO from the free amino acids but, as with thin layer chromatography, quantifying the results is more difficult. More recently, we have been able to isolate SMCO on short ion-exchange columns, the effluent of which is scanned for ninhydrin-positive material by a method developed by Gosden. This method promises to be comparatively quick (10 minutes per sample) and easily quantified colorimetrically.

Thiocyanates, also present in some Brassicas, cause goitrogenic effects in sheep. They form coloured complexes with potassium nitrate in nitric acid and so can be measured by an automated method. A standard auto-analyser manifold has been adapted for the purpose in such a manner that sample and blank readings are obtained simultaneously, instead of by the sequential monitoring of each sample and its control.

A means of estimating grinding energy (developed by Chenost as a measure of fibrousness in grass) was adapted to measure the electrical energy required to mill barley and oats. The system consists of a Glen Creston microhammer mill wired to a transducer, output being monitored by a chart recorder. Milling energy is thus expressed as a trace of the power used. Results showed that a ranking of barleys in order of milling energy also ranks them in order of

malting quality, so this method promises to be a rapid (70 seconds per sample) means of predicting malting quality. In oats, it was found that milling energy correlates well with husk percentage ($r = +0{\cdot}73$).

Some development work on the identification of low molecular weight tRNA by electrophoresis was also undertaken. Bands from tRNA preparations, varying from 4*s* to 15*s*, were easily separated using toluidine blue as the RNA stain. It has been proposed that electrophoretic separation of viral RNA could serve as a diagnostic test for certain viruses. Potato spindle tuber virus (PSTV), for example, has an RNA of about 10*s* and could thus potentially be identified by the system. Details of the method have been passed to the appropriate authorities concerned with PSTV testing.

Cytology Laboratory

(Worker: Judy A. Fantes)

There has been a consistently heavy demand for routine cytology throughout the year.

Most of the *Brassica* work involved screening the progenies of crosses between *B. napus* and interspecific triploid hybrids (genome constitutions—AAC, ACC). Only 21/770 had thirty-eight chromosomes, the desired number: offspring of similar crosses were examined for high pollen stainability as a possible rapid screening method. Other *Brassica* work included ploidy checks, chromosome counts of plants produced by *in vitro* embryo culture and meiotic studies.

Pollen stainabilities and mitotic counts were completed for the remaining *Poa* hybrids and parents.

In *Solanum*, 104 dihaploids and 126 tetraploid hybrids, both derived from interploidy crosses, were isolated by root tip counts. Many (about 1,200) pollen fertility estimates provided guidance for diploid/dihaploid crossing plans. Chromosome counts were obtained from root-tips of cuttings of colchicine-treated dihaploids.

Statistics and Computing

(Workers: R. J. Killick, Gillian McConnell)

Our computing needs continue to be met by the Edinburgh Regional Computing Centre. Some difficulties were experienced during the year, notably the ERCC computer operators' strike during the summer and the

removal from Edinburgh of the IBM 370/158. The service given by this machine has been replaced by a comparable service from IBM equipment at the University of Newcastle. Statistical advice and analyses have been undertaken for all the crops with which the Station is concerned, although the effort is unevenly distributed. Two significant computer programs were written during the year, one to facilitate the maintenance of the Commonwealth Potato Collection and one to provide an information retrieval system for the potato breeders' data base.

Photography and Illustration

(Worker: Joyce Sutherland)

The volume of work increased during the year and requests were more evenly distributed throughout the various departments.

Routine work included the production of various types of slides (colour, monochrome and diazochrome), colour and monochrome prints, graphs, charts and diagrams for publication and display purposes.

A new portable display system has proved valuable on several occasions to exhibit various aspects of the work, both within and outwith the Station, and has been particularly useful for educational purposes.

Workshops

(Worker: A. E. Hamilton)

The greater part of the workshop effort, as in past years, has been taken up by maintenance of and running repairs to transport, powered machines and other implements. A number of major repairs were also carried out, such as fitting new engines to cereal plot seeders, necessitating modification to the frame and steering of the traction unit.

All agricultural, laboratory and workshop machines were examined and guards were fitted where necessary; similarly, electrical installations in greenhouses were inspected from the safety aspect and are being appropriately upgraded to comply with the recent Safety at Work regulations.

Several of the larger machines for plot work were modified. Thus, the single-plant potato harvester was further modified by adding a hydraulic tipping hopper which can be elevated sufficiently to enable the contents to be tipped conveniently into a trailer, by providing permanent weather protection

for the operators and by making it easier to clean during a wet harvest. The elevator of the Garvie plot combine was modified to improve the feed to the drum and the hydraulics were altered to give increased road speed. The swede harvester was fitted with a stronger collecting box and a lever system to facilitate weighing.

A great many lesser jobs on buildings and equipment were also done, for example: fabrication and erection of storage facilities for steel, wood and oil; modification of all tractors and trailers to make them interchangeable; modification of greenhouse ventilator controls; and construction of new and less noisy cereal hummlers, manifold boxes for auto-analysers and electrophoresis tray supports.

The Murrays

(Farm Superintendent: G. R. White)

The year was marked by a cold wet spring and a hot dry summer, the month of June being particularly warm. September was extremely wet but the remaining months were comparatively dry. Total rainfall was 601 mm compared with 600 mm in 1974, 434 mm in 1973 and 448 mm in 1972.

Seed bed preparations for cereals and potatoes were straightforward but cultivations for Brassicas were difficult. After incorporating TCA for couch control, the ground never dried out properly and subsequent cultivations did little to produce a tilth. Another 15·2 ha (40 a) treated with TCA in June, when the ground was drier, gave a good tilth and the stubble turnips sown in it grew well.

The area of cereals was 43·3 ha (107 a). This was made up of 12·5 ha (31 a) of winter wheat, 20·2 ha (50 a) of spring barley and 11·3 ha (28 a) of cereal plots. All farm cereals received 345 kg/ha (2·75 cwt/a) of grain fertiliser (23·0-11·5-10·0). The barley seed had been treated with Milstem. On the whole, the barley did well; there was little lodging and, apart from Cottage field where Golden Promise yielded 3893 kg/ha (31 cwt/a), yields of both Golden Promise and Midas averaged over 5650 kg/ha (45 cwt/a). Following a difficult autumn, winter wheat yields were disappointing: Atou yielded 5650 kg/ha (45 cwt/a) and Cappelle Desprez, which shed badly before harvest, 3767 kg/ha (30 cwt/a). Practically all the barley, which was too high in nitrogen for malting, went for feed.

Potatoes occupied 12·1 ha (30 a), of which 1 ha was an early potato trial and

selection plot planted in mid-March; the remainder was planted at the end of April. Eptam, to control couch, and potato fertiliser (15-15-19) at the rate of 816 kg/ha (6·5 cwt/a) were incorporated in the soil before ridging. Granular Thimet was applied in the drills before covering the tubers. Sencorex was used as a pre-emergence herbicide and the crop was sprayed with systemic aphicide at two-week intervals from the end of June until lifting began in mid-September. Fungicides were incorporated in the spray from the end of July.

In view of the increase in aphid-borne viruses in potatoes over the past few years, an area of Pentland Dell was sprayed weekly with aphicide. Seed was kept from areas that had been sprayed weekly and fortnightly and will be planted in 1976 to assess the benefit, if any, of more frequent spraying in reducing infection.

The potatoes grew well and yields were good, though apparently not as high as in 1974.

About 6 ha (15 a) were sown to Brassica trials. The field was treated with TCA for couch control and Treflan was applied pre-sowing for general weed control. Turnip fertiliser (12-24-12) was applied at the rate of 1256 kg/ha (10 cwt/a) for swedes, which were sown on the ridge. The other Brassica plots received 880 kg/ha (7 cwt/a) potato fertiliser (15-15-19). The condition of the ground, following a cold wet spring, was such that it proved impossible to produce a good tilth for the swedes and kales and the swedes, in particular, suffered as a result. Later sown plots went into a better surface tilth but compaction of the ground during the cultivations resulted in the formation of a pan which restricted growth during the late summer and autumn. Land (16·2 ha (40 a)) ploughed out of grass in 1974 was treated with TCA and stubble turnips were sown. These were let for grazing and ploughed in December in preparation for potatoes in 1976.

Twenty-three hectares (57 a) of grass were let for grazing by sheep and cattle. Two crops of hay were taken from another 12·1 ha (30 a) sown after potatoes to reduce fertility in preparation for cereals trials.

In an attempt to avoid the difficulties associated with the use of TCA, before sowing Brassicas, the wheat stubble was sprayed with Roundup before ploughing for Brassicas in 1976. It is also hoped to control potato ground-keepers with this chemical. Groundkeeping potatoes, many of them pre-dating our occupancy, pose a considerable problem on the farm.

Winter wheat (11·3 ha (28 a)) was sown in October; it is mainly Atou, but 2·4 ha (6 a) of Maris Fundin is also being tried.

The fencing programme was completed by the erection of fences separating two ex-rotation areas from the main fields. Ten fields, averaging a little less than 12 ha (30 a) each, are now defined and several new field names were adopted.

2. SUMMARY OF REPORT

1. *Barley genetics*

Objective: to provide essential background information on barley breeding methods and systematics for subsequent use in breeding programme.

Biometrical analyses of various kinds continue to provide useful guidance for breeding, in selecting parents and indicating where progress may be expected. Collection records are being computerised.

2. *Barley biochemistry*

Objective: to gain essential understanding of starch-breaking enzymes in barley malt in support of programme to breed barleys for whisky manufacture.

Studies of high diastase mutants progress satisfactorily though the very highest levels of activity have not yet been achieved by this means. Exceptionally high activities have been produced by combining complementary enzymes from different genetic sources and this approach seems promising.

3. *Barley breeding*

Objective: to breed spring barley varieties for Scotland with specific objectives: feed and barleys chemically specialised for whisky manufacture and for brewing.

The breeding programme goes well (though some promising material had to be discarded for disease susceptibility) and another winter generation was grown in New Zealand. Disease resistance and malting quality tests were extended and refined. A composite cross of barleys tolerant of acid soil was started.

4. *Oat breeding*

Objective: to breed spring oats for Scotland, including, as secondary objectives, resistance to oat-stem eelworm and tolerance of marginal environments.

The three oats in trials (provisional names: Arkle, Leven, Etive) performed very well. Eight more lines (including three eelworm resisters) will enter final Station trials in 1976 and there is much promising material coming on. Natural crossing in composites was 2·4–4·0 per cent (higher than expected).

5. *Hybrid swedes*

Objective: to take practical advantage of known hybrid vigour in the crop by breeding hybrid swede varieties.

Yield heterosis was again demonstrated but it is proving difficult to exceed Bangholm Ruta, a recent and very high yielding conventional cultivar.

6. *Swede breeding*

Objective: to breed by conventional methods new swede varieties which shall replace Pentland Harvester for mechanised cultivation.

Selection within an established variety (Scotia) is proving surprisingly effective. Some attention was turned to diseases and resistance to both mildew and clubroot was detected. Resistance to the latter disease is being introduced to swedes by backcrossing from turnips.

8. *Kale improvement*

Objective: to test theoretical ideas that kale improvement should be expedited by using unconventional parents and/or crossing patterns.

The very high yield potential of genetically widely based kales was again confirmed and selections will be tried on a larger scale in 1976. Attention is being paid to the content of chemicals known to be toxic to stock.

9. *Brassica wide crosses*

Objective: to test the idea that nutritious and high yielding substitutes for rape can be made from crosses between different *Brassica* species.

The problems of crossing *B. oleracea* and *B. campestris* to make artificial *B. napus* have been essentially solved. This will widen the genetic base of swede-rape breeding and facilitate the introduction of desired characters from the parent species. Two leafy, tetraploid *campestris* varieties, Appin and (provisionally) Ballater, by-products of this work, promise very well in place of stubble turnips for late sowing. Incompatibility studies in relation to the production of rape-turnip F_1 hybrids progress.

10. *Raphanobrassica*

Objective: to test the idea that polyploid hybrids between the different genera *Raphanus* (radish) and *Brassica* can be made into a new forage species having the field characteristics of rape but with clubroot resistance.

Seed fertility improved and trials (the first possible) at four sites gave dramatic results. *Raphanobrassica* far outyielded rape controls at early sowing and was palatable to sheep. At later sowing it did less well than stubble turnip types so seems to be a competitor with rape. Resistance to mildew and clubroot was confirmed. Radishes suitable for incorporation in new *Raphanobrassica* stocks are being developed. Clubroot race identification studies progressed well and useful sources of resistance were identified.

12. *Winter kill in ryegrass*

Objective: to develop techniques for selection against winter-kill susceptibility in ryegrass.

Joint work on winter kill with the other two plant breeding institutes was completed. The remaining work is devoted to Italian ryegrasses and a winter-resistant variety is in prospect.

13. *Cocksfoot breeding*

Objective: to breed a nutritious and high yielding derivative of Scotia cocksfoot.

Clonal polycross seed, the basis of a variety, with high digestibility, should be available in 1976.

14. *Poa breeding*

Objective: to breed interspecific hybrids of the native grass, *Poa pratensis*, as hardy, perennial, rhizomatous grasses for the hills.

Many hybrid lines give signs of good yields and some at least are true breeding (apomictic). Attention is being given to problems of establishment.

16. *Potato breeding*

Objective: to breed new potato varieties (early and maincrop) for ware and processing (crisps, chips, dehydration, canning).

PSTV problems were again restrictive but breeding material is being progressively cleared and infections were again confirmed as being very rare. Pentland Squire entered the Spanish National List and Pentland Javelin was recommended by the NIAB. Some very promising new clones are in advanced trials: a first-early, three eelworm-resistant maincrops and an outstandingly good crisping variety. A trial in collaboration with ADAS confirmed that *vernei* resistance to PCE is associated with much reduced multiplication of the nematode.

18. *Potato economic genetics*

Objective: to define improved breeding plans by study of genetic control of economic characters.

One biometrical experiment was completed and another one set up. Analysis of the former showed that both general and specific combining ability effects occurred, which effect depending upon which one of the eight economic characters that was scored. This indicates that family performance can sometimes be predicted (*e.g.*, for maturity and specific gravity), sometimes not (*e.g.*, yield, and table quality).

19. *Potato blight*

Objective: to gain improved understanding of the inter-relations of potatoes and the blight fungus, including study of the mechanism of field resistance and variability in the fungus.

Methods of assessment, in the field, of field resistance in foliage and tubers were further investigated. Foliage and tuber reactions were but little related and both must be assessed separately. Further results—striking but not yet interpretable—were obtained on somatic recombination in the fungus.

20. *Commonwealth potato collection*

Objective: to augment, maintain, classify and distribute the Commonwealth Potato Collection for the use of potato breeders.

The Collection was cleared of PSTV and distribution is now possible again. In all, there were six infections (rate 0·3 per cent in seed lines).

21. *South American tetraploid potatoes*

Objective: to develop populations of South American tetraploid potatoes for use in breeding.

The Neo-Tuberosum material has been practically cleared of PSTV and selected clones (with some potentially very useful qualities) flow each year into the general breeding programme.

22. *Dihaploid and diploid potatoes*

Objective: to develop diploid potatoes (having half the normal chromosome number) for use in breeding.

Efforts to develop disease resistances in diploids and dihaploids progressed well. Methods of using these materials at the tetraploid (*i.e.*, ordinary potato breeding) level are being investigated.

23. *Potato cyst eelworm biology*

Objective: to investigate host parasite relationships in potatoes carrying *vernei* field resistance.

Work on this project was resumed with the initiation of a study of the effect of *vernei* field resistance on hatching of the nematode; it was inhibited.

24. *Potato virus resistances*

Objective: to develop resistance to viruses (X, Y, leafroll, spraing) in the breeding programme.

Routine screening of a large amount of material for PVY and PLRV continued successfully and work on the spraing viruses was resumed. Two promising clones entered regional trials.

25. *Potato cyst eelworm resistance*

Objective: to develop resistance to eelworms in potato breeding programme.

Routine screening of material with *vernei* field resistance continued. High levels of resistance are emerging but the best resisters are not yet satisfactory in other characters.

26. *Potato blight resistance*

Objective: to incorporate resistance to blight in breeding programme.

Screening, in glasshouse and in epidemic conditions in the field, continued satisfactorily. A great deal of resistance from a variety of sources is now in hand.

27. *Potato tuber disease resistance*

Objective: to incorporate resistance to tuber diseases (wart, scab, gangrene, skin spot, blackleg) in breeding programme.

Work was facilitated by the entry into use of eight controlled environment chambers for tuber storage. Much gangrene resistance was apparent, especially in the high specific gravity breeding material.

28. *Exploration unit*

Objective: to explore crops which are not otherwise being studied at the SPBS but which might have breeding potential in Scotland.

Composite crosses of wheat and beans continued and trials of beans and oilseed rape were carried out. A collection of 1,400 white clovers was observed and eighty selections are being tried for early growth. Three years of maize trials, now concluded, have given no evidence that available varieties are adapted in Scotland.

3. THE LAST DECADE

N. W. Simmonds

General

Ten years ago the SPBS was a very small station indeed and poorly equipped for its tasks. Now, thanks to sustained support by the Department of Agriculture and Fisheries for Scotland over the decade, its situation is immeasurably improved. The numbers of scientists and technical staff have roughly doubled and of assistants quintupled; so the assistant/scientist ratio has risen from about 0·4 to 1·0. In parallel, expenditure has roughly trebled in real terms (though the station remains small in absolute size). The increased expenditure per scientist reflects vastly improved laboratories, glasshouses, equipment of all kinds and specialised resources such as workshops, photographic laboratory and modest controlled environment facilities.

It is not only in technical resources that the position has improved. At the time of writing (March 1976) we are just (as noted elsewhere in the report) putting to use the new common room and " general purpose room ". They will greatly facilitate contacts, formal and informal, among staff and will also, one hopes, help to enhance the already keen interest taken by members of the Board in the work of the station.

Ten years ago it was evident that the forty-odd acres of very poor land at Pentlandfield were too few and anyway quite unsuitable for serious plant breeding (even though later much improved in quality by the ashing programme of the late 1960s). The acquisition, by the DAFS, of the Murrays for lease to the SPBS from the 1971 season onwards was a major step forward. The farm, however, though the land is good, was in poor shape, with decayed buildings, fences and trees and much wrack. Now we have new cottages and sheds, fences have been renewed or resited and a rotation appropriate to the research programme devised. There are problems still, ranging from local drainage troubles and potato groundkeepers to leafroll and bad luck with weather. Also, distance from Pentlandfield (though it could hardly have been less) is a diseconomy. But improvement is steady, if unspectacular, and the Murrays has now nearly replaced Pentlandfield as a site for all the more important plot work.

Concurrently with the above developments there has been a substantial (and very necessary) extension of trials work off the Station. Ten years ago, there were two oat plots in the north, and an oats and barley plot at Dunbar. In 1975 there were seven cereals trials sites widely spread over Scotland,

brassicas in three sites in Scotland and northern England and potatoes in seven sites in ware areas of England and Wales, as well as several in Scotland. To speed the barley work, an extra generation was taken in New Zealand in 1975-76. In addition, collaborative trials work with other institutes (especially the other plant breeding institutes) has increased, a highly desirable trend which will no doubt progress. All in all this means that, not only has the flow of breeding material greatly increased, but it is also being far more thoroughly tested.

The programme

The time scale of plant breeding is measured in decades rather than years and is, unfortunately, tending to increase, as a result of statutory demands. This means that work initiated in the last decade can be, at best, approaching fruition now. In this section it will emerge that most of the work of the Station is in exactly this position: recently initiated, therefore yet to be fully realised. The agricultural world tends to think of the SPBS as the place that bred Craigs Royal, Pentland Crown and Pentland Dell (and some promising successors). Crown and Dell are indeed the Station's leading achievement to date but, nowadays, potatoes are less than half the work of the Station and a substantial part of the potato programme itself is new. Pentlandfield is far from being what I once heard it described as: " yon tattie place ".

Potatoes. Ten years ago there was a well established potato programme with widely acknowledged expertise in breeding for resistance to viruses and blight. A decade later, the throughput of seedlings has roughly doubled, new objectives have been added and work begun about that time is approaching fruition.

Of the new objectives, processing properties and resistance to tuber diseases are perhaps the most important in the short term. On the processing side, the prime need is for high-specific-gravity, low-sugar varieties suitable for crisps and chips. The use of the Murrays made possible the HSG programme (*Annual Report*, **51**, 7, 1972) and will ensure a continued flow of likely clones. Meanwhile, we record elsewhere in this *Report* (see also **54**, 25, 1975) the emergence of outstanding crisping quality. As to resistance to tuber diseases, many varieties (including some of ours) have failed for want of it. The controlled environment chambers that have recently come into use in the new east wing will greatly facilitate testing.

Two aspects of potato breeding initiated rather more than ten years ago are now nearing first fruition: *vernei* resistance to eelworm and field-resistance to blight (see this *Report*). Both are concerned with race-non-specific

(" durable ") resistance to disease and both present formidable problems of combining the resistance with good characters in other respects. Both programmes are now producing materials at or near trials level and some useful varieties seem certain to emerge in time. The JCO attaches particular importance to nematode control and both resistances will be of very substantial economic value.

In the longer term, two other jobs started in the decade are likely to be very important. One is the application of biometrical genetic principles to potato breeding plans, with resultant economy of operation; the other stems from the South American primitive cultivars contained in the Commonwealth Potato Collection. Briefly, the problem is how to use this tremendous store of variability to widen the base of potato improvement. The approach has been to " recreate " the north temperate potatoes starting from South American materials (see *Annual Report*, **48**, 18, 1969). It was pioneered at the JII and SPBS and the products of the first cycle of crosses into the breeding programme are just emerging to the trials stage. Hereafter there will be a continuous flow. The results are yet incalculable but a sober prediction would be of higher yields and a great array of quality and disease resistance characteristics for the breeders to work on. There is a similar programme in the USA (based originally on our example) and some impact on potato improvement seems fairly sure.

Cereals. Oat breeding has a long history at the SPBS, until relatively recently directed towards the needs of the north and west. However, since the war, the crop has largely been displaced by barley or grass and oats came to be thought of mainly as an alternative cereal for the lowlands. Accordingly, the SPBS breeding was, ten years ago, aimed at a new objective—lowland oats—with results that are just becoming apparent. The three very promising varieties now in official trials (this *Report*) are the first products.

Barley breeding at the SPBS is very much the product of the last decade. The work has excellent promise but is too young yet to have produced varieties. From the start we recognised that (unlike the situation in many other crops) English and Scottish varietal needs are different; not only is there an ecological difference but malting for whisky production makes special demands. So Scottish barley needs to be bred in Scotland, in the appropriate environment and in touch with the maltsters who will use some of it. Both feeding and malting barleys are in prospect in the next few years, their emergence hastened by the New Zealand winter growing mentioned elsewhere in this report. Feeding and malting objectives may not be as different as they might seem because there is a fair prospect of enhanced protein content and quality in high diastase barleys (*Annual Report*, **54**, 10, 1975): these are primarily designed to displace the imported barley which malts the maize

that makes the neutral spirit component of blended whisky. So the Station has a lively barley programme coupled with the essential biochemical expertise (in which it already has a modest international reputation). (For a fuller account of the development of the SPBS barley programme, see *Arable Farming*, March 1976, 25.)

Brassicas. The recent history of these crops has been one of decline. Yet they still form an important part of the Scottish farming scene (both relatively and absolutely more important than in the south) and have truly remarkable biological potential—as the JCO has recently recognised. Swedes and kales produce twice as much digestible dry matter per acre as barley and do so at a time of year when conservation is the only alternative; stubble turnips produce winter feed from land that would otherwise be fallow; rapes have a key place in sheep enterprises.

All this was appreciated at the SPBS ten years ago, together with the fact that the Brassicas offer quite remarkable possibilities for unconventional combinations, wide hybrids and new crops. The programme, then very small, is now substantial and holds outstanding promise: widely based kales with high yield potential, hybrid swedes, turnip-rape hybrids that outyield rape, leafy stubble "turnips", artificial *napus*, *Raphanobrassica*. The last three are, at the moment, making dramatic progress, as described elsewhere in this report. It now seems certain that *Raphanobrassica* will join Triticale (wheat-rye) as another of the very rare examples of new crop species synthesised by purposeful breeding.

Grasses. Ten years ago there was no grass breeding *per se* at Pentlandfield. The genecological studies of the time were replaced by a small breeding effort which is approaching practical issue (see this report) in two new varieties (a winter-resistant Italian ryegrass and a digestible cocksfoot) and, further off and less certain, *Poa* hybrids for the hills.

Prospect

As noted in the introduction to this report, "rationalisation" will probably leave the SPBS working on potatoes, cereals and brassicas, the three areas in which the work is already strongest. All three accord well with JCO and SADC recommendations and the second and third attend to peculiarly Scottish interests (which are not being attended to elsewhere); the potato breeding is, naturally, more UK- than Scottish-orientated but it, too, has unique features, of great economic potential, especially among the disease resistances, which are not being covered by other breeders. In short, the Station's work seems well fitted to the likely needs of the next decade.

Ten years ago, commercial breeding was just starting and increasing competition between commercial and state breeders was predictable. It has, indeed, developed and is most acute for crops with large acreages or expensive seed, namely wheat, barley, ryegrasses and many vegetables. The commercial breeder cannot, in economic reason, concern himself with breeding for ecologically or technologically specialised small acreages (Scottish barleys and brassicas), nor can he reasonably be expected to adopt breeding plans or objectives which would restrict seed sales (*e.g.*, virus-resistant potatoes). Yet specialised varieties and cheap seed are in the interests of agriculture; more generally, society at large will benefit from the coexistence of strong commercial and state sectors. There might be some disagreement with the last statement but, at all events, the SPBS programme tends to be complementary to rather than competitive with commercial breeding; it contains nothing in direct competition with a major British commercial breeding effort.

The SPBS has been shown to be socially " profitable " in cost-benefit terms (see *Annual Report*, **54**, 49, 1975). That analysis, made three years ago, may need revision sooner than one had thought. If so, the analyst will be faced with some pretty problems in counting the benefits of the disease resistant potatoes, the oats, the malting barleys and the new forms of *Brassica* that are emerging from the work of the last decade.

4. *SIXTH SSRPB LECTURE*

THE PROSPECTS FOR ANIMAL BREEDING

J. W. B. King, MA, PhD, FRSE

Director, Animal Breeding Research Organisation, Edinburgh

Predictions of the future are notoriously fallible yet, despite the risks involved, some view of future changes is necessary for the planning of research and particularly for genetical research where the implications are especially long term. Despite prognoses to the contrary, I believe that we can look forward to the continuation of a vigorous and prosperous animal-based industry in Britain and the European Economic Community. I would expect animal production to continue without diminution in value, although perhaps suffering a decrease in volume, at least until the year 2000 and still then to form an integral part of the agricultural scene. If these predictions are wrong, then I would contend that they are likely to be in error only in matters of degree or in timing, in a way that would not negate the provision we should make in planning for the future. While intensive forms of livestock production may come under increasing pressure for food sources, the feasible improvements in efficiency of such enterprises provides them with resilience to resist such changes. For less intensive forms of production, the ability of animals to crop marginal lands and to use the by-products of other crops produces a situation which seems virtually unassailable.

The prospects for the improvement of animal performance by genetic means appear to be good in all species of farm animals. Both poultry and pigs have an established record of improvement which encourages the application of similar methods to cattle and sheep. Although some may suggest that the further improvement of poultry production by mass selection methods has reached a situation of diminishing returns, the evidence for this is rather equivocal. With pigs there are no signs of diminution in the rate of improvement and investment in breeding programmes should continue to provide dividends. If it is recognised that non-ruminants have a continuing place in the agricultural economy and will continue to consume a proportion of the cereal crop, then production costs could be reduced by the likely success of plant breeders in providing improved varieties of cereals with better protein content.

For ruminants the position is rather different between the various species. In dairy cattle the widespread adoption of artificial insemination has made

large-scale breeding methods based on progeny testing a reality. It is doubtful whether these schemes have yet made anything like the possible contribution to future improvement that should be possible with concurrent attention to the meat production possibilities. In many countries the beef industry derives directly and indirectly from dairy cattle and clearer recognition of this relationship should make it possible to make better use of this particular resource. For beef cattle and sheep, genetic improvement is in most cases taking rather faltering steps. There is a desperate need for better definition of selection objectives, for the setting up of defined breeding programmes and the establishment of schemes providing dependable remuneration to those willing to invest in genetic improvement. Much of the marginal land used by sheep and cattle presents climatic problems for animal breeders. Adaptability to cold, or in some countries to heat, are characteristics for which the geneticist can probably hold out predictions of real improvement. Such climatic conditions usually take with them shortages of feed supply and, where any replacement of the natural vegetation is economically viable, it is legitimate to look to the plant breeder to provide improved varieties for such conditions.

Looking further into the future prospects for larger steps forward are certainly enhanced by continued research into methods of biological engineering. In large animals the one real success story has been artificial insemination and, while some other techniques of reproductive physiology promise great things, much work has yet to be done in translating promise into reality. One such technique is ova transplantation in cattle, already utilised for the multiplication of stocks in short supply, but yet to prove itself as a permanent feature of the cattle breeding scene. Further developments, such as sex control and genetic engineering, hold out even more dazzling prospects but the likelihood of success in any one decade must be so low that we would be wise to plan future animal production and the improvement of its efficiency with the proven tools already at our disposal.

5. VARIETIES BRED BY THE STATION

The following varieties are on the market:—

Oats	ALBYN EMPRESS	PENTLAND PROVENDER*
	SHEARER	
Swede	PENTLAND HARVESTER	
Grasses	SCOTIA PERENNIAL RYEGRASS	SCOTIA COCKSFOOT
Potatoes	CRAIGS ALLIANCE	CRAIGS ROYAL
	PENTLAND BEAUTY	PENTLAND CROWN
	PENTLAND DELL	PENTLAND HAWK*
	PENTLAND GLORY*	PENTLAND JAVELIN*
	PENTLAND IVORY*	PENTLAND SQUIRE*
	PENTLAND LUSTRE*	PENTLAND RAVEN*
	PENTLAND METEOR*	ROSLIN CASTLE*
	PENTLAND MARBLE*	CROFT*

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., Newton Hall, Newton, Cambridge.

The commercial development of the two Scotia grasses is also in the hands of the National Seed Development Organisation.

A garden variety of *Brassica oleracea*, PENTLAND BRIG, is a by-product of the Station's Brassica work. It is a horticultural kale used for producing succulent young leafy shoots and is marketed by the NSDO. The leafy stubble-turnips, APPIN and BALLATER, will be marketed by the NSDO in 1977.

The oats, ALBYN EMPRESS and SHEARER, are maintained by Mr R. Miller, Tullochgorum.

6. 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:*

Agricultural Development and Advisory Service (Gleadthorpe, Terrington and Mepal E.H.F.; Rosewarne E.H.S.; Swansea, Derby, Beverley).
Animal Breeding Research Organisation, Edinburgh.
Animal Diseases Research Association, Edinburgh.
Commonwealth Mycological Institute, Kew.
Department of Agriculture and Fisheries for Scotland, Scientific Services, Edinburgh.
Edinburgh Centre of Rural Economy.
Food Research Institute, Norwich.
Forestry Commission, Research Branch, Edinburgh.
Grassland Research Institute, Maidenhead.
Hill Farming Research Organisation, Edinburgh.
Long Ashton Research Station, Long Ashton, Bristol.
National Institute of Agricultural Botany, Cambridge and Cockle Park.
National Seed Development Organisation, Newton, Cambridge.
Plant Breeding Institute, Cambridge.
Plant Pathology Laboratory, Harpenden.
Potato Marketing Board, London.
Poultry Research Centre, Edinburgh.
Rothamsted Experimental Station, Harpenden.
Rowett Research Institute, Aberdeen.
Scottish Horticultural Research Institute, Dundee.
Scottish Institute of Agricultural Engineering, Edinburgh.
Swedish Seed Association, Svalöf.
Welsh Plant Breeding Station, Aberystwyth.

(b) *Universities and Colleges:*

ARC Unit of Statistics, University of Edinburgh.
Edinburgh Regional Computing Centre.
Edinburgh School of Agriculture.
Edinburgh University, Department of Botany.
Heriot-Watt University, Department of Brewing and Biochemistry.

Newcastle upon Tyne University, School of Agriculture.
North of Scotland College of Agriculture, Aberdeen.
Stirling University, Department of Biology.
University College of Wales, Aberystwyth.
West of Scotland Agricultural College, Ayr.

(c) *Industrial Collaborators:*

Hugh Baird and Sons Ltd., Pencaitland, E. Lothian.
Bayer (UK) Ltd., Bury St Edmunds, Suffolk.
Brewing Industry Research Foundation, Redhill, Surrey.
Dalgety Agricultural Research, Timaru, New Zealand.
Golden Wonder Ltd., Corby, Northamptonshire.
Imperial Foods Ltd., Imperial House, London.
Miln Marsters Group, Chester.
Moray Firth Maltings, Inverness.
Pentlands Scotch Whisky Research Ltd., Edinburgh.
Rank, Hovis, McDougal Ltd., Cupar, Fife.
Rothwell Plant Breeders Ltd., Caistor, Lincs.
Scottish Agricultural Industries Ltd., Edinburgh.
Sinclair McGill (Scotland) Ltd., Ayr.
Suttons Seeds Ltd., Reading, Berks.
Twyford Seeds Ltd., Adderbury, Banbury, Oxfordshire.

(d) *Individuals:*

G. H. Cauldwell, The Firs, Friskney, Boston, Lincs.
T. Clark, Over Roxburgh Farm, Roxburgh, Border Region.
J. Dunning, Cold Harbour Farm, Bishop Burton, Beverley, North Humberside.
V. Free, Ayton Castle Estate, Ayton, Berwickshire.
J. S. Graham, Queenstonbank, North Berwick, East Lothian.
J. F. MacBrayne, West Byres, Ormiston, East Lothian.
A. Macintyre, South Ledaig, Argyll.
W. McCrone, Cairnside, Kirkcolm, Stranraer.
G. McClung, Swanston Farm, Edinburgh 10.
R. Miller, Tullochgorum, Inverness-shire.
M. D. Milne, Straiton Farm, Edinburgh 15.
J. Riddell, West Peaston Farm, Ormiston, East Lothian.
R. G. Robinson, Christchurch, New Zealand.
R. Rowe and Sons, Over Ardoch, Braco, Perthshire.
Roxburghe Estates, Roxburgh.
J. Small, Vicarsford, Leuchars, Fife.
G. A. Storrar, Rossie, Auchtermuchty, Fife.
Strathallan Growers, Ruthvenvale Mills, Auchterarder.
R. Trotter, Ormiston Mains, Ormiston, East Lothian.
A. B. Turnbull, Home Farm, Penrice, Glamorgan.
A. R. Wilson, Brightmony, Auldearn, Nairn.

7. STAFF LIST

(In post 31st March 1976)

Director: N. W. Simmonds, Sc.D., A.I.C.T.A., F.R.S.E., F.I.Biol.

FORAGE DEPARTMENT

Head: R. N. H. Whitehouse, M.A.

PSO: M. J. Allison, B.Sc., Ph.D.
F. J. W. England, B.Sc., Ph.D.
I. H. McNaughton, M.A., D.Phil.

SSO: S. Gowers, B.Sc., Ph.D.
A. M. Hayter, B.Sc., Ph.D.
G. R. Mackay, M.Sc.

HSO: J. E. Bradshaw, M.A., M.Sc., Ph.D.
I. M. Chapman, B.Sc.
R. P. Ellis, B.Sc., Ph.D.
Miss I. K. Munro, B.Sc.
Miss C. L. Snell, M.Sc.
Miss C. J. Williamson, B.Sc.

SO: I. A. Cowe, H.N.C.
R. J. Giles, B.Sc.
M. S. Phillips, B.Sc.
J. S. Swanston, B.Sc.
R. B. W. Williamson, H.N.C., M.R.I.C.
A. Young

Photographer: Mrs J. Sutherland

ASO: R. Borzucki, H.N.C.
J. Brown
Miss F. M. Bruce
S. J. Cormack
D. M. Farrer
Miss D. Gemmell
R. S. Hird
K. Ireson
Miss C. M. McParland
D. D. Mathieson
Miss J. E. Middlefell
Miss S. E. Millar, O.N.C
J. McGregor, S.D.A.
R. McHale
Miss D. C. Page
J. A. Scott
Miss D. Watt
Miss E. A. Young
G. R. Young

Experimental Workers: Miss S. A. Byiers
Mrs I. Davidson
G. R. Drabble
Mrs E. Hoy
Mrs M. H. McGuigan
Miss L. Macpherson
Mrs J. Speirs
Mrs M. H. Tulloch
Miss E. Vallery

POTATO DEPARTMENT

Head: J. H. W. Holden, B.Sc., Ph.D.

PSO: T. M. W. Davidson, B.Sc., Ph.D., N.D.A.
J. M. Dunnett, B.Sc., Ph.D., M.I.Biol.
D. R. Glendinning, B.Sc.
Miss J. F. Malcolmson, B.Sc., Ph.D., M.I.Biol.

SSO: C. P. Carroll, M.Sc.
R. J. Killick, B.Sc., Ph.D., M.I.Biol.
A. W. Macarthur, B.Sc.
R. L. Wastie, M.A., Ph.D.

ASO: G. J. Bleazard
D. Fleming
Miss F. A. F. Hadden
Miss S. Mann
Miss F. Mathison
Mrs J. M. Spence
G. E. L. Swann
Mrs A. M. Watt, B.Sc.
Miss L. A. Wilson

HSO:	J. M. S. Forrest, B.Sc., Ph.D. A. A. MacFarlane Miss H. E. Stewart, H.N.C., M.I.Biol. C. J. W. Torrance, H.N.C.	Experimental Workers:	Mrs S. Bell M. Campbell Mrs M. Dugan Mrs E. Wann
SO:	M. J. De Maine, B.Sc. Mrs J. A. Fantes, B.A., M.A. Miss R. M. Ford, B.Sc. Mrs L. E. M. Gray, B.Sc. Mrs G. McConnell, B.Sc. Miss R. M. Solomon, B.A., M.Sc.		

Field and Works

Head:	D. W. Speed, B.Sc.	ASO:	T. G. Archibald
Technical Officer:	A. E. Hamilton	Grieve:	W. Dick
Craftsmen:	G. Stevens W. J. Warburton	Agricultural Workers:	N. Carnochan J. Currie A. Hunter J. Hunter J. Hutchinson H. B. Jamieson A. Knox M. Paolozzi J. Roddie J. Russell R. Simpson G. Wilson W. Wilson
Handyman/Mechanic:	W. L. Beirne		
Handyman:	J. G. Butt		
Groundsman/Driver:	A. E. Cochrane		
Experimental Worker:	Mrs J. Turner		

The Murrays

G. R. White, B.Sc. (Superintendent)
T. Gifford (Tractorman)
D. Ritchie (Tractorman)
R. Tait (Tractorman)

Administration

H. C. M. McLeod (Secretary)
P. P. Bonnington (Assistant Secretary)
Mrs A. Fulcher (Clerical Officer)
Mrs M. M. Inglis (Clerical Officer)
Miss S. McLeod (Clerical Officer)
Miss I. M. Hayes (Director's Personal Secretary)
Mrs J. E. Heritage (Shorthand Typist)
Mrs C. M. Leith (Shorthand Typist)
Mrs J. B. P. Stevenson (Shorthand Typist)
Miss G. Lightbody (Clerical Assistant)

8. BOARD OF DIRECTORS, 1975-76

Trustees

H.M. SECRETARY OF STATE FOR SCOTLAND, Scottish Office, New St Andrew's House, Edinburgh EH1 3TB.
JOHN ARBUCKLE, O.B.E., Barony Cottage, Newburgh, Fife KY14 6HL.
W. ANDREW BIGGAR, O.B.E., M.C., B.Sc., F.R.Ag.S., Magdalene Hall, St Boswells TD6 0EB.
JAMES GRAY, O.B.E., T.D., (James Gray & Co. (Stirling) Ltd.), Stirling FK8 2DQ.
ROBERT L. SCARLETT, C.B.E., C.D.A., S.H.M., V.M.H., Sweethope, Musselburgh.

Chairman of Directors

JOHN ARBUCKLE, O.B.E., Barony Cottage, Newburgh, Fife KY14 6HL.

Vice-Chairman

JAMES GRAY, O.B.E., T.D., (James Gray & Co. (Stirling) Ltd.), Stirling FK8 2DQ.

Ordinary Directors

1973

JOHN ARBUCKLE, O.B.E., Barony Cottage, Newburgh, Fife KY14 6HL.
GEORGE CLAPPERTON, Sheriffhall Mains, Dalkeith EH22 1RX.
A. PATTULLO, M.C., J.P., Littleton of Airlie, Kirriemuir, Angus.
JAMES M. ROY, (Gordon Innes Ltd.), 69 Bogie Street, Huntly, Aberdeenshire.
E. F. SHERRIFF, (Sherriff & Sons Ltd.), The Mill, Great North Road, Hatfield, Herts.
W. STEVEN, The Brax Farm, by Arbroath, Angus.

1974

J. LESLIE DAWSON, B.Sc., (S.A.I. Ltd.), West Mains of Ingliston, Newbridge, Midlothian EH28 8NZ.
O. T. GRIFFIN, B.Sc., Balnafoich, Dores, Inverness-shire.
JAMES R. MARSHALL, Duncrub Park, Dunning, Perthshire.
DOUGLAS V. RENNIE, South Belton, Dunbar, East Lothian.
G. A. STORRAR, M.C., B.Sc., J.P., Rossie, Auchtermuchty, Fife.
H. A. WATERSON, M.Sc., West of Scotland Agricultural College, Agronomy Department, Auchencruive, Ayr KA6 5HW.

1975

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.
JAMES McFARLANE, Kames, East Mains, Leitholm, Coldstream, Berwickshire TD12 4JW.
WILLIAM H. PORTER, West Scryne, Carnoustie, Angus.
DEREK A. J. RANDALL, The Miln Marsters Group, King's Lynn, Norfolk.

Directors Co-opted

W. H. M. GILL, Rosskeen, Invergordon, Ross-shire.
J. B. D. HERRIOTT, B.Sc., Ph.D., Edinburgh School of Agriculture, West Mains Road, Edinburgh EH9 3JG.
Sir DAVID LOWE, C.B.E., D.Sc., F.R.S.E., F.R.Ag.S., Elvingston, Gladsmuir, East Lothian.

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

Professor ROBERT BROWN, D.Sc., F.R.S., Edinburgh University, Botany Department, King's Buildings, Mayfield Road, Edinburgh EH9 3JA.
H. P. DONALD, C.B.E., Ph.D., D.Sc., F.R.S.E., 5 Glenorchy Road, North Berwick, East Lothian.
W. O. KINGHORN, B.Sc., 25 Cumlodden Avenue, Edinburgh EH12 6DK.
Sir MAURICE YONGE, C.B.E., D.Sc., F.R.S., P.R.S.E., 13 Cumin Place, Edinburgh EH9 21X.

Standing Committee—Finance

JOHN ARBUCKLE, *Convener.*
W. A. BIGGAR.
R. BROWN.
G. CLAPPERTON.
J. D. G. DAVIDSON.
W. H. M. GILL.
G. B. R. GRAY.
O. T. GRIFFIN.
J. B. D HERRIOTT.
Sir DAVID LOWE.
R. L. SCARLETT.
Sir MAURICE YONGE.
VICE-CHAIRMAN (*ex officio*).

Research Committees

Brassicas

J. B. D. HERRIOTT, *Convener.*
G. CLAPPERTON.
G. B. R. GRAY.
W. H. PORTER.
D. V. RENNIE.
H. A. WATERSON.
CHAIRMAN (*ex officio*).
VICE-CHAIRMAN (*ex officio*).

Cereals

O. T. GRIFFIN, *Convener.*
Mrs B. A. GORDON.
Sir DAVID LOWE.
A. PATTULLO.
D. A. J. RANDALL.
W. STEVEN.
H. A. WATERSON.
CHAIRMAN (*ex officio*).
Vice-Chairman (*ex officio*).

Grasses

G. CLAPPERTON, *Convener.*
J. LESLIE DAWSON.
G. B. R. GRAY.
J. B. D. HERRIOTT.
A. PATTULLO.
W. STEVEN.
CHAIRMAN (*ex officio*).
VICE-CHAIRMAN (*ex officio*).

Potatoes

W. M. H. GILL, *Convener.*
H. P. DONALD.
Mrs B. A. GORDON.
W. O. KINGHORN.
Sir DAVID LOWE.
J. R. MARSHALL.
J. McFARLANE.
W. H. PORTER.
J. M. ROY.
E. F. SHERRIFF.
G. A. STORRAR.
CHAIRMAN (*ex officio*).
VICE-CHAIRMAN (*ex officio*).

Farm Advisory

G. CLAPPERTON, *Convener.*
J. D. G. DAVIDSON.
G. B. R. GRAY.
J. McFARLANE.
A. PATTULLO.
D. V. RENNIE.
G. A. STORRAR.
CHAIRMAN (*ex officio*).
VICE-CHAIRMAN (*ex officio*).

9. ADMINISTRATION

Meetings

The Board met four times: on 10th April 1975, 5th June 1975, 24th July 1975, 20th November 1975.

The Finance Committee met on 5th June 1975.

The Brassicas Research Committee met on 21st October 1975.

The Cereals Research Committee met on 23rd April 1975, 14th August 1975, 16th December 1975.

The Farm Advisory Committee met on 8th May 1975, 11th December 1975.

The Grasses Research Committee met on 9th October 1975.

The Potatoes Research Committee met on 18th November 1975.

Board of Directors

The Board welcomed on election for the first time: Mr James McFarlane, Mr William H. Porter and Mr Derek Randall.

Finance

The abstract of audited accounts on pages 67 to 77 reveals the Society's financial position at 31st March 1976. The cost of the research programme at the Scottish Plant Breeding Station was met by a maintenance grant of £597,000 from the Department of Agriculture and Fisheries for Scotland. Sundry items of income at Pentlandfield amounted to £1,025. The unspent balance of the maintenance grant for the year amounted to £104, which has been added to unspent balances of grants from previous years, increasing them to £15,749.

Capital expenditure at Pentlandfield amounted to £17,493 on equipment and £155,810 on buildings, the main item being the new East Wing, for which DAFS grants were received. The Department had also approved the expenditure of £33,413 for a new storage building at The Murrays farm. As the farm is let to the Society by the Secretary of State for Scotland, capital expenditure at The Murrays farm is not included in the Fixed Assets of the Society.

Membership

At 31st March 1976 the total membership was 305, comprising 188 Life Members and 117 Annual Members. Five new members were elected during the year and fifteen died or resigned.

Election of Directors

In accordance with the rules of the Society, the following Directors retire from the Board at this time:—

George Clapperton, Sheriffhall Mains, Dalkeith EH22 1RX.
A. Pattullo, M.C., J.P., Littleton of Airlie, Kirriemuir, Angus.
James M. Roy (Gordon Innes Ltd.), 69 Bogie Street, Huntly, Aberdeenshire.
E. F. Sherriff (Sherriff and Sons Ltd.), The Mill, Great North Road, Hatfield, Herts.
W. Steven, The Brax Farm, by Arbroath, Angus.

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

John M. Fell, 78 High Street, Boston, Lincolnshire.
W. H. M. Gill, Rosskeen, Invergordon, Ross-shire.
J. B. D. Herriott, B.Sc., Ph.D., Edinburgh School of Agriculture, West Mains Road, Edinburgh EH9 3JG.
Sir David Lowe, C.B.E., D.Sc., F.R.S.E., F.R.Ag.S., Elvingston, Gladsmuir, East Lothian.
C. D. Scott, Waterside, Newburgh, Aberdeen.
C. G. Spence, Biel, Dunbar, East Lothian.

Fifty-Fourth Annual General Meeting

MINUTE OF PROCEEDINGS AT THE FIFTY-FOURTH ANNUAL GENERAL MEETING OF MEMBERS OF THE SCOTTISH SOCIETY FOR RESEARCH IN PLANT BREEDING, held at the Scottish Plant Breeding Station, Pentlandfield, Roslin, Midlothian, on Thursday, 24th July 1975.

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

Minute. The Minute of the 53rd Annual General Meeting, held at the Scottish Plant Breeding Station on Thursday, 18th July 1974, having been circulated prior to the meeting, was taken as read and was approved and signed.

Apologies. Apologies for absence were intimated by the Secretary.

Annual Report and Accounts. The 54th Annual Report of the Directors, embodying the audited accounts for the year ended 31st March 1975, which had been distributed to members before the meeting, was submitted by the Chairman.

After a brief speech the Chairman moved and Mr James Gray, O.B.E., T.D. (James Gray & Co. (Stirling) Ltd.), Stirling, seconded the adoption of the Report and Accounts and the motion was carried unanimously.

Election to the Board of Directors. A motion by Mr W. Andrew Biggar, O.B.E., M.C., B.Sc., F.R.Ag.S., Magdalene Hall, St Boswells, supported by Mr O. T. Griffin, B.Sc., Balnafoich, Dores, Inverness-shire, was unanimously adopted to elect to the Board of Directors the following members:—

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.

James McFarlane, Kames, East Mains, Leitholm, Coldstream, Berwickshire.
William H. Porter, West Scryne, Carnoustie, Angus.
D. A. J. Randall, The Miln Marsters Group, Kings Lynn, Norfolk.

Appointment of Auditors.

On the motion of the Chairman, seconded by Mr G. Clapperton, Sheriffhall Mains, Dalkeith, Messrs Brown, McDonald and Fleming, Chartered Accountants, were re-appointed Auditors of the Society.

This concluded the business of the meeting.

In the informal business of the meeting, the Chairman, in the course of his address to members, paid tribute to the late Dr William Black, O.B.E., B.Sc., Ph.D., F.R.S.E., F.I.Biol., formerly head of the Potato Department at the Station, and the late Mr F. R. Horne, C.B.E., M.A., N.D.A., N.D.D., a former member of the Board of Directors. He said that Dr Black had spent almost a life-time at the SPBS and that he had been an excellent leader of the potato breeding team; his name would long be associated with potatoes that bore the prefix "Pentland". Referring to Mr Horne, the Chairman said that he had been a Director for eleven years (1957 to 1968) and during his term of office he had been an enthusiastic and extremely helpful colleague. Mr Arbuckle said that both Dr Black and Mr Horne would be sadly missed and that agriculturists throughout the land would revere their memory.

The Chairman went on to say that, as a Visiting Group would be coming to the Station later in the year, he would depart from his normal practice of picking out highlights of the Annual Report and would, instead, review the past six years. He said that progress, if unspectacular, had been steady and that, in any case, plant breeding did not lend itself to quick results. There was however much promising material in the pipeline and this was due to the imaginative breeding programmes and the effort of all the staff at the Station. Mr Arbuckle reminded the meeting that DAFS had acquired a farm for the use of the Station; it was steadily improving and would, he was sure, be a great asset for the future. Much new laboratory space, glasshouses and equipment had also been provided and essential support services such as chemistry, photography and workshops had been initiated during the six years. All these improvements in facilities had a solid foundation for the future and were greatly appreciated by the Society and staff.

Mr Arbuckle, in thanking his fellow Directors for their continued support, said that research committees had now been established for all the groups of crops in the research programme and that he was sure that they were performing

a useful function. The Chairman thanked the Department of Agriculture and Fisheries for Scotland for its continued support which, he sincerely believed, was money well spent.

Mr Arbuckle then thanked the staff for their excellent efforts. He intimated that Mr J. L. Fyfe, formerly head of the Forage Department and latterly Deputy Director and Mr D. Cameron, who had spent the past thirty years in oat breeding, would be retiring this year. He wished them both a long and happy retirement. He concluded by congratulating Dr Simmonds on being appointed Honorary Professor in the University of Edinburgh.

Dr Simmonds spoke on plant breeding in general and potato breeding in particular. He said that a common approach to plant breeding was to " cross the best with the best and hope for the best ", but that this became ineffective when the genetic base was too narrow. He said that potato collections had, on the whole, been unsuccessful because little practical success could be attributed to their use in breeding. The majority of leading varieties were old; for example, King Edward and Majestic in Britain, Bintje in Europe and Russett Burbank in North America were all about seventy years old. Some success, however, had been achieved with the varieties Pentland Crown, Pentland Dell and Maris Piper but these appeared to be exceptions rather than the rule. Dr Simmonds said that it was sometimes difficult to identify a narrowness of genetic base as the cause of poor progress and that to broaden it was expensive and time-consuming. Work at the SPBS provided an excellent example of a deliberate attempt to broaden the base. Primitive South American potatoes of the Andigena group had been converted, over a period of sixteen years, into excellent breeding material which was now entering the programme at Pentlandfield in the form of Neo-Tuberosum. He expected that new varieties with improved yield and disease resistance would flow from this work and that a longer term result would be a virtual reconstruction of the crop. The Director said that this Station was endeavouring to broaden the genetic base also of cereals and Brassicas and that he thought that plant breeding in general would increasingly need to follow this pattern.

Mr J. I. Smith, C.B., Secretary of the Department of Agriculture and Fisheries for Scotland, in his address to the meeting, said that the effort on agricultural research in Scotland, which had quadrupled over the past twenty years, was clearly paying off and, in view of the Government's aim of near self-sufficiency in food production, he foresaw further expansion in this field in the longer term. However, because of the current economic climate, he thought that the next few years would be difficult and that we were entering a period of consolidation. Mr Smith added that the Department appreciated the efforts of Mr Fyfe and Mr Cameron and wished them a happy retirement.

Mr G. B. R. Gray moved a vote of thanks to the Chairman on the closing of the informal meeting.

Staff

The following appointments were made during the year:—

HSO	J. E. Bradshaw, M.A., M.Sc., Ph.D J. M. S. Forrest, B.Sc., Ph.D. C. J. W. Torrance, H.N.C.
SO	Mrs J. E. Fantes, B.A., M.A. Mrs L. E. M. Gray, B.Sc.
ASO	S. J. Cormack Miss F. A. F. Hadden Miss C. M. MacParland Miss F. Mathison
Experimental Workers	M. Campbell G. R. Drabble Mrs E. Hoy
Field and Works	W. L. Beirne A. M. Bryce A. Cochrane W. Ross R. Simpson
Administration	Mrs A. Fulcher Miss G. Lightbody

The following staff left employment:—

SPSO	J. L. Fyfe, M.Sc., Deputy Director (retired)
PSO	D. Cameron, B.Sc. (retired)
HSO	Miss F. G. A. Megginson, B.Sc., M.Sc
ASO	W. M. M. Eddie Mrs I. C. Fraser Miss K. W. Fraser Mrs A. E. Leakey, B.Sc. Mrs L. E. Scott, O.N.C. Miss E. J. H. Taylor Miss H. E. Templeton

Experimental Worker	R. M. Bruce
Field and Works	A. M. Bryce Mrs J. Campbell M. MacPartlan N. Paolozzi W. Ross V. Schacht (retired)
Administration	Miss G. J. Thomson Mrs E. M. Walley

Three retirals occurred during the year. Mr J. L. Fyfe, Head of the Forage Department at the Station from 1967, and latterly Deputy Director, retired in October 1975. Mr Fyfe, a graduate of the University of Newcastle-upon-Tyne, had spent forty years in agricultural research, first at the Commonwealth Bureau of Plant Breeding and Genetics in Cambridge (1935-38) and then at the PBI, before coming to the SPBS. He did distinguished work on legume breeding (particularly beans) at Cambridge and contributed much to the development of the lively programme of the Forage Department at this Station, to computing activities and to the Station's building programme. Mr Fyfe retired with the best wishes of his colleagues and of the Board for a long and happy retirement by the Tweed, taking angling advantage, no doubt, of the situation.

Mr Donald Cameron retired early in 1976 after nearly thirty years at the Station. He graduated from St Andrews University in 1936 and worked on a rubber estate in Malaysia before joining the army there. He was made prisoner-of-war and came to the SPBS in 1946. Mr Cameron bred oats, at Craig's House and later at Pentlandfield. Several of his varieties made useful contributions to the agriculture of the north and west of Scotland; and, as recorded elsewhere in this report, his efforts look like producing some excellent lowland oats as well. In addition, his many skills with machines and equipment were highly valued by colleagues. He retires to Argyllshire with the warm good wishes of colleagues and the Board for many years of successful sailing and fishing.

Mr Victor Schacht retired in September 1975 after nearly twenty-two years service. Mr Schacht was born in East Prussia and settled in Britain after having been made prisoner-of-war. As Caretaker/Handyman, the Station owes him much for his able management of the boilers and for his highly skilled joinery work. He retired with good wishes from colleagues and Board.

Dr J. M. Dunnett resigned as from the end of March 1976 to return to his native Caithness to grow seed potatoes and probably breed them too. Dr

Dunnett, a graduate of Edinburgh University (B.Sc. 1953, Ph.D. 1960), joined the SPBS staff in 1953 and bred potatoes under the late Dr Black. His studies of eelworm populations led to the recognition of a new race of the nematode. Many excellent new varieties now going through the breeding pipeline will have passed through his hands, most notably, perhaps, those with PCE resistance derived from *Solanum vernei*. Dr Dunnett moves to Caithness with warm good wishes of colleagues and Board for success in his new ventures.

I offered my resignation to the Chairman during the year, explaining that I felt a desire to move towards more academic and less administrative activities. I shall leave Pentlandfield with much regret but look forward to new tasks in the Edinburgh School of Agriculture (from April 1 1976) with keen interest.

Staff and Board heard with great regret of the death, in Edinburgh on May 16th 1975, of Dr W. Black. Dr Black retired from the SPBS in 1968 (see *Annual Report*, **48**, 43, 1969) but continued active in potato work in Kenya until just before his death.

Five members of staff made visits abroad with the aid of travel grants from ARC. Dr Holden attended the 6th Triennial Conference of the European Association for Potato Research at Wageningen, 14th-20th September 1975; the theme of the conference was potato quality. Mr Whitehouse, Dr Allison and Dr Hayter attended the 3rd International Barley Genetics Symposium in Münich, 5th-12th July 1975. Mr Whitehouse was a member of the organising committee and all three presented papers. Dr Gowers attended a conference on club root disease and visited institutes at Wageningen on 28th-30th October 1975.

With the aid of travel grants from the Society, Dr Wastie attended the EAPR Triennial Conference at Wageningen (14th-20th September 1975) and Dr Bradshaw attended the Eucarpia Cereals Section Conference at Vejle, Denmark, 26th-27th February 1976.

Mr Glendinning was invited to attend and present a paper to a meeting on "Exploration and maintenance of germ plasm resources", organised by the International Potato Centre (CIP), at Lima, Peru, 15th-19th March 1976. His paper was entitled: "Strategy of maintenance and distribution of the Commonwealth Potato Collection".

Members of staff attended a number of meetings, formal and informal, within the UK during the year. Among them were the first of what is to be an annual gathering of ARS cereals breeders. The meeting was held at the PBI Cambridge on 24th-25th June 1975; twenty-five workers attended, including Mr Whitehouse, Mr Cameron, Dr Allison, Dr Hayter and Dr Ellis from the SPBS. The next meeting is to be held at Pentlandfield in July 1976. Potato workers attended five gatherings at various times and places on the problems of potato diseases and eelworms; Dr Holden addressed the

Annual General Meeting of the VTSC Growers' Association at Aviemore, 14th November 1975.

The Director gave several seminars/lectures to various audiences during the year, among them one to the ASCAR Symposium held at the Royal Botanic Gardens, Kew, 22nd-24th October 1975. The meeting was held under the Anglo-Soviet Cultural Exchange Agreement and was arranged by MAFF; a Russian delegation was present and the theme was "The conservation of world plant resources". He served on SADC and several committees connected with Research Councils' computing affairs earlier in the year but resigned later in anticipation of his move. He also served on the JCO Potato Committee and on the PMB Research and Development Committee. He visited Guyana and Barbados in November 1975 in connection with sugar cane breeding.

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

10. PUBLICATIONS

CARROLL, C. P., and LOW, R. J. (1975). Flowering behaviour and seed fertility in dihaploid *Solanum tuberosum*. *Potato Research*, **18**, 416-27.

CARROLL, C. P., and LOW, R. J. (1976). Aspects of male fertility in group Tuberosum dihaploids. *Potato Research*, **19**, 109-121.

CHARLES, A. H., ENGLAND, F., and THOMSON, A. J. (1975). The effect of nitrogen application and autumn management on autumn growth, winter " burn " and spring growth of *Lolium perenne* L. at Aberystwyth, Edinburgh and Cambridge. *Journal of the British Grassland Society*, **4**, 315-25.

ENGLAND, F. (1976). Genetic relationships between winter survival in Italian ryegrass (*Lolium multiflorum* Lam.) and yield in the previous season. *Journal of Agricultural Science, Cambridge*, **86**, 287-92.

GLENDINNING, D. R. (1975). Chilean potatoes: an appraisal. *Potato Research*, **18**, 306-07.

GLENDINNING, D. R. (1975). Neo-Tuberosum: new potato breeding material. 1. The origin, composition and development of the Tuberosum and Neo-Tuberosum gene pools. *Potato Research*, **18**, 256-61.

GLENDINNING, D. R. (1975). Neo-Tuberosum: new potato breeding material. 2. A comparison of Neo-Tuberosum with unselected Andigena and with Tuberosum. *Potato Research*, **18**, 343-50.

GLENDINNING, D. R. (1975). Neo-Tuberosum: new potato breeding material. 3. Characteristics and variability of Neo-Tuberosum and its potential value in breeding. *Potato Research*, **18**, 351-62.

GLENDINNING, D. R. (1976). Neo-Tuberosum: new potato breeding material. 4. The breeding system of Neo-Tuberosum and the structure and composition of the Neo-Tuberosum gene-pool. *Potato Research*, **19**, 27-36.

GOWERS, S. (1975). Methods of producing F_1 hybrid swedes (*B. napus* ssp. *rapifera*). *Euphytica*, **24**, 537-41.

GOWERS, S. (1975). The problems of producing F_1 hybrid swedes (*B. napus* ssp. *rapifera*). In: Wills, A.B. and North, C. (Eds.). Cruciferae, 1974. (*Proceedings, Meeting of Vegetable Crops Section, Eucarpia*, Sept. 1974, 122-29.)

HOLDEN, J. H. W. (1976). Oats. In *The Evolution of Crop Plants*, Ed. Simmonds, N.W., London, 86-90.

MACARTHUR, A. W., and KILLICK, R. J. (1976). Environmental and genetic variation in some economically important traits in potatoes. *Journal of Agricultural Science*, **86**, in press.

MACKAY, G. R. (1974). On the genetic architecture of fresh weight yield and some of its components in kale. In: Wills, A. B., and North, C. (Eds.), Cruciferae, 1974. (*Proceedings, Meeting of Vegetable Crops Section, Eucarpia*, Sept. 1974, 122-29.)

MACKAY, G. R. (1974). Some preliminary results from a study investigating the feasibility of producing interspecific hybrids between *B. napus* and *B. campestris* as higher yielding alternatives to forage rape. In: Dijkstra, J. (Ed.), New Ways in Fodder Crop Breeding. (*Proceedings, Meeting of Fodder Crops Section, Eucarpia*, May 1973,

MACKAY, G. R., and LOW, R. J. (1975). Spontaneous triploids in forage kale, *Brassica oleracea* var. *acephala*. *Euphytica*, **24**, 525-29.

MCNAUGHTON, I. H. (1976). Turnips and relatives; swedes and rapes. In *The Evolution of Crop Plants*, Ed. Simmonds, N. W., London, 45-48, 53-56.

MALCOLMSON, J. F. (1976). Assessment of field resistance to blight (*Phytophthora infestans*) in potatoes. *Transactions of the British Mycological Society*, in press.

RIGGS, T. J., and HAYTER, A. M. (1975). A study of the inheritance and inter-relationships of some agronomically important characters in barley. *Theoretical and Applied Genetics*, **46**, 257-64.

ROGERS, W. G., and KILLICK, R. J. (1975). Factors affecting the assessment of potatoes to gangrene (*Phoma exigua* var. *foveata*). *Annals of Applied Biology*, **81**, 51-9.

WATSON, P. J., and FYFE, J. L. (1975). *Potentilla erecta* in two contrasting habitats—a multivariate approach. *Heredity*, **34**, 417-22.

Other publications:

CROSSETT, R. N., CAMPBELL, J. D., and STEWART, H. E. (1975). Compensatory growth in cereal root systems. *Plant and Soil*, **42**, 673-83.

FORREST, J. M. S., and DIXON, A. F. G. (1975). The induction of leaf-rolls galls by the apple aphids *Dysaphis devecta* and *D. plantaginea*. *Annals of Applied Biology*, **81**, 281-88.

WASTIE, R. L. (1975). Diseases of rubber and their control. *Pest Articles & News Summaries*, **21**, 268-88.

FANTES, J. A., and CAMENZIND, R. (1975). Karyotype and chromosomal banding pattern in *Heteropeza pygmaea*. *Chromosoma*, **50**, 421-29.

SIMMONDS, N. W. (Ed.) (1976). *The evolution of crop plants*, London.

11. ABSTRACT OF ACCOUNTS

ABSTRACT OF ACCOUNTS

For Year ended 31st March 1976

INCOME

1975			
£ 494	Sales of Produce, etc.	£ 213	
118	Annual Subscriptions	119	
307	Rents received	693	
£ 919	*Total Ordinary Income*	£ 1,025	
453,400	Maintenance grant from Department of Agriculture and Fisheries for Scotland—	£597,000	
£454,319	*Total Income*	£598,025	
	Department of Agriculture and Fisheries for Scotland—		
15,582	Unexpended maintenance grants brought forward at 1st April 1975	£15,645	
2,037	Capital Grants—The Murrays Farm	33,413	
			49,058
£471,938			£647,083

EXPENDITURE

1975			
	Salaries:—		
£215,106	Scientific and Technical Staff	£276,123	
19,701	Administrative and Clerical Staff	25,158	
7,634	Pensions and Supplementation	8,833	
£242,441			£310,114
19,993	Superannuation		3,172
56,477	Wages		88,821
18,244	National Insurance		25,972
10,808	Apparatus and Equipment (Including Safety Equipment £916; 1975 Nil)		11,330
18,594	Chemicals and Materials		25,217
6,876	Travel and Subsistence (Including Visits Abroad £23; 1975 Nil)		11,091
5,034	Rates and Rents		10,942
16,022	Power, Heat and Light		24,209
6,213	Stationery, Postages and Telephones		8,095
787	Library Books and Periodicals (Including Binding)		1,500
1,284	Printing		1,397
3,716	Vehicles—Purchased £7.446		
5,917	Maintenance 9,024		16,470
1,198	Audit and Legal Expenses		594
—	Property Alterations		1,603
2,983	Property Repairs		2,620
585	Trial Centres		3,282
2,790	Edinburgh Centre of Rural Economy		5,309
6,531	Repairs and Servicing		6,714
820	Seed Testing		863
112	Transport		650
1,842	Staff Recruitment		2,874
250	Staff Training		1,013
1,188	Furniture and Fittings		465
1,265	Hire Charges and Rentals		2,516
409	Land improvement		—
20,066	The Murrays Farm—net operating costs		29,077
1,811	Miscellaneous		2,011
£454,256			£597,921
2,037	The Murrays Farm—improvements		33,413
15,645	Department of Agriculture and Fisheries for Scotland—unexpended maintenance grants carried forward at 31st March 1976		15,749
£471,938			£647,083

BALANCE SHEET

as at 31st March 1976

1975			
	I Funds:—		
£466,406	Balance brought forward as at 1st April 1975.	£525,127	
1,128	*Add:* Adjustments in respect of previous years	—	
	Grants received from Dept. of Agriculture and Fisheries for Scotland during year to date:—		
38,924	Capital Works	155,810	
18,669	Capital Equipment	17,493	
£525,127			£698,430
	II Current Liabilities:—		
3,089	Sundry Creditors	£ 331	
	Department of Agriculture and Fisheries for Scotland:—		
15,645	Unexpended Maintenance Grants . .	15,749	
			16,080
£543,861			£714,510

Edinburgh, *28th May, 1976.*—The undersigned, having had access to all the Books and Accounts 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 same as to be correct, duly vouched, and in accordance with the law.

16 Alva Street, Edinburgh.

Messrs BROWN, MACDONALD & FLEMING, *Auditors.*

JOHN ARBUCKLE, *Convener, Finance Committee.*

1975		Cost	Less Charged to Revenue	Nett
	I Fixed Assets:—			
£452,088	1. Heritable Property . .	£607,895	—	£607,895
72,550	2. Capital Equipment . . .	90,043	—	90,043
£524,638		£697,938	—	£697,938
31,432	3. Implements and Tools. . .	36,040	£ 36,040	
11,102	4. Vehicles	18,477	18,477	
60,670	5. Laboratory Apparatus. . .	66,318	66,318	
14,677	6. Furniture and Fittings. . .	15,143	15,143	
9,943	7. Library Books	11,509	11,509	
£652,462		£845,425	£147,487	£697,938
127,824	*Less:* Charged to Revenue to 31st March 1975			
£524,638				
	II Current Assets:—			
5,817	Sundry Debtors	£ 403		
13,406	Cash and Bank Balances	16,169		
				16,572
£543,861				£714,510

LIFE MEMBERSHIP SUBSCRIPTIONS AND DONATIONS ACCOUNT

for the year ended 31st March 1976

1975				
	Income			
	Balances brought forward at 1st April 1975:—			
	Investments at cost—			
£ 6,105	Narrower range		£ 6,355	
6,960	Wider range		7,210	
£13,065			£13,565	
290	Recoverable Income Tax		323	
65	Sundry Debtors		—	
993	Bank of Scotland—Current and Savings Accounts		1,106	
£14,413			£14,994	
—	Less: Sundry Creditors		8	
£14,413				£14,986
	Gross Interest/Dividends on Investments:—			
	Narrower range	£ 551		
525	Wider range	571		
462				1,122
	Interest on Savings Bank Account			35
29	Life Subscriptions			40
60	Donations			50
50				£16,233
£15,539				

1975				
	Expenditure			
£ 3	Registrar of Friendly Societies			£ 3
85	SSRPB Lecture			103
75	Retirement Gratuities (Messrs J. L. Fyfe, D. Cameron, J. Dunnett, V. Schacht)			350
133	Hospitality			294
146	Travel Grant to Dr J. Bradshaw (1974: Dr Holden)			210
52	Donation to SPBS Common Room Fund (1974: Bawden Memorial Trust)			150
59	Bank Charges			35
	Balances carried forward at 31st March 1976:—			
	Investments at cost (see Appendix)—			
6,355	Narrower range	£ 6,800		
7,210	Wider range	7,762		
		£14,562		
324	Recoverable Income Tax	390		
1,105	Bank of Scotland—Current and Savings Accounts	235		
		£15,187		
(8)	Less: Sundry Creditors	99		
			15,088	
£15,539			£16,233	

W. J. REID AND JAMES MUNRO BEQUESTS

	Balances brought forward at 1st April 1975:—			
	Investments at cost—			
£ 1,792	Narrower range		£ 1,792	
424	Wider range		424	
£ 2,216			£ 2,216	
41	Recoverable Income Tax		48	
135	Bank of Scotland—Current and Savings Accounts		270	
			£ 2,534	
—	Less: Sundry Creditors		1	
				£ 2,533
	Gross Interest/Dividends on Investments—			
	Narrower range	£ 124		
120	Wider range	34		
28				158
—	Interest on Savings Bank Account			9
				£ 2,700
£ 2,540				

£ 7	Bank Charges			£ 6
	Balances carried forward at 31st March 1976:—			
	Investments at cost (see Appendix)—			
1,792	Narrower range	£ 1,942		
424	Wider range	574		
		£ 2,516		
48	Recoverable Income Tax	54		
270	Bank of Scotland—Current and Savings Accounts	124		
		£ 2,694		
(1)	Less: Sundry Creditors	—		
			2,694	
£ 2,540			£ 2,700	

DR. WILSON MEMORIAL FUND

1975	Income		
	Balances brought forward at 1st April 1975:—		
	Investments at cost—		
£ 317	Narrower range	£ 317	
249	Wider range	249	
		£ 566	
£ 566			
10	Recoverable Income Tax	11	
74	Bank of Scotland—Current and Savings Accounts	105	
			£ 682
£ 650			
	Gross Interest/Dividends on Investments:—		
20	Narrower range	£ 21	
14	Wider range	17	
			38
—	Interest on Savings Bank Account		5
			£ 725
£ 684			

1975	Expenditure		
£ 2	Bank Charges		£ 2
	Balances carried forward at 31st March 1976:—		
	Investments at cost (see Appendix)—		
317	Narrower range	£ 317	
249	Wider range	283	
		£ 600	
11	Recoverable Income Tax	13	
—	Sundry Debtors	1	
105	Bank of Scotland—Current and Savings Accounts	109	
			723
£ 684			£ 725

J. C. THYNE BEQUEST

	Balances brought forward at 1st April 1975:—		
	Investments at cost—		
—	Narrower range	£1,050	
—	Wider range	1,050	
		£2,100	
—			
—	Recoverable Income Tax	24	
—	Bank of Scotland—Current and Savings Accounts	103	
			£2,227
	Gross Interest on Investments:—		
£ 37	Narrower range	£ 134	
37	Wider range	134	
			268
34	Interest on Savings Bank Account		5
2,119	Bequest from J. C. Thyne Trust		—
			£2,500
£2,227			

—	Travel Grant to Dr R. Wastie		£ 197
—	Bank Charges		16
	Balances carried forward at 31st March 1976:—		
	Investments at cost (see Appendix)—		
£1,050	Narrower range	£1,049	
1,050	Wider range	1,048	
		£2,097	
24	Recoverable Income Tax	91	
103	Bank of Scotland—Current and Savings Accounts	99	
			2,287
£2,227			£2,500

APPENDIX

INVESTMENTS AS AT 31st MARCH 1976

Life Membership Subscriptions and Donations Fund (" B " Account)

Book Value		Gross Interest/ Dividends for Year to Date	Middle Price as at Date	Market Value as at Date
	(Narrower Range)			
£ 1,508·39	£1,581·40 6½% Funding Stock 1985/87	£ 102·80	£71%	£ 1,122·51
2,253·58	£2,359·35 8¾% Treasury Loan 1997	206·44	£66·5%	1,568·97
1,493·09	£1,648·20 8½% Treasury Loan 1980/82	140·10	£92%	1,516·34
1,099·96	£1,153·00 Stirling County Council 7¾% Loan 1977/79	89·36	£87%	1,003·11
445·26	£450·00 City of Westminster 13% Red. Stock 1981	12·28	£98%	441·00
£ 6,800·28		£ 550·98		£ 5,651·93
	(Wider Range)			
£864·09	1,980 Ordinary 25p shares National Commercial Banking Group	£65·27	66p	£ 1,306·80
714·05	413 Ordinary 25p shares Guardian Royal Exchange Assurance Co.	44·93	216p	892·08
1,498·89	830 Ordinary 5p shares London & Manchester Assurance Co. Ltd.	57·20	126p	1,045·80
608·82	345 Ordinary £1 Stock Units Imperial Chemical Industries Ltd.	62·77	392·5p	1,354·12
1,372·87	345 Ordinary 25p shares Shell Transport & Trading Co. Ltd.	67·83	403p	1,390·35
794·57	1,420 Ordinary 50p shares Claverhouse Investment Trust Ltd.	60·08	55p	781·00
290·99	1,161 Ordinary 25p shares Imperial Group	75·75	75p	870·75
1,172·28	£1,468·20 8½% Treasury Loan 1980/82	124·80	£92%	1,350·74
445·26	£450·00 City of Westminster 13% Red. Stock 1981	12·28	£98%	441·00
£ 7,761·82		£ 570·91		£ 9,432·64
—	Bank of Scotland " B " Savings Account Interest	£ 34·97	—	—
£14,562·10	" B " ACCOUNT TOTAL	£1,156·86		£15,084·57

W. J. Reid and James Munro Bequests (" C " Account)

	(Narrower Range)			
£ 1,333·85	£1,359·29 6½% Funding Loan 1985/87	£ 88·36	£71%	£ 965·10
199·70	£208·00 Stirling County Council 7¾% Loan 1977/79	16·12	£87%	180·96
258·73	£215·00 English & International Trust Ltd., 7% Convertible Stock 1986	15·05	£77·5%	166·62
149·58	£150·00 City of Westminster 13% Red. Stock 1981	4·10	£98%	147·00
£ 1,941·86		£ 123·63		£ 1,459·68
	(Wider Range)			
£ 165·59	80 Ordinary £1 Stock Units Imperial Chemical Industries Ltd.	£ 14·55	392·5p	£ 314·00
258·72	£215·00 English & International Trust Ltd. 7% Convertible Stock 1986	15·05	£77·5%	166·62
149·59	£150·00 City of Westminster 13% Red. Stock 1981	4·09	£98%	147·00
£ 573·90		£ 33·69		£ 627·62
—	Bank of Scotland " C " Savings Account Interest	£8·52	—	—
£ 2,515·76	" C " ACCOUNT TOTAL	£ 165·84		£ 2,087·30

Dr Wilson Memorial Fund (" D " Account)

Book Value		Gross Interest/ Dividends for Year to Date	Middle Price as at Date	Market Value as at Date
	(Narrower Range)			
£ 265·77	£276·60 6½% Funding Stock 1985/87	£ 17·98	£71%	£ 195·96
51·20	£35·00 English & International Trust Ltd. 7% Convertible Stock 1986	2·45	£77·5%	27·12
£ 316·97		£ 20·43		£ 223·08
	(Wider Range)			
£ 232·04	133 Ordinary 25p shares Guardian Royal Exchange Ltd.	£ 14·49	216p	£ 287·28
51·20	£35·00 English & International Trust Ltd. 7% Convertible Stock 1986	2·45	£77·5%	27·12
£ 283·24		£ 16·94		£ 314·40
—	Bank of Scotland " D " Savings Account Interest	£4·83	—	—
£ 600·21	" D " ACCOUNT TOTAL	£ 42·20		£ 537·48

J. C. Thyne Trust (" E " Account)

	(Narrower Range)			
—	£1,050·00 City of Birmingham 13% Bonds (1 year) (redeemed July 1975)	£ 105·05	—	—
£ 1,048·55	£1,060·00 City of Westminster 13% Red. Stock 1981	28·94	£98%	£ 1,038·80
1·45	Cash	—	—	—
£ 1,050·00		£ 133·99		£ 1,038·80
	(Wider Range)			
—	£1,050·00 City of Birmingham 13% Bonds (1 year) (redeemed July 1975)	£ 105·05	—	—
£ 1,048·55	£1,060·00 City of Westminster 13% Red. Stock 1981	28·94	£98%	£ 1,038·80
1·45	Cash	—	—	—
£ 1,050·00		£ 133·99		£ 1,038·80
—	Bank of Scotland " E " Savings Account Interest	£ 4·68	—	—
£ 2,100·00	" E " ACCOUNT TOTAL	£ 272·66		£ 2,077·60
£19,778·07	TOTALS	£1.637·56		£19,786·95
		(8·28% on invested capital)		

12. LIST OF MEMBERS

The following information is the latest known to the Society. It would be appreciated if necessary alterations could be intimated to the Secretary.

ABERDEEN

Dempster, D. G., Aberdeen University Farms, Tillycorthie, Udny.
Lee, E. M., Haddo, Methlick.
Morrison, Douglas, Crop Husbandry Division, School of Agriculture, 581 King Street, Aberdeen.
Roy, James M. (Gordon Innes Ltd.), 69 Bogie Street, Huntly.
Salmon, A. B., 20 Harlow Road, Aberdeen.
Scott, C. D., Waterside, Newburgh.
Shackleton, J. F. (Benjamin Reid & Co.), 20 Hadden Street, Aberdeen.

ANGUS

Arbuckle, William S., N.D.A., Old Dounie, Carnoustie.
Adam, Andrew, Newhouse of Glamis, Glamis, Forfar.
Archie, Alex. R., South Leckaway, Forfar.
Barr, John M. (Pattullo, Barr & Co. Ltd.), West Dock Street, Dundee.
Barrow, J. R., Findowrie Farm, Brechin.
Batchelor, D. Hill, 6 Union Place, Montrose.
Braes, Robert, West Ballochry, Montrose.
Fairlie, Denis W. W., Kirkton, Monkie, Dundee.
Forster, E. A., Mains of Benholm, Benholm, Montrose.
Galloway, George L., East Balmirmer, Arbroath.
Henderson, Frank M., 7 Bingham Terrace, Dundee.
Inverarity, J. A., Cransley, Liff, by Dundee.
Mackie, George Y., Ballinshoe, Kirriemuir.
Milne, Alex. S. Timaru, Trinity, Brechin.
Murray, T. P. Douglas, 2 Castle Street, Forfar.
Porter, A. Gordon, J.P., East Scryne, Carnoustie.
Porter, John Gray, S.D.A., Balhungie, Monifieth, Carnoustie.
Porter, William H., West Scryne, Carnoustie.
Pattullo, A., M.C., J.P., Littleton of Airlie, Kirriemuir.
Rankin, G. M., Westdrums, Brechin.
Renwick, J. H., Border, Arbroath.
Robertson, G. Kenneth, Heatherstock, Forfar.
Smith, Stanley B., Crosston, Duninchen.
Steven, William, B.Sc., Brax Farm, by Arbroath.
Wallace, D., Pitpointie, Auchterhouse, Dundee.
Warnock, John, Charleton Road, Montrose.
Young, Charles, B.Sc., Shielhill, Dundee.

ARGYLL

Ferguson, Hugh, B.Sc., Beach Hill, Campbeltown.

AYRSHIRE

Drummond, H., Curragh, Girvan.
Dunlop, Quentin, Old Trees, Maybole, Ayrshire.
Hannah, John J. M., 3 Baird Road, Alloway, Ayr.
Harvey, N. P., c/o Sinclair & McGill (Scotland) Ltd., P.O. Box 23, 67 Kyle Street, Ayr.

Kidd, David, N.D.A., S.D.A., S.D.D., 2 Marlepark, Ayr.
McGill, J. Becket F., 52 Carcluie Crescent, Ayr.
Rae, Angus C., B.Sc.(Agric.), M.Sc., Sinclair & McGill (Scotland) Ltd., 67 Kyle Street, Ayr.
Stevenson, Robert H. U., Corseclays, Ballantrae, Girvan.
Stewart, John, 63 The Avenue, Girvan, Ayrshire.
Waterson, H. A., M.Sc., Agronomy Department, The West of Scotland College of Agriculture, Auchincruive, Ayr.
Watson, John, Sinclair & McGill (Scotland) Ltd., 67 Kyle Street, Ayr.
Watson, J. G., Sinclair & McGill (Scotland) Ltd., 67 Kyle Street, Ayr.
Young, R. W. P., Sinclair & McGill (Scotland) Ltd., 67 Kyle Street, Ayr.

BANFF

Cumming, Robert G. (Messrs R. Cumming & Son), Easter Baldavie, Boyndie.
Currie, William, Greenhill, Deskford, Cullen.

BERWICKSHIRE

Calder, Harry, Billiemains, Duns.
Cochrane, J. A. (Scottish Agricultural Industries Ltd.), 1 Guards Road, Coldstream.
Dykes, Thomas S., Redheugh, Cockburnspath.
Elliot, A. D., Kettleshiel, Duns.
Forrest, R. L., Mersington, Greenlaw.
Forrest, W. Logan, B.Sc., Mersington Farms Ltd., Greenlaw.
Gerrard, H., Woolands, Cockburnspath.
Glen, Mrs J. D., Gunsgreenhill, Ayton.
Hamilton, James, Printonan, Duns.
Harrower, William P., Blackadder Mount, Edrom, Duns.
Mather, James, Printonan, Duns.
Meikle, R. W., Broomdykes, Duns.
McCreath, Geoffrey C. (H. G. McCreath & Co.), 44/48 Hyde Hill, Berwick.
McFarlane, J., Kames East Mains, Leitholm, Coldstream, Berwickshire.
McKerrow, M., Addinston, Lauder.
Pate, G., East Cruicksfield, Duns.
Walker, Maxwell, Springwells, Greenlaw.

CAITHNESS

Bruce, James S., 26 Union Street, Wick.
Morris, John, Olrig House, Castletoun, Thurso.
Thurso, The Viscount, East Mains, Thurso.

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EAST LOTHIAN

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Miller, James B., Ferrygate, North Berwick.
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Watson, Rupert, Fenton Barns, North Berwick.
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Gibb, John, Fliskmillian, Newburgh.
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Jennings, Ian, Nether Cleuch, Dalry.

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Barr, William, Harelaw, Lanark.
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Bowser, D. S., Argaty and the King's Lundies, Doune.
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ROSS AND CROMARTY

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Gill, W. H. M., Rosskeen, Invergordon.
Gill, William L., Rosskeen, Invergordon.
Gill, John D., Brucefield, Portmahomack, Ross-shire.
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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. OX12 9JT
Meat Research Institute	Langford, Bristol BS18 7DY
Poultry Research Centre	King's Buildings, West Mains Road, Edinburgh EH9 3JS
Weed Research Organisation	Begbroke Hill, Sandy Lane, Yarnton Oxford OX5 1PF

State-aided Institutes in England and Wales:

Animal Virus Research Institute	Pirbright, Woking, Surrey GU24 0NF
East Malling Research Station	East Malling, Maidstone, Kent ME19 6BJ
Glasshouse Crops Research Institute	Worthing Road, Rustington, Littlehampton, 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. MK45 4HS
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. AL5 2JQ
Welsh Plant Breeding Station	Plas Gogerddan, Aberystwyth, Cardiganshire SY23 3EB
Wye College, Department of Hop Research	Ashford, Kent TN25 5AH

State-aided Institutes in Scotland:

Animal Diseases Research Association	Moredun Institute, 408 Gilmerton Road, Edinburgh EH17 7JH
Hannah Research Institute	Kirkhill, Ayr KA6 5HL
Hill Farming Research Organisation	Bush Estate, Penicuik, Midlothian EH26 0PH
Macaulay Institute for Soil Research	Craigiebuckler, Aberdeen AB9 2QJ
National Institute of Agricultural Engineering (Scottish Station)	Bush Estate, Penicuik, Midlothian EH26 0PH
Rowett Research Institute	Bucksburn, Aberdeen AB2 9SB
Scottish Horticultural Research Institute	Invergowrie, Dundee DD2 5DA
Scottish Plant Breeding Station	Pentlandfield, Roslin, Midlothian EH25 9RF