SCOTTISH PLANT BREEDING STATION
PENTLANDFIELD, ROSLIN, MIDLOTHIAN

REPORT

TO THE

ANNUAL GENERAL MEETING

OF

THE SCOTTISH SOCIETY FOR RESEARCH IN PLANT BREEDING

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BY THE

BOARD OF DIRECTORS

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1. REPORT BY THE DIRECTOR

General

The exhibition of the work of the Station at the Royal Highland Show, 1971, mentioned in the last report, took place as planned and was, by common consent, highly successful. The exhibition was designed by the Central Office of Information to a brief prepared by us, and our best thanks are due to that office for an excellent job.

The first SSRPB lecture was given on 15th April 1971, to an appreciative audience at the Bush by Sir Frederick Bawden, F.R.S., under the title " Science and Crop Yields ". Sir Frederick died suddenly in February 1972; he was a great man and an outstanding scientist and he will be sorely missed.

The second SSRPB lecture is planned for 13th April 1972. It will be given by Dr K. L. Blaxter, F.R.S., Director of the Rowett Research Institute. His title will be " Plants for Animals ". A summary is included later in this report.

Further building progress was made during the year. The new laboratory west wing was occupied in January 1972 and appears to be both satisfactory in use and attractive in appearance. Staff are greatly encouraged by having modern laboratories in which to work. Two new potato glasshouses were completed during the year and went into service in the autumn of 1971. By 1973 they, with other enhanced facilities, will enable us to double the throughput of potato seedlings from about 50,000 to 100,000. Construction of three more glasshouses is just starting at the time of writing (February 1972) and reconstruction of the blight laboratory to provide improved facilities for potato disease studies is planned. Two cottages are being built at The Murrays and a new steading is planned for completion by the harvest of 1972. This is all very satisfactory and the Station is now approaching the state of being a well-found institute.

The Fulton recommendations for the unification of the scientific classes were put to effect in the autumn of 1971. The old Scientific, Experimental and Assistant Classes were merged and a one-class structure substituted. The new grades (which appear in the Staff List later in this report) are Assistant Scientific Officer (ASO); Scientific Officer (SO); Higher Scientific Officer (HSO); Senior Scientific Officer (SSO); and Principal Scientific Officer (PSO). The intention is that promotion shall be by merit alone and that the way to the top shall be open to all regardless of grading at entry. The old problems of class-to-class promotion therefore disappear. The signs seem good that, given experience in working it, the new system will achieve what is intended.

The year was made memorable by the publication of the Government

Green Paper "*A Framework for Government Research and Development*" (Cmd. 4814) in November 1971. One part of this Paper, the Rothschild Report, generated much public discussion and nearly universal antagonism. Lord Rothschild proposed, among other things, that three-quarters of Agricultural Research Council funds should be transferred to the Ministry of Agriculture, Fisheries and Food for use by that Ministry, under the guidance of a yet non-existent Chief Scientist, on contract research and development. Since the report abounded in ambiguities, the detailed implications of what Lord Rothschild intended were far from clear, but it was generally agreed that there would probably follow: a reduction in total agricultural R and D, emphasis on short as against long-term research, fragmentation of the agricultural research service, much damage to staff morale and recruitment, and interpolation of an unnecessary bureaucracy between scientist and farmer. For Scotland, the implications were even less clear than for England, because the Scottish Agricultural Research Institutes were referred to only in a footnote.

Lord Rothschild emphasised the need for enhanced public accountability by the Research Councils. Informed observers mostly agreed with him as to the need, while disagreeing about the best means to satisfy it. At the time of writing, the Chief Scientific Adviser is collating submissions on the Green Paper, and the Select Committee on Science and Technology is conducting its own investigation of the matter. The Board of Directors submitted a letter on the subject to the Secretary of State for Scotland in February 1972. It is likely that, by the time this report is published, the Government will have issued a White Paper as a basis for policy. Government has already endorsed the customer/contractor principle adumbrated by Lord Rothschild but is thought likely to heed public protest by applying that principle rather more cautiously than Lord Rothschild proposed.

Potato Investigations

A new clone was submitted for Plant Variety Rights and entered for Statutory Performance Trials in 1971, following successful field trials at the Terrington, Gleadthorpe and Arthur Rickwood Experimental Husbandry Farms, and at the Station's new farm, The Murrays. This clone, number 6123b (1), derived from the cross (Roslin Riviera × 2534(36)) × Pentland Dell, is an early maincrop in maturity date with yield potential and dry matter content similar to Pentland Crown, although slightly earlier and with better tuber shape. It possesses the same resistance to virus Y as Pentland Crown but is, in addition, resistant to viruses X, A and B. It shows superior resistance to gangrene and marked resistance to tuber blight. Since one of the main breeding objectives of early maincrop varieties is to raise the saleable yield, clone 6123b (1) is seen as a possible advance on Pentland Crown because of its improved keeping quality.

The first year of trials and experiments with potatoes at The Murrays gave encouraging results and enabled selection to be practised under conditions much closer to those found in ware growing areas than had hitherto been possible. The significance of this point for the efficiency of selection was well brought out when, at the end of the season, maturity dates, recorded during the season were compared with weighed yields after lifting. Maturity was recorded in seven arbitrarily defined classes and the data are summarised in the table:—

Maturity yield of 4th-year clones in 12-tuber plots at The Murrays, 1971

	1E	E	2E	2E+	EM−	EM	EM+
Yield, kg/plot	8·2	10·5	12·7	16·3	17·0	19·1	23·6
No. clones	19	17	53	33	32	90	20
% clones	7·5	6·7	16·9	13·0	12·6	35·4	7·8

(Mean yield of Pentland Crown; 15·9 kg from 66 plots; maturity EM to EM+)

At Blythbank, clones with second early maturity (2E+) usually outyielded early maincrop. These data from The Murrays show a clear relationship between maturity date and yield and for the first time permit the assessment of yield potential of early maincrop clones and the definition of sub-categories within the broad early maincrop grouping.

The material in the fourth to seventh years of the general breeding programme was derived mainly from well-tried parents. This material provides annually about twenty early maincrops meriting replicated trials and of these about four or five are expected to be really promising candidates for further trials and consideration as potential new varieties. On the other hand, younger material, in its second and third years under selection at Blythbank, is the first of a wave of progenies derived from new untried parents selected for eelworm resistance, virus resistance or derived from the advanced clones of the Neotuberosum programme. The progenies derived from these new parents can be expected to include a larger proportion of clones which are inferior in one or more agronomic characters such as yield, maturity date or tuber shape. As this material, over the next four years, replaces the progenies of established parents now at The Murrays, the numbers of candidates for advanced trials can be expected to decline. This is an inevitable consequence of the broadening of the genetic base of the breeding material. However, as data from progeny tests of these newer parents becomes available, the more intensive exploitation of the best of them can begin and will result in second and third waves with higher retention rates through to the advanced generations.

A programme for the selection of high dry matter lines suitable for processing was begun by raising a large batch of seedlings under glass. These will be grown on as single plants at The Murrays and subjected, in the first field year, to rigid selection for high specific gravity. One-half of the seedlings were grown on sand beds with capillary watering of the pots. Results were satisfactory in terms of plant growth, tuber development and labour saving and it is intended that all the seedlings, up to a total of 80,000, will be grown in this way in future. The provision of new glasshouse accommodation, with forced draught, automatically controlled ventilation and aphid screening, effectively closes the one loophole in the system for control of virus infection in breeding stocks. Hitherto there has been a constant threat of leaf-roll infection of seedlings grown in unscreened houses. When this has in fact occurred, infected plants have been removed in the following year at Blythbank, but this was an unsatisfactory solution, in that Blythbank is intended as a virus-free haven for nuclei of breeding lines; furthermore, the rogueing of single plants represents loss of breeding material.

Some two thousand third-year clones, grown in three-tuber plots at Blythbank, were descended from crosses of *Solanum vernei*, a source of non-race-specific field resistance to eelworm. Unfortunately, the wild species itself and many of the *vernei* × Tuberosum derivatives in this material contain bitter tasting glycoalkaloids in the tubers. Selection of glycoalkaloid-free lines by taste is not possible because the taster's palate quickly becomes dulled. A simplified chemical test has therefore been developed, based on a published German method which utilises the development of a coloured complex on filter paper from the interaction of extracted glycoalkaloid with antimony trichloride. This test has been used initially to screen out the clones with zero or with very low glycoalkaloid content. Using more refined techniques and colorimetric determinations, it is hoped to study the genetic control of glycoalkaloid content and its relationship, if any, to eelworm resistance.

The virus resistance breeding programme continued with emphasis on the transfer of comprehensive resistance to virus Y into agronomically acceptable clones. In addition, and in parallel, the programme continues for the transfer of quantitative field resistance to Y from Phureja group diploids to Tuberosum. Most of these Y-resistant stocks are also immune to virus X and have a lower, but improving, level of resistance to leaf-roll virus. Leaf-roll resistance is not in itself difficult to achieve but, as it is associated in its expression with other, agriculturally undesirable characters, the selection of commercially viable clones with a high expression of leaf-roll resistance is a slow process. The most advanced products of this programme are now appearing in significant numbers in the regional trials at the three co-operating Experimental Husbandry Farms and at The Murrays.

In addition, the annual screening for virus resistance of material passing through the fifth year of the general breeding programme was continued. Replicated trials involving 1,300 three-tuber plots were planted at the Plant

Breeding Institute, Cambridge, to assess reaction, under conditions of heavy field infection, to virus Y and leaf-roll. The produce of each Cambridge trial is brought back and grown in the subsequent year at Pentlandfield for the scoring of secondary symptoms.

Evidence has been accumulating on the susceptibility of Pentland Crown to tobacco rattle virus. Simultaneously, and doubtless because of the steadily rising acreage, growers and merchants have expressed increasing concern about the adverse effects of "spraing" symptoms on market values of samples so affected. The first information was obtained in 1970 (see 50th Annual Report 1970-71) on variation in reaction to this virus in the breeding material. Following this lead, a serious attempt was begun in 1971 to investigate the range of variation in advanced breeding lines and the genetics of resistance to both soil-borne viruses. Two hundred clones were exposed to infection on land in Fife infected with tobacco rattle virus. Ten of these clones gave a negative response, which may indicate effective resistance, but regrowing in 1972 will check on the possibility of their being escapes from infection. Suitable unselected progenies are being prepared for genetic studies.

Potato mop top virus trials were conducted at three centres. Some 200 clones were grown at each; 22 showed no symptoms but little significance can yet be attached to this figure. Tubers from these "no response" plots will be planted in 1972 for observation of secondary symptoms. However, preliminary indications are that resistance to both viruses (or to their vectors) may be present in the advanced breeding material. The co-operation of colleagues at the Scottish Horticultural Research Institute, Invergowrie, has been of great value in the location of suitable trials sites.

The examination of the Commonwealth Potato Collection for the presence of potato spindle tuber virus continued. Plants grown at Pentlandfield under strict phytosanitary control, were sampled by collaborators from the Department of Agriculture and Fisheries for Scotland, Scientific Services, East Craigs, who conducted the standard "tomato" test in their glasshouses. Plants from lines shown by this test to be free from infection were inter-pollinated for seed renewal of the Collection. The Collection was divided into several groups differing in the likelihood of infection being present; the screening procedure was then carried out systematically, beginning with clonal material that had been grown in the quarantine house at the same time as the first infected clone, followed by seed progenies already harvested from plants at maximum risk and so on. Some 215 tuber lines and 400 seed lots were tested during the year. To date, infection has been demonstrated in two clones and two seed lines. One seed line was recently harvested from clonal material grown in the quarantine house at the same time as the known clonal reactor, but the other seed line had been in store in the Collection for many years. The screening will continue in 1972, when a strong effort will be made, in conjunction with DAFS, to complete the screening of the Collection. It is clear that, because it may be seed transmitted, the virus represents a threat to all potato collections. It is possible for infection to be present but undetected in wild species collections unless the appropriate specific tests are made. We hope to be in the happy, and possibly unique, position of being able to guarantee that seed lots from the Commonwealth Potato Collection are free from potato spindle tuber virus, when distribution is resumed.

In the Neotuberosum breeding project, an effort is being made to establish an earlier maturing sub-population by manually intercrossing early selections. A tendency to late maturity and to undesirable tuber shapes are two characters which have responded less rapidly than others in the mass selection experiment. In other respects, the best clones selected from the population are proving to be a valuable source of parents for the general breeding programme. Many clones now equal Pentland Crown in yield at Pentlandfield. About four-fifths of the clones are wart-resistant, half are resistant to virus X and one-third to virus Y, while others have given progeny with marked field resistance to blight. While cooking tests were disappointing, due to frequent blackening, specific gravities are generally high and crisping tests gave good results.

The experiment, begun in 1970, to estimate the frequency of cross-fertilisation and hence the amount of gene flow in the seed production plots of the mass selection Neotuberosum experiment was continued in 1971. A clone carrying a dominant marker gene for anthocyanin pigmentation of seedling hypocotyls was interplanted with a non-pigmented receptor clone. Seedling progenies from berries of the receptor clone were grown for scoring the frequency of pigmented seedlings resulting from natural cross fertilisation, together with progenies derived from manual cross pollination of marker pollen on receptors. Despite the apparent scarcity of bumble bees in 1970, 86 per cent of natural sets gave marked seedlings, indicating natural cross-pollination. Marked seedling frequencies in progenies were often very low and the possibility of some cross-pollination of the remaining 14 per cent cannot be excluded. Frequencies of marked seedlings varied widely from progeny to progeny and never attained the frequencies resulting from the manual crosses. Thus all natural sets were partly selfed. For three receptor clones, overall selfing was estimated at 90, 85 and 85 per cent. It would appear, therefore, that while most berries were formed on flowers which had been insect visited, effective cross-fertilisation was low. This apparent paradox may be explained by the way in which bumble bees manipulate a potato flower. Visitation is for the purpose of pollen rather than nectar collection and the bee hangs from the corolla, vibrates the flower and shakes pollen onto the lower surface of its abdomen whence it is combed into the pollen sacs. In this process considerable self pollination of the stigma probably occurs.

This study was taken a stage further by relating the field performance of seedlings and the selection or rejection decisions made on them, to their breeding origin. Thus, manually selfed- and open-pollinated progenies were very similar while those derived from the manual crosses were vegetatively more vigorous and gave higher tuber yields. However when final selections were made on tuber characters, such as shape and depth of eye, a higher proportion was retained from the selfed- and open-pollinated progenies than would have been expected from their inferior vigour and yield. Since improvement in tuber size and shape has always been a major selection criterion in the Neotuberosum project, the indications from this experiment are that good shapes have become fixed in a few lines in the population, through inbreeding on the one hand and a tendency to selective elimination of the products of crossing on the other. In order to maintain the genetic resources of the Neotuberosum population, as distinct from the élite clones already isolated, it may be necessary to introduce new variation from the basic Andigena source.

Work continues on the mass selection programme for the improvement in field and tuber characters of the diploid population derived from Phureja and Stenotomum sources. Tuber quality surveys were made. Seventy-two clones were submitted to the standard cooking test. Nine were classed as waxy in texture and the remainder were intermediate or floury. These texture scores were supported by specific gravity measurements made on seventy-eight clones. Fifty-nine of them had S.G. values greater than 1·080 (the S.G. of the Pentland Crown control used), ten had values above 1·100 (equivalent to 24 per cent dry matter), the highest being 1·119 (about 28 per cent dry matter). After-cooking darkening was infrequent and, where it occurred, it appeared to be associated with white flower colour. No white-fleshed types occurred and the majority were in the range cream-lemon-pale yellow. Intense yellow colours, outside the normal tetraploid range, were recorded in seven clones. This variation in tuber characters is of considerable interest and may have long-term practical value in the production of varieties for special purposes. Tuber yields per plant in the best clones were similar to, but tuber sizes were much less than, the Tuberosum controls.

The present holding of primary dihaploids numbers 150. Effectively, the number is less because tests are in progress for virus infection and all reactors will be discarded. Loss of material due to this cause should cease to be a problem when new aphid-proof glasshouse facilities become available in 1972. Fertility studies on dihaploids have been hampered in the past by the very low frequency of male-fertile primary dihaploids. However, a number of fertile lines obtained from Cambridge and the Netherlands have been intercrossed with each other and with Pentlandfield material to set up a pool of more fertile outcrossed material. This will be used for future studies on fertility as well as for breeding purposes. The induction of new dihaploids will in future be confined to the use of fertile advanced lines from the general breeding programme which can be selected, apart from fertility, for their known reactions to pathogens as well as for tuber and yield characteristics. In this way it should be possible to raise the general level of usefulness of the gene pool in the primary dihaploid lines.

In 1971, commercial varieties were used as yield controls in the field plots of dihaploid × diploid hybrid clones; six hybrids equalled Pentland Crown in yield. This is not to suggest that the parity would be maintained in an agricultural crop, but rather that total tuber yield does not appear to be a major problem in this material. In future, selection work will be directed primarily towards the improvement of tuber size, shape, and quality, and in particular to the introduction of tuber dormancy, which is notably lacking at the moment. For this purpose seed of seven Stenotomum progenies, chosen as sources of tuber dormancy from the Commonwealth Potato Collection, because of their origin in the highest altitudes and lowest latitudes in which the group has been collected, have been crossed with seven of the élite diploid clones. Studies of the degree of dormancy in parents and progeny are proceeding. In cooking tests, tubers of the dihaploid × diploid lines were of intermediate to waxy texture with flesh colours in the range cream to yellow. There was no after-cooking darkening and specific gravities were usually higher than Pentland Crown, in the range 1·085 to 1·100 (21–24 per cent dry matter).

Blight reaction tests were continued on leaflet samples from families of first year seedlings in the general breeding programme. Different types of resistance were again evident; tubers of selections were retained for further testing and for use in the investigations on the nature of these different manifestations of field or quantitative resistance. In order to assess the correlation between blight reaction in detached leaflet tests and that of field-grown plants, progenies which had been scored in 1969 by leaflet tests were subjected to field blight at Blythbank in 1971 in three-tuber plots. Results, yet incompletely analysed, should provide valuable data on the extent to which leaflet tests reflect field performance. Other, though less direct, evidence on this point was obtained during the year. Tests for resistance were made in the glasshouse on whole plants from families which had shown resistance in leaflet tests. In general, the two sets of results were in agreement, a finding which supports the continued use of detached leaflets for the testing of large numbers of seedling plants under uniform and controlled conditions. Both of these tests are severe. They are conducted under conditions favourable to the growth of the fungus and plants which show resistance under these conditions can be expected to do so in the field. At Blythbank blight reaction was recorded on single plants from families selected as resisters in the 1970 leaflet tests. In families derived from *Solanum vernei*, considerable resistance was observed where upper leaf surface resistance had been noted in leaflets in the previous year. Less blight than on controls was recorded in some Andigena-derived families which had been selected for sporulation resistance. This is the first evidence obtained in the field that the different manifestations of resistance observed in glasshouse tests could be of significance in blight control; it will provide a valuable impetus to the applied research on understanding the nature of resistance. Other interesting facets of this problem were revealed during the year and will be pursued as soon as circumstances allow. In parallel tests of identical Neotuberosum leaflets inoculated on the one hand with a race 4 culture, and on the other with race 1234+, differences in susceptibility were recorded. In separate leaflet tests on different Neotuberosum material but also lacking R genes, atypical hypersensitive type reaction and sub-normal sporulation were found.

It is now clear that there is no correlation between blight reaction of the foliage and that of the tubers. Small plot tests at Blythbank revealed that clones with a very high degree of foliage resistance might be very susceptible to tuber infections. To what extent the latter could be attributed to spore bombardment of the soil surface by adjoining plots with susceptible foliage, or to the greatly reduced spore production over a long period by the resisters, is not clear. This aspect of field resistance as it applies to monoclone crops obviously needs, and will receive, attention in the future. It seems likely that susceptible tubers in a crop with moderate foliage resistance could be at greater risk than those growing under a fully susceptible canopy.

Routine testing for tuber reaction to blight, gangrene, scab and skin spot of fifth-year material from the general programme continued. This work is now an integral part of the breeding programme. The results obtained, with the exception of skin spot, were satisfactory and the levels of resistance observed were promising. Very little disease resulted from the skin spot inoculations. This failure was undoubtedly due to inability to control the tuber environment during incubation but, with new facilities now being planned, it is expected that this situation will be rectified in the near future, and that all the latent tuber disease testing will be performed under controlled conditions.

A number of biometrical studies were completed during the year. The possibility of using a penetrometer for assessing dry matter content of tubers had been investigated in the past and while, for reasons of speed, specific gravity measurements are preferred and used, the analysis of the data from the penetrometer study is of interest. Twenty-eight cultivars were scored for penetrometer readings, specific gravity values and dry matter percentages. Genetic variation was demonstrated for each of the three characters and all three were shown to be positively correlated. Thus selection for high dry matter by means of the penetrometer or specific gravity tests is justified. Using a combination of both scores was no more efficient than the use of specific gravity alone. Because of the very high genetic correlation between dry matter and specific gravity and because the heritability of the latter was shown to be greater, selection for high dry matter would better be done by selecting for high specific gravity than by selecting directly on dry matter content. This is satisfactory since specific gravity is the easiest of the three measurements to make.

Biometrical genetics in general has been concerned almost exclusively with diploids and, at this level, has proved a useful adjunct to plant and animal breeding programmes. Potatoes however are autotetraploids, with a tetrasomic pattern of inheritance, and past breeding has proceeded without benefit of knowledge of the genetic basis of the metrical traits under selection. Information on the types of gene action controlling these traits should help in selection efficiency by indicating the most appropriate choice of parents and the most suitable method of selection to adopt. The theoretical expectations of means and variances were calculated for progenies obtained from a cross between two inbred tetraploid lines. These expectations were shown to be very complex, involving up to ten parameters. A scaling test was derived to detect epistasis regardless of the degree of double reduction. The complexity revealed by this study, while not entirely unexpected, is of such a magnitude that the conclusion to be drawn is that, rather than attempt the formal biometrical-genetic approach, it is probably more useful to concentrate on the estimation of combining abilities.

This point was followed up in relation to field resistance to blight. As discussed above, first-year seedling progenies are routinely scored for blight reaction in detached leaflet tests. Some of this material was arranged in mating designs known as North Carolina 1 and 2. Analysis of the experiments revealed clearly that most of the genetic variation between progenies was due to specific combining abilities between particular parents. Although in the North Carolina 2 experiment there was some evidence that parents M 109-3, 3683a (2) and 2516 (2) did give rather better progenies than the other twenty-seven parents tested, general combining ability was of little significance in this material. These results are of great interest to breeders concerned with this important character. They indicate that, on the whole, parents cannot be classified as good or bad parents for blight resistance since the reaction of the progeny depends on unpredictable genetic interactions between particular pairs of parents which may only be determined by testing pilot progenies. Progeny testing is thus a necessary prerequisite to efficient breeding for blight resistance.

Since the transfer to The Murrays of the greater part of the potato selection work, only the second- and third-year material (single- and three-tuber plots) is now grown at Blythbank for selection purposes. This has enabled the operation of a seed production regime on the Blythbank plots with burning-off of foliage at times appropriate to the production of seed size tubers and without the conflicting requirements of selection which had to be met in the past. The availability of two centres has permitted the resolution of another dilemma. While maturity scores and yield data can be recorded at The Murrays under blight-free conditions, due to the operation of a suitable spraying routine, blight reactions may be recorded each year at Blythbank on the second- and third-year material. Transplanted glasshouse-grown infected plants are used as primary foci of inoculum. Thus the opposing requirements are met by spatial separation of the two groups of material. One is deliberately subjected to blight conditions and the other is to be maintained in a largely blight-free state.

New overseas contacts were made during the year and old contacts maintained with Thailand and India, who have received Pentlandfield breeding material in the past. Material was sent for the first time to Jamaica and Ghana; several of the newer Pentlandfield varieties were sent to France, Norway and Russia, and a large selection of material went to Canada. Much seed material from the breeding programme was sent to Nairobi as a contribution to the Kenya potato breeding programme. Finally, it has to be recorded with regret that, despite requests to overseas recipients for information on the performance of material supplied, with few exceptions they rarely respond.

The first year's development work on the single plant potato harvester was a considerable success. Extensive modifications were made to an old Grimme machine. Field trials in 1971 showed that the principles adopted to achieve separation on the belt, of tubers of different single plants, were sound. As a result of this first year's experience it has been decided to purchase the necessary parts of a new machine, to carry out the modifications which have already been tested and to add certain additional refinements which suggested themselves in the field trials. We now have a good prospect of mechanising the harvest of our expanding acreage of single tuber plots, a prospect which meets with the approval of the farm staff.

Work in the cytology laboratory during the year has involved potatoes, *Brassica*, *Raphanus*, *Poa* and *Hordeum*. Much of the *Brassica* work has consisted of ploidy checking in colchicined material and its progeny. In addition, meiotic examinations have been made in dihaploid potatoes and in kale. A search for translocations was made in barley breeding material, and an increasing amount of photomicrography has been done as part of the cytology service.

Forage Crops Investigations

Oat breeding. The advent of Plant Variety Rights is bringing about a change in emphasis in the selection programme. Varieties which give a high yield under lowland conditions dominate the scene, as they always have done, but whereas, formerly, a special purpose variety suited to the needs of a marginal area could be released and allowed to find its place in the economy (as happened with Bell and more recently Shearer) there is less prospect of finding a market for similar varieties in the future. This is perhaps exemplified by Pentland Provender, the first and possibly the last special purpose oat to be released by the Station since the Act came into force. It is an early ripening variety for late upland districts; one of its favourable characteristics is a resistance to summer drought. As a special purpose variety it was not expected to reach a large acreage but so far it has made remarkably little headway.

Oat varieties suited to the needs of marginal areas are relatively more important to-day than they were ten years ago; marginal land forms a substantially larger proportion of the total acreage as a result of the displacement of oats by barley over much of the lowland arable area. The lowlands, however, form the seed reservoir for the less favoured areas and to be successful the variety released for marginal conditions must be acceptable to the lowland farmer.

Selection and early generation testing from composites continued at centres in Argyll, Inverness and East Lothian. Initial screening of selections takes place at the centres of origin with the most promising of them going into later generation trials which are common to all centres. A good all-round performance is looked for with strong emphasis on acceptability to the lowland farmer. Facilities for trials on a larger scale than is possible at the selection centres are now available, with Statutory Performance Trials as the final link in the chain. Concurrent with the latter are the Index Trials, of which the object is to establish whether a new variety is uniform, stable and distinct. Stocks of five selections are now being multiplied to provide, in the autumn of 1972, the 500 heads and 2 cwt. of seed required for this purpose, with a further six to follow in 1973.

Of the five stocks for 1972 application, two (Aa 743 derived from Ayr Commando × Albyn Bard; and Aa 744 from a cross involving Elder, Star, Marvellous and Sun II) were selected for their performance in Argyll and Inverness; they may prove unsuited to general cultivation. The remaining three—C.253 (Onward × Sun II, selected in Inverness), C.258 (Albyn Bard × (Elder × (Star × Marvellous)), selected in Inverness) and C.284 (Onward × Sun II, selected in East Lothian)—have, in a series of trials at the three centres and over a period of five years, outyielded Blenda on 11 out of 15, 10 out of 15, and 8 out of 13 occasions, their overall performance being respectively 106·9 per cent, 105·0 per cent and 100·0 per cent of Blenda. In the same series of trials, Forward was rated 86·5 per cent and Condor (10 trials in Inverness and East Lothian only) 103·6 per cent. Also in the same series, 12 trials over 4 years, a stem eelworm resistant selection, E.284 ((Milford × *A. ludoviciana*) × Lightning^2) was rated at 96·7 per cent of Blenda, having outyielded it on 4 occasions. The future of this and of another resistant selection, E.542 ((Milford × *A. ludoviciana*) × Blenda[2]), less extensively tested but of the same order of yield, both of which are being multiplied for P.V.R. application in 1972, will depend on the value which the farmer places on eelworm resistance. By the time a final decision is called for, these may be surpassed by resistant selections of 3rd and 4th backcross material now entering trials.

In breeding special purpose varieties, one area of activity calls for particular mention—namely, the machair of the Western Isles. Single plant selections were made in Tiree in the autumn of 1971. These are at present being multiplied at Pentlandfield for trial in alkaline soil conditions. The source of these selections was a bulk of eelworm-resistant hybrids found to have some tolerance to high pH. A variety peculiarly adapted to the machair has no commercial future, though one with another attribute such as eelworm resistance may have; the long-term solution to the problem may lie in the continuing cultivation of mixed or composite cross populations, though there is at present no provision for these to be legally sold.

Two-thirds of the oat museum, containing 405 accessions, was grown in the field and glasshouse. Description of key morphological characters has begun. The collection of eelworm resistant lines bred at the Station was also grown. No attempt at description is being made in this case.

Although no new crosses have been made in the last two years, routine winter inoculation of hybrid material is still taking place. F_2 hybrid material was grown this year at Currievale on land known to be infested with oat stem eelworm (*Ditylenchus dipsaci*). It was hoped that this method would screen out the most susceptible plants from a bulk of seed larger than can normally be handled. Unfortunately weather conditions did not favour attack and only a few plant showed symptoms. At harvest, nine hundred plants were selected and their progeny subjected to winter inoculation tests. The results of the tests showed that there was a very high proportion of susceptible plants, confirming that the screening effect in the field had been negligible. The exercise did result however in only agronomically desirable material being subjected to winter tests and also enabled two generations to be grown in a year whereas normally only one generation is grown. A large-scale attempt to use multivariate methods to detect a second major gene for resistance to eelworm failed to do so, probably because the measurements used were not adequate.

Barley breeding. To assess the importance of mildew as a factor limiting barley yields in Scotland, a series of trials has been run since 1969 in which the varieties Golden Promise, Ymer and Julia were compared, with and without seed treatment with the commercial product, Milstem. To get good control of mildew, Milstem was applied at twice the rate recommended by the makers and so the trials should not be regarded as a test of the fungicide.

The varieties were chosen to represent a range from susceptible (Golden Promise) to resistant (Julia). In 1969 there were 13 trials to harvest, with very small plots. Mildew on the untreated plots of Golden Promise ranged from negligible to moderately severe. Some of the sites gave very low yields indeed. In 1970 and in 1971 five trials were grown, with larger plots. There was a fair amount of mildew in all these trials and yields were satisfactory. To test whether a better response to nitrogenous fertiliser is achieved when mildew is controlled, a top dressing was applied to half of each plot in three of the 1971 trials. This increased tillering and mildew infection and reduced the 1,000-grain weight but had so little effect on yield that no conclusions could be drawn.

The mean yields are shown in the table. The overall response of Golden Promise to fungicide treatment is about 4 cwt/acre (49 g/m²). In 1970 and 1971 its response was about 5 cwt/acre; given that Golden Promise was probably grown on more than a third of the barley acreage in Scotland, it is clear that mildew must have caused substantial losses. The Station's barley breeding must take account of mildew resistance. In 1971, Ymer gave as big a response as Golden Promise to Milstem and it may be that more resistance than Ymer's would be necessary. On the other hand, Golden Promise may have been, in Shakespeare's words, " a mildew'd ear, blasting his wholesome brother ", and, if most barley in Scotland had the Ymer level of resistance, damage might be reduced to tolerable levels. The Julia level of resistance is obviously very good, but a breeder could probably afford to trade some of it off against a higher potential for yield or quality. These trials by the Station ran parallel to a larger series with the same treatments, organised by Dr J. Gilmour (Edinburgh School of Agriculture), which have led to very similar conclusions.

Yields (g/m²) from 3 year's Milstem trials

Variety	Golden Promise		Ymer		Julia	
Milstem	−	+	−	+	−	+
1969 (13)	392	418	433	432	431	434
1970 (5)	511	568	558	581	572	590
1971 (5)	482	548	490	555	485	510
Mean	462	511	494	523	496	511

(100 g/m² = 8·0 cwt/acre)

Variety-nitrogen trials were run at the same three centres as in 1970, but in 1971 a spray to control mildew was introduced as an additional factor. The intention was to see whether differential responses to mildew and to nitrogenous fertilising were responsible for inconsistencies in variety performance at different sites (genotype-environment interaction) and, in particular, whether mildew infection reduced response to nitrogen. There were large and statistically significant main effects of all factors and also significant interactions of spray with sites, varieties with sites and nitrogen with sites. The interactions involving only the factors under control were not statistically significant, suggesting that site attributes which were not under study were causing most of the inconsistencies in variety performance at different sites. Some confirmation of the suspicion that mildew infection limits response to nitrogen emerged; Golden Promise, notoriously susceptible to mildew, gave yields about equal to the average of all ten varieties at any level of nitrogen when it was sprayed and also at the lowest (30 units) level when it was not sprayed. With 60 and 90 units of nitrogen it fell behind the average by 32 and 43 g/m² (about 2½ and 3 cwt/acre) respectively. Statistically, the odds against this result being due to chance fluctuation are about 12 to 1; further confirmation is needed. Summaries of data on yield, mildew infection, tillering and lodging can be provided on request to the Station.

The diastatic power (DP) and α-amylase activity (α) of green malt were determined plot-by-plot for seven of the ten varieties in the 1970 variety-nitrogen trials. In the first place these determinations were made manually by Institute of Brewing methods. Kjeldahl nitrogen of the grain was also determined manually. The results confirmed the conclusions stated in the 1970-71 Annual Report: DP is correlated with N and with α; when the source of variation is environmental, α and N are not correlated but when it is genetic there is a small positive correlation (in this case not statistically significant).

With the acquisition of an automatic analyser the distillation and titration part of the Kjeldahl procedure was replaced by an automatic colorimetric procedure, DP determination was fully automated, α determination on heated extract was replaced by an automatic method using β-limit dextrin and green malt was replaced by gently kilned malt. The relations of the results of those obtained manually was thoroughly checked by repeating all determinations done on one variety-nitrogen trial. With DP and N determinations the agreement was good after the initial snags had been overcome. The newer method for determining α is believed to be more precise; it shows different relationships to the other measurements and further work on this aspect is needed. Kilning reduced DP by an average of 35 per cent. The whole procedure increased the operator's output several times.

A result of possible direct practical importance was that the variety Akka produced kilned malts with a DP in excess of 300° Lintner. This is in the range obtained from imported Canadian barley. Other features noted in Akka were high N, freedom from mildew, earliness, rather low yield and a tendency to throw up late tillers in response to nitrogenous top-dressing.

The beginning of a selection experiment in a barley composite cross, using the "halo" test to measure DP, was described in the 1970-71 Annual Report. Plants were classified into high (H), medium (M) and Low (L) DP and 100 progenies were grown in each class in 1970. From each progeny, 5 plants were selected at random and 10 grains from each were set out for germination. Some trouble was encountered with dormancy (less in the H progenies) but halo diameters were determined from those seeds which did germinate. The means for the three classes were H 18·36 ± 0·05 mm, M 17·94 ± 0·05 mm and L 18·04 ± 0·04 mm. M and L are not significantly different but H is significantly higher than either. The response to selection for high DP corresponds roughly to a difference of 40° Lintner. A further 100 selections in each of the H, M and L classes were grown in 1971 and halo measurements of the produce have now begun.

The start of another selection experiment, with a different barley composite cross, was also noted in the 1970–71 Report. It was concerned with the use of canonical analysis to select high-yielding feeding barley. An error in calculation led us to believe that none of the 900 progenies met the formal criteria for selection. In fact there should have been 16, 15 of which were actually included in a replicated trial grown in 1971 with 37 other progenies and control varieties. Canonical analysis was again used to narrow the choice of progenies; the limits of the canonical variates were defined in a different way. Conventional methods of progeny-test selection from composites were also started in 1971. By selecting against excessive height, earliness and mildew susceptibility, 703 F7 progenies were reduced to 276 for further examination in 1972. From later composites, 1,100 single plants were taken for progeny tests in 1972.

Parents, F_1 and F_2 generations of the large diallel cross were grown for the second and final time. The 1971 site, at The Murrays, gave rather better conditions than in 1970 at Pentlandfield. The same attributes as in 1970 were recorded and the analysis of one of them (days to heading) has been completed. The development of computer programs and file-handling procedures may also be regarded as complete, but a start has yet to be made on measuring malt attributes.

Canonical analysis has also been applied to the 1970 diallel data. In this experiment, data are available for a large number of variates and the relationships within the material are known. In the analysis for the parents and F_1, 76 per cent of the variation was accounted for by the first two axes. When these were plotted against each other a rather surprising result emerged. It was expected that the points representing hybrids would fall close to the mid-parental points and, indeed, in the case of hybrids between two-row parents or hybrids between six-row parents this was so. However, hybrids between two-row and six-row parents were displaced quite markedly from their expected positions and tended to form a separate constellation. When distances were calculated in canonical units, using all significant canonical variates, the deviations of the six-row by two-row crosses from the mid-parental position were again unexpectedly large. It is not easy to interpret these results but, if they are confirmed by analysis of data from the 1971 diallel experiment, the evidence will be very strong for complex genetic or cyto-genetic interactions in hybrids of two-row by six-row parental origin. This phenomenon was not detected when the analysis was applied to the parents and F_2 generation.

Diallel analysis of the first two canonical variates showed that no non-additive variation was present in the first but that both additive and non-additive variation was detectable in the second.

Pedigree breeding has been started in both the feeding barley and high diastase projects. Over 14,000 F_2 plants grown at The Murrays have given rise after selection to some 1,500 F_3 progenies representing 30 crosses of interest for feeding barley. In the high diastase project 5,000 F_2 plants from Midas × Akka were reduced to 1,000 by selecting for tillering and against height; F_2 plants of Clermont × Olli and Clermont × Pirkka were more stringently screened. We are indebted to the DAFS Scientific Services for the loan of automatic dibbing equipment for this work. F_2 seed of about 150 crosses was produced, in the field or greenhouse, for both programmes.

The project concerned with transferring the gene for high amylose content from Glacier to nine other varieties reached the stage at which six back-crosses have been completed for all eight recurrent parents (Akka, Golden Promise, Julia, Midas, Proctor, Sultan, Ymer and Zephyr). With the exception of the Golden Promise derivative, all 6th back-cross lines have been selfed at least once and, in some cases, twice. During the back-crossing the recurrent parents were used as pollinators and so only two types of endosperm needed to be distinguished, one having three normal alleles and the other two mutant alleles plus one normal. With practice, this was quite feasible on the basis of starch grain size, the homozygous normal having starch grains of a higher average size. On selfing the advanced back-cross plants it was, however, found that the starch-grain phenotype of the original mutant in Glacier was not recovered. The simplest explanation is that the expression of the gene is different in the new backgrounds. Further experiments will be needed to test whether this explanation is both necessary and sufficient. Meantime, the intended procedure has had to be modified to allow for identification of homozygous high-amylose derivatives by chemical tests, implying a delay of a generation to grow enough material. A suitable chemical procedure for screening is being sought and attempts are also being made to refine the examination of starch grain preparations.

Further evidence was obtained on the linkage relations between three single loci, controlling respectively variation in α-amylase, in β-amylase and in esterase isozymes in germinating grain. No linkage was detected between any of them. The rarer type of β-amylase (11 out of 36 cases) is relatively more frequent in varieties with high DP and so the average effect of the substitution is under study. Examining the amylase found in grain as it develops in the ear showed that different isozymes of β-amylase appear and fade out in the course of maturing. One of these may be controlled by the same locus involved with the malt β-amylase polymorphism, but another shows variation which is not reflected in the isozymes of malt.

By using abscisic acid as a screen, 23 grains were selected from about 8,000 M2 grains produced from Ymer treated with the mutagen, ethyl methane sulphonate. The theory that this procedure would select for higher production of gibberellic acid (see 1970–71 Report, p. 23) received some confirmation when it was found that 2 of the 23 resulting progenies germinated quickly. Thin layer chromatography showed, furthermore, that their production of gibberellic acid (GA3) was equivalent to that found in high DP types. One of the two may be a contaminant rather than a mutant, but this does not detract from the value of the screening technique. The nitrogen content of each of the 23 selections has been measured and DP estimations are in progress.

The recording of ear and grain characters of accessions in the barley museum continued and for 559, out of a total of 984, has been completed. Characters of the growing plants have been recorded for 326 of the 559 accessions.

Grass breeding. From pollinations made in 1968 using *Poa pratensis* as pollen parent on the mainly apomictic species *P. ampla* and (less extensively) on *P. iberica* and *P. longifolia*, hybrid offspring were identified in 1970. In 1970–71, seed was produced from the hybrids by selfing, back-crossing, sib-pollination and open-pollination in the greenhouse. This was used to plant 87 progenies in the field as spaced plants in August 1971. No data were collected from these small plants but observations were made on representatives of 22 of the progenies which were also planted in June. The degree of variation within progenies suggested that the F_1 hybrids had produced a high proportion of their offspring sexually, even when both parents were mainly apomictic. The rhizomatous habit derived from *P. pratensis* was observed in 66 per cent of all these plants. There were two families derived from *P. iberica* × *P. pratensis* hybrids. They were leafy and vigorous and at the end of February 1972 still showed a few plants with little frost damage. Further pollinations of *P. ampla* and *P. pratensis* were made in 1969 and 80 possible hybrids were cloned and planted with their parents in a replicated trial in 1970. Data for multivariate classification of this material are now almost complete. The plants showing no winter damage were either *P. ampla* itself or offspring with the erect, bunch habit. Seed has been raised from this series, in the same way as with the 1968 series, for planting in 1972.

Progress has been made with the selection project aimed at a high-yielding variety of cocksfoot with good digestibility, to replace Scotia cocksfoot. In the second-cycle composite, *in vitro* digestibilities (DOM) ranged from 47 to

78 per cent; only 12 per cent of the plants were below 60 per cent DOM and 15 per cent reached 70 per cent or more. In the first-cycle composite almost half were below 60 per cent DOM. F_3 seed of 114 progenies, representing parents with at least 70 per cent DOM, has been sown in the greenhouse for planting as clones in the field. This project continues to be hampered by low output of digestibility determinations. In the current year electricity cuts caused a back-log of several hundred determinations.

Our other composite cross with cocksfoot, based on nearly 500 accessions, reached its third generation with the harvesting of seed from a sward plot. An incomplete diallel cross involving 18 of the accessions was studied in a field experiment, now terminated. Analysis of the results is proceeding; heritabilities for yield in different cuts ranged from 0·25 to 0·45. Digestibility determinations from the numerous plots, although intended, proved to be beyond our capabilities.

Some 200 plants of Italian ryegrass, selected for winter hardiness, produced seed after replanting in an isolation plot. Progenies have been raised in the greenhouse from these for comparison with a bulk (derived from the remaining 2,000 unselected plants) and with control varieties. Inbreeding of both perennial and Italian ryegrass continued. The second generation of selfing and the first of full-sib mating were completed during 1971. A large experiment on grass breeding techniques, using Italian ryegrass, was successfully established in the field. It involves 120 progenies from a North Carolina 1 design of crosses, planted at three spacings in each replication. Some observations were made in 1971 but most of the data will be recorded in 1972.

In collaboration with the Welsh Plant Breeding Station and the Cambridge Plant Breeding Institute an experiment with perennial ryegrass was conducted with the objective of finding a management which would give a good discrimination between varieties in respect of winter hardiness. Nitrogenous fertilisation and cutting sequences were the management factors. So far, none of our plants have died, but there were large effects of management and variety on the proportion of leaf damage. On the basis of results at all three centres, it should be possible to choose a management which maximises the difference between varieties in this respect. At Pentlandfield, our own variety Scotia came through the winter with the least leaf damage. To get a substantial winter kill, it seems we would have to site plots at a higher elevation than Pentlandfield's 600 feet (180 m).

A nucleus of typical Scotia ryegrass plants has been established at The Murrays in isolation for seed production.

Brassica breeding. The breeding of a replacement for Pentland Harvester swede, with its uniformity and high yield but with better resistance to raan, continued along the established lines of inbreeding with selection. The seven crosses of which Pentland Harvester was one parent produced F_4 seed for replicated trials in 1972. F_3 progenies of nine other crosses were grown at The Murrays, with varying numbers of replications; selections for selfing have been made, taking account of size and shape, freedom from raan and freedom from club root. Another cross was grown as F_2 for selection, and F_3 seed was produced from two crosses.

All the élite lines of Pentland Harvester were grown with and without boron fertilisation. Some will be selected to produce a new stock of breeder's seed. A few lines showed markedly less raan than those in adjoining rows and one showed no raan at all. Two isolation plots have been planted with roots from these lines.

In the hope of exploiting the marked hybrid vigour found in intervarietal crosses of swedes, attempts are being made to develop self-incompatible lines. A station selection, called APZ by Dr Davey, and found by him to be self-sterile, was retested. It gave more seed from selfing flower buds than from selfing open flowers; this is characteristic of self-incompatible brassicas. Confirmation was obtained by examining pollen-tube growth on self-pollinated stigmas, using fluorescent staining and an ultra-violet light microscope. Although pollen germination was poor, the pollen tube coiling characteristic of self-incompatibility was observed. Six lines of APZ were isolated in the field with the variety Parkside and seed has been obtained to estimate natural crossing. Another selection also showed better seed set on bud-selfing than on open-selfing but UV examination of self-pollinated stigmas showed compatible tube growth. From the routine selfing programme, 27 plants showing low seed sets were examined and all showed compatible pollen-tube growth. Two lines of artificial *B. napus* (amphidiploid *B. campestris* $\times$ *B. oleracea*) showed incompatible pollen tube growth after selfing; a third has still to be tested. In an attempt to produce more plants of artificial *B. napus*, 1,250 flowers of tetraploid kohl rabi were pollinated by tetraploid turnip; 231 ovules showing some development were used for embryo culture but no plants were obtained. Only one ovule had a visible embryo and this was so big it was probably pure *B. oleracea*. Another possible way of breeding self-incompatible swedes would be to transfer *S*-alleles from *B. campestris* by back-crossing. With this aim, three varieties of turnip have been crossed with three varieties of swede.

Because embryo culture is so important in relation to wide crossing in Brassica (*e.g.*, to obtain artificial *B. napus*) the technique was studied in some detail, using normal swede embryos. Little success was obtained with embryos at the pre-heart stage but with later stages quite good development was obtained. Gibberellic acid, though not essential, proved useful in promoting root development.

Male sterility might also be used to exploit hybrid vigour. Several thousand flowering swedes examined yielded nine plants with shrivelled anthers. Seed has been produced from seven of these; in some cases self-fertilisation was possible, some pollen having been produced at the end of the flowering season.

Tetraploid turnips produced at the Station for use as parents of amphidiploids may have economic value in their own right and so a 5 × 5 diallel cross has been made with them, parallel with the same matings among the diploids from which they were derived. In a late-sown trial (1st July 1971), comparing two Dutch tetraploid turnips with their corresponding diploids and with British diploids, the highest yields of dry matter were obtained from the Dutch diploids.

In the 1970–71 Annual Report evidence was given to show that maternal-type plants (matromorphs) arising when *B. oleracea* was pollinated by *B. campestris* were not completely homozygous. A wide range of flowering times was observed in a progeny produced by selfing a matromorph. Early and late plants were selfed again to see whether genetical variation was involved; if it were, it would provide further evidence of heterozygosity in the matromorphs. On the hypothesis that matromorphs arise by diploid parthenogenesis with failure or restitution of the second division of meiosis, they should be more inbred than plants resulting from one generation of selfing. If so, the latter would give more variable progenies on selfing than would matromorphs. Multivariate comparisons of two progenies of each type showed the matromorphs' progenies to be less variable. This agrees with the hypothesis but is not enough to prove it because the progenies traced back to different grandparents. Seed has now been produced which will allow the critical comparison to be made.

A by-product of the matromorph work was a pair of lines of artificial *B. napus*, different from most which have been produced in that their cytoplasm is derived from *B. oleracea*. It is arguable that natural *B. napus* has cytoplasm derived from *B. campestris*; the cross is easier with *B. campestris* as female and *B. napus* crosses easily with *B. campestris* but rarely with *B. oleracea*. The artificial *B. napus* has therefore been crossed reciprocally with both swede and rape.

Among the matromorphs from kale was one that was female-sterile but male fertile. Cytological examination showed it to be diploid ($2n = 18$) with variable desynapsis in its pollen mother cells. Crosses to other plants produced normal offspring but five plants obtained after persistent bud selfing showed desynapsis like their parent. Probably a recessive gene is involved and, to check this, hybrids with normal plants have been selfed to study segregation for desynapsis.

A pilot study was conducted on the possible commercial use of sesquidiploid (effectively triploid AAC) hybrids of turnip and rape. Individuals of Bruce or Wallace turnips were isolated with individual plants of different rape varieties. The "hybrid" progenies from turnip were compared in a replicated trial with the varieties from which the rape plants were taken. The frequency of hybrid plants in the progenies ranged from 30 to 95 per cent, a wider range than could be put down to sampling error. The hybrids tended to resemble the tetraploid parent (*B. napus*) but had more leaf and less stem. At harvest only one "hybrid" progeny (actually mixtures of hybrids and inbreds) failed to yield more than the comparable rape variety. Unexpectedly, the differences from the controls were not correlated with the frequency of actual hybrids. There was a correlation of 0·65 between yield of progeny and yield of control, suggesting that choice of rape parent is important. The next step is to use turnips of uniform genotype in respect of self-incompatibility (*S*) alleles and so 20 progenies produced by bud selfing are being raised from which to identify and multiply *S*-allele homozygotes.

The work on *Raphanobrassica* continues to be hampered by sterility. The new F_1 hybrids, produced by crossing tetraploid fodder radish with tetraploid kale hybrids, showed the usual low fertility on bud selfing; most plants gave no seed at all. About 500 plants in F_3 were grown in a polycross arrangement in the field and here there were signs that the inevitable selection for fertility was producing some response. Even so, 68 per cent of the plants were sterile. The most fertile plant gave 572 seeds and 24 plants gave over 200 seeds each. A consequence of the intense selection for fertility is that the range of original hybrids still represented in F_4 seed is very restricted. Aneuploids with $2n = 35$ or $2n = 37$ chromosomes were fairly frequent in a sample of F_3 plants. With a view to testing for resistance to club root, infective material has been collected from a fairly wide range of hosts and sites, with the collaboration of the three Scottish Colleges of Agriculture.

A single hybrid, resulting from many pollinations of tetraploid fodder radish with tetraploid stubble turnips, proved to be triploid ($2n = 28$). It showed mainly 9 bivalents and 10 univalents at meiosis. It crossed fairly readily with diploid radish but produced only one seed by bud-selfing. About half its pollen was stainable. Chromosome numbers in its open-pollinated progeny ranged from 19 to 22, suggesting a rapid elimination of *B. campestris* chromosomes.

In connection with the work on wide crossing, diploid or auto-tetraploid forms have had to be developed, some of which appear worth testing in field trials as potential fodder varieties in their own right. A late-flowering, tetraploid fodder radish, in a bolting trial at The Murrays with a range of six sowing dates, gave no bolting from early July sowing. In this respect it is clearly better than commercial fodder radish. Other tetraploid radishes have yielded no better than the corresponding diploids. A late-flowering diploid fodder radish, in trials at the Grassland Research Institute, Hurley, gave a lower crude fibre and a higher water-soluble carbohydrate content than commercial fodder radish; here also the tetraploids gave no better yield than the corresponding diploids. An autotetraploid of *B. campestris* ssp. *oleifera* var. *nipposinica* gave about the same yield of dry matter as broad-leaved Essex rape but with lower digestibility, crude protein and water-soluble carbohydrate. A tetraploid form of Canson thousand-headed kale was not inferior to its diploid progenitor in dry matter yield but was lower in digestibility. In general it looks as though tetraploidy *per se* has little to offer.

In further trials involving the hexaploid *B. napocampestris* (NC), six NCs, based on different *B. napus* cultivars and *B. campestris* sub-species, were compared with commercial rapes. All NCs were significantly lower in dry matter yield than Giant English rape, again partly a reflection of their lower dry matter content. Three NCs significantly outyielded dwarf Essex rape. Considerable leaf senescence, due to early frosts, may have influenced the results.

An autotetraploid form of 'Maris Kestrel' marrow-stem kale has been produced for use in inter-specific and inter-generic hybridizations in the hope of creating artificial forms of rape and *Raphanobrassica* with high stem edibility. The breeding objective might be described as "marrow-stem rape or rape-substitute".

The Murrays

On the whole, the first year has been fairly successful. Soil samples taken during winter 1970–71 showed satisfactory levels of phosphate and potash; pH was good, apart from 118 acres, which have now been limed.

One hundred and fifty acres of barley were sown, principally Ymer, but with about 20 acres of Golden Promise. The remainder of the cereal acreage was made up of 10 acres of oat multiplication plots, oat trials and barley trials. Fertiliser was applied at the rate of 2¼ cwt per acre (284 kg per ha) of 20-14-14 fertiliser. The cereals grew well on the whole, though couch grass presented a local problem and there were some wild oats, which were rogued out as far as possible. By late August there was considerable lodging, despite the relatively low rate of nitrogen applied.

Harvesting started on 25th August and finished on 23rd September. Lacking facilities for drying grain, harvesting was restricted to periods when the grain was dry enough to store until removed by purchasers. As a result of shortage of storage space the last field harvested suffered considerable losses from lodging and shedding. Yield varied from 31 to 38 cwt per acre for Ymer and was 41 cwt for Golden Promise. Grain moisture percentages ranged from 14·5 to 19·5. Out of a total of 243 tons, 65 suffered a price reduction for high moisture. Gross cash returns from barley were £5,918. The oats were sold for seed and realised £210.

Approximately 19 acres of commercial potatoes were planted. These were mainly Pentland Crown with 1 acre of Kerr's Pink. The area was divided to provide four blocks of selection and assessment plots, totalling 8 acres. The ground was dunged and fertiliser was applied at the rate of 8 cwt per acre potato fertiliser (14-14-21). Again, couch grass presented a problem, but the potatoes generally grew well. The crop was sprayed for blight on two occasions and the shaws pulverised or burned down in early October. Lifting started on 18th October and was completed on 8th November. Pentland Crown yielded about 11 tons per acre, Kerr's Pink about 8 tons. The principle has been accepted that, from 1972, no commercial potatoes will be grown. The smaller the acreage the better, from the health viewpoint. So, from this year, potatoes will be experimental and domestic only.

Seventeen acres were allocated to Brassicas. Of this area, 11 acres were sown with swedes, 3 acres of this being selection and trial plots of new swede hybrids. The remaining 8 acres were given over to commercial varieties following treatment with Treflan (which was effective). Fertiliser was applied at the rate of 8 cwt per acre potato fertiliser (14-14-21). Difficulty in getting a good tilth for sowing caused uneven brairding which, aggravated by drought, resulted in delayed growth. Eventually a moderate crop was obtained, which was eaten off by sheep.

The remaining 6 acres of Brassicas were sown with trials of kales, rapes, napocampestries, fodder radish and stubble turnips for yield assessment and study of effects of sowing dates. Selections were made for seed production.

Grass consisted of 87 acres, which were let for grazing. For most of the year stocking with sheep and cattle was heavy. One half-acre plot of Scotia ryegrass was sown in the spring for seed production and two half-acre plots of S.22 and one half-acre plot of Scotia were sown in the autumn.

Thirty-two acres of grass were ploughed in winter 1970-71 and this area was fallowed during 1971 to provide clean ground for potato and cereal plots in 1972. The area was cultivated throughout the summer and a good weed kill was obtained.

Four acres of winter beans and 20 acres of winter wheat were sown in the autumn; these have wintered well and a small area of spring beans will be sown for comparison with the winter beans.

In general the principal problem encountered during 1971 has been couch grass. Plans have been made for a systematic attack on the weed during 1972 and in subsequent years, along the following lines. The area to be fallowed will be "roto sprayed" with T.C.A. after initial cultivations; the area to be sown with Brassicas will be "roto sprayed" with T.C.A. in early spring; and Eptam will be applied to potato ground immediately before planting. In the autumn all cereal stubbles will be chiselled as early as possible, perhaps in combination with paraquat treatment. It may be necessary to reconsider the cereal varieties sown, with perhaps a change to longer-strawed types which will provide more competition for the couch grass.

2. RESEARCH, DEVELOPMENT AND EXPLOITATION IN AGRICULTURE *

N. W. Simmonds

Introduction

There is a considerable current stir of interest in the process of industrial innovation. British agriculture is a major science-based industry which has been effectively transformed by the exploitation of R and D over the past 20 years. During that time the total British agricultural product has increased by over 30 per cent, while manpower employed has halved. Despite these achievements, conventional wisdom has it that exploitation of agricultural R and D is slow and inefficient. I believe this to be a half truth, and my object in this paper is to show that there are significant areas of R and D which are remarkably efficiently exploited.

Some definitions are necessary. They are given here because experience teaches that disagreement about definitions is a common source of confusion in discussion of this subject. Research (R) in this context is applied research, the investigation of scientific problems with a practical outcome in view. Development (D) is the application of research findings to a short-term practical objective. Exploitation (E) is the establishment in industrial practice of a piece of development work. (I am not discussing here the question of diffusion through the industry—Rogers 1962.) Normally, all three phases can be distinguished in the process of agricultural innovation but boundaries are often unclear and the observer sees simply a continuum of R through D to E. Nevertheless the distinctions, though undoubtedly a little arbitrary, are useful.

The products of agricultural R and D and the practical outcomes of exploitation on the farm and in related industries are various, so various indeed that it is not reasonable to discuss them collectively. I suggest that a workable breakdown to facilitate at least a partial analysis is as follows. The innovation is:—

(1) a new breed of plant or animal,
(2) a new chemical, material or medicament,
(3) a new piece of machinery or a structure,
(4) a new strategy, system or method.

* This article is substantially based on the Director's remarks to the 1971 Annual General Meeting of the Society.

It will be noted that the first three classes of innovation listed above have one thing in common: the products are tangible. This is not true of (4) and I shall suggest later that the difference is important.

I propose now to take four examples of agricultural innovation, one in each of the four classes above, describe them briefly and see whether any useful generalisations can be drawn. Three are current innovations which are now being exploited, so that success or failure in each case is yet uncertain. The fourth is well established. I chose them on the basis of familiarity and easy access to information. There were not chosen as being especially typical of the four categories of innovation, but I shall suggest later that many other examples could well have been chosen (at least for the first three categories) and would have led towards similar conclusions. All four examples come from the work of Scottish agricultural research institutes but no special significance attaches to this: examples could well have been drawn from other sources.

Examples

(1) As an illustration of a new breed of plant I take three new potato varieties produced at the Scottish Plant Breeding Station. These are Pentland Squire, Pentland Raven and Pentland Marble. They were all grown first as seedlings in 1960-61 and were named as new varieties in 1970. They are the products of a long-term potato breeding programme which is applied research (R) at the D end of the spectrum. All three are aimed at processing uses—Squire having shown promise for dehydration, Raven for chipping and Marble for canning. The first two could be useful general ware potatoes regardless of processing use, but Marble is wholly specialised; if it should fail for canning it would fail altogether. The three were submitted for Plant Variety Rights in 1967, went through Statutory Performance Trials in 1968 and 1969, and received grant of Rights in 1970. Their exploitation may be said to start from this point. Rights are held jointly by the Scottish Society for Research in Plant Breeding and the National Seed Development Organisation (NSDO); this last is a statutory body set up by Parliament, and its function is to promote new plant varieties bred at the State-aided agricultural research institutes. Royalties from such varieties are collected by NSDO and profits return ultimately to the public purse. Stocks of Pentland Marble derived from virus-tested stem cuttings (VTSC—another recent innovation) were started by the Department of Agriculture and Fisheries for Scotland in 1970 and first reached specialist seed growers in 1971; the first certified acreages should emerge in 1973. Pentland Squire and Pentland Raven are a year behind this schedule. Meanwhile the NSDO maintains ordinary seed stocks by contract with seed growers and the produce of these is used to promote interest in the varieties among farmers and processors.

First indications as to processing potential came from routine observations on specific gravity and cooking tests made during the later phases of the breeding programme. These indications were then followed up in the case of Squire and Raven by small-scale industrial tests of suitability for dehydration (to make powder or flake); these tests, which continue, were carried out by collaborating processing companies and they suggested that Squire was indeed very promising, Raven less so. Pentland Marble's potential for canning was explored by the Food and Vegetable Preservation Research Association in 1969-70 and highly favourable reports influenced the decision to release the variety. Industrial tests followed and continue.

In parallel with these processing tests, field trials were carried out in 1969 and 1970, by favour of the Agricultural Development and Advisory Service, on three Experimental Husbandry Farms in ecologically contrasted sites in English potato-growing areas. All three varieties entered the national potato trials run by the National Institute of Agricultural Botany in 1970 and may achieve recommendation about 1973. Meanwhile, commercial seed stocks will be developing, and commercial exploitation by farmers and processors of such of the three as ultimately find a useful place should begin about the same time. The final outcome of success or failure will probably become clear about 1975 or 1976.

I shall now try to summarise what I take to be the main features of the situation. First, applied research took about ten years and D and E jointly will have taken about six. Biological limitations inherent in rate of multiplication and the need for repeated observations are such that these times could not be appreciably shortened. Second, many bodies, agencies and people had a hand in the work and the whole process sounds rather confusing and untidy; a count reveals seven official bodies, one society, one research association, six industrial firms and a dozen or so growers—all of whom contributed. In practice, difficulties are few and the procedure for exploiting new potato varieties is a routine which needs only minor adjustments to suit the occasion. The third main feature is that new potato varieties are eagerly sought and tried out by seed growers, farmers and processors; at least a sizeable minority of all three groups are highly conscious of the economic possibilities of innovation in this area.

(2) As an example of the introduction of a new chemical to agricultural practice I take the louping ill vaccine recently developed at the Animal Diseases Research Association (ADRA) at Moredun, Edinburgh. Louping ill is a tick-borne virus encephalitis which has, on occasion, caused heavy losses in sheep flocks. The early research which showed that the disease was caused by a tick-borne virus was done at ADRA in 1929 and nearly all subsequent developments were due to the same Institute. The outcome of the development work which followed was a vaccine which became commercially available in

1935-36 and remained in general use until withdrawn in 1967. By the late 1930s, less than ten years after the initial recognition of the nature of the disease, British sheep flocks were pretty effectively protected and losses declined greatly.

Effective as it was, the old vaccine had its drawbacks, and development (D) work on a new vaccine was started at ADRA about 1966. In 1969 a new process of extracting an inactivated antigen from tissue culture systems was discovered and gave exceptionally promising results. These were confirmed in field trials carried out in 1970 and a British Patent was confirmed in the same year. The development work in the field was greatly assisted by the Department of Agriculture and Fisheries for Scotland and the Veterinary Investigation Officers of the three Scottish Colleges of Agriculture. The new vaccine met all the requirements of effectiveness in use and safety in manufacture, and an exclusive licence to make it was taken up by the Wellcome Research Laboratories in 1970. The vaccine went on sale in September 1971 and is expected to be in general use in 1972. Information about the prospects got round the sheep-farming community long before development work was complete, by way of the annual reports of the ADRA (in 1970 the Association had nearly 1,000 members), the farming press and, no doubt, by word of mouth too.

The conclusion to be drawn from this example is that several official bodies, one commercial firm and several farmers collaborated in the D and E phases of this innovation but that this diversity, as with the potato breeding example, proved no barrier to rapid and effective exploitation. D took only four years and E will have occupied only another two by the time the vaccine is in general use. The Director of the Moredun Institute tells me that he would regard this sort of pattern and pace of development of a new vaccine as normal.

(3) As an example of the development and exploitation of a new piece of agricultural machinery I take the potato harvester designed by the National Institute of Agricultural Engineering, Scottish Station (NIAE(SS)). This is the first piece of agricultural field machinery ever designed around electronic equipment. The essential feature of the machine (which was due to Dr D. L. Slight, then of the Department of Agriculture and Fisheries for Scotland) is an ingenious sorting device which separates clods and stones from potatoes by means of a system consisting of X-ray sources, sensors and movable nylon fingers which pass or divert an object according to whether or not it interrupts the radiation. The scientific principles were well enough known, so the initial job was one of development, of designing the sorting device and incorporating it into a working potato harvester. This took five years, 1960-64. By then it was apparent that efficient high speed separation was indeed possible. The patents covering the essential components were assigned to the National

Research Development Corporation (NRDC) in 1963 and arrangements to develop a commercial machine embodying the new device were made with two engineering firms in 1964.

Several difficulties in the development of a production harvester incorporating the separator were encountered but these were, though not without delays, overcome and the first commercial machines went into service in 1969. In 1970, comparative trials of commercial potato harvesters were run by the Potato Marketing Board (PMB) and these showed the machine that incorporated the NIAE device—the Whitsed Electronic—to have the highest rate of work of all the machines tested: 5·0 tons/man-hr as compared with a range 0·4 to 1·4 for the other machines. However, the machine was less satisfactory in other respects (*e.g.*, damage and leavings) and electronic sophistication means that it is expensive. Whether it (or a descendent of it) will be widely adopted in British potato agriculture is yet uncertain; it seems to have at least a fair chance of success and we may perhaps expect to see other applications of the separating device.

The machine was brought to the attention of potato farmers by demonstration at the Royal Highland and Agricultural Society's Show in 1967, by publications from the NIAE(SS), by radio and television broadcasts, by articles in the agricultural press, by commercial advertisement and by the published report of the PMB 1970 trials. By the time these trials were completed (in the autumn of 1970) there can have been few of the more enterprising potato farmers who did not know about it, and a fair number must have seen it in operation.

The development phase (D) of the machine took about nine years (1960–68); this was perhaps two years longer than it would have been in the absence of the delays mentioned above. Exploitation (E) started in 1969 and may be expected to end about 1973 when the economic potential of the machine should have become clear and the potato farmers should have made their decisions as to the extent to which they propose to use it. D and E will therefore jointly have taken about 13 years, which, delays notwithstanding, does not seem unreasonably slow for a sophisticated piece of machinery that embodies an entirely new principle.

The conclusions to be drawn from this example are much like those that flow from the two preceding ones. There is a natural and well-charted route of development from the R and D institute (here the NIAE(SS)), via other official bodies (the NRDC), to manufacturing industry and so to commercial exploitation. Again, the advanced sector of the farming community was well informed about the innovation by the time it was available and eager to try it out. Once again there were no major obstacles to development and exploitation, though there were delays which lengthened the development time by perhaps two years.

(4) As an example of the development of a new system of agricultural practice I take the case of barley beef, which arose from work at the Rowett Research Institute, Aberdeen, during the past decade. In the late 1950s there was widespread interest in nutritional aspects of cereals as concentrated food for ruminant animals. Economic circumstances were pressing farmers towards intensive systems of management which involved continuous feeding with diets of closely controlled composition. The idea of intensive finishing of stock for market was well established (as in the " feed lots " of the U.S.A.), but intensive rearing was yet to come.

The first steps (R) were taken by Preston and his colleagues in 1960. They had felt the need for a simple, reproducible diet for experimental purposes, so they tried bruised barley without added roughage. Aberdeen Angus calves grew too fat, so they tried Friesian calves instead—which grew very well indeed. At the time Friesian bull calves (surplus from the dairy herd) were cheap and so was barley. The economic possibilities were evident and rapidly exploited (E). By 1962 Preston was advocating his new system vigorously by lectures, articles and visits. The Aberdeenshire farming community was receptive and the Aberdeen Barley Beef Producers Association was formed. By the middle 1960s the system was in use througout Britain and was estimated at the peak to have contributed about one-quarter of the beef reaching the U.K. market. The system, however, was vulnerable to its own success, for the price of Friesian bull calves rose and the barley beef contribution fell to a current figure of about 7 per cent.

The barley beef system, though workable and successful, presents several nutritional problems which have, however, largely been overcome, or at least fairly well understood. The wider practical outcome has been a great increase in the overall use of cereals in feeding beef cattle, coupled with an enhanced awareness of the potential of high energy diets in general. And not the least important result has been the stimulation of nutritional research on rumen biochemistry and microbiology, bloat, liver damage and the potential of high energy diets for other ruminant livestock.

The main conclusion to be drawn from this example is that the translation of research into exploitation was extraordinarily rapid. The R phase was really one experiment which lasted a year (1960-61); there was no formal development (D); exploitation (E) started at once and the system was in widespread farming use by 1965. The lack of a development phase meant that some pioneer farmers got into considerable difficulties. Had the system not been inherently viable the result could have been a débâcle. But it *was* viable and the immediate economic appeal was great. The importance of enterprising farmers in exploitation is even more evident than in the three previous examples. Personal advocacy by Preston, published literature and farming societies were adequate to provide the necessary flow of information.

In the short term, barley beef was a valuable system of beef production in its own right; in the longer term, its main significance must be in its effect on stimulating awareness of the potential of high energy diets in general and the need for applied research to extend their use.

Discussion

I think that certain generalisations can legitimately be drawn from the four examples described above. Consider the first three: the potato varieties, the louping ill vaccine and the potato harvester. They have several features in common, namely: (1) they are tangible products; (2) the route from R through D to E involves several or even many agencies but, minor obstacles and delays notwithstanding, the route is well established and simply followed; (3) the speed of D and E seems to be at least satisfactory; (4) a section of the farming community is highly receptive to innovation, to the extent of itself actively promoting it (cf. Rogers, 1962); (5) information about the innovation is effectively disseminated by open days, lectures, shows, publications, advertisements, press, broadcast and word-of-mouth; (6) in the final result the three innovations may range all the way from utter failures to great successes but points (1) to (5) seem valid regardless of the practical outcomes.

The question now is: can these conclusions be generalised? Clearly they cannot on the basis of the three examples alone. However, general experience and much discussion with colleagues in other institutes suggests that the examples are, in fact, fairly typical and that the conclusions they yield can reasonably be generalised. I therefore assert (albeit rather tentatively) that, for a tangible product of agricultural R and D, points (2) to (5) in the preceding paragraph generally hold good; innovations of this kind are quickly and effectively exploited. Obviously this conclusion should be tested by examining many more case histories, bearing in mind the possible existence of useful innovations that failed or languished.

Now consider the fourth example, barley beef. This was exploited remarkably quickly, but I doubt whether it can be regarded as typical of the group of innovations represented by new systems or methods. Generalisation seems very difficult here and could be effectively attempted, I think, only on the basis of a good sample of case histories. Very tentatively indeed, the enterprising farmer seems to be equally important, but in contrast to the situation with tangible innovations there is no defined route from R through D to E. Sometimes an innovation of this kind must await a different and tangible innovation before it can itself become effective; thus zero-cultivation and sod-seeding depend upon suitable herbicides; and high-nitrogen regimes in cereals depend upon the availability of short-strawed varieties. Contrariwise, many tangible innovations involve the farmer in some change of crop or animal husbandry. Nevertheless there are innovations (of which barley beef is a good example) which depend purely upon doing new things with old resources. Innovations in animal husbandry seem to be predominantly of this kind; though, even here, tangible innovations are not wanting. In crop husbandry, by contrast, intangible innovations occur but seem to me probably to be of lesser importance than the array of new varieties, machinery, herbicides and fungicides that have contributed so greatly. If this is correct, tangible innovations form a sizeable minority of the whole.

Several colleagues have pointed out to me that my definitions of R and D given above (Introduction) disagree with theirs. Since any two persons' definitions in this field hardly ever do agree (cf. much of the argument about what Rothschild really meant) this is not surprising. Fortunately, it does not matter for the present purpose. My conclusion that much applied R and D is quickly exploited is true or false regardless of boundaries. Thus new potatoes do pass quickly into agricultural practice, whether potato breeding is regarded as applied research or as development.

This article was drafted before the publication of the Rothschild report. Whether the application of his proposals would impede or expedite agricultural R and D is a question still very much under debate. What is not in doubt, I think, is that some, at least, of the innovations which emerge from that R and D are now swiftly and effectively transferred to agricultural practice. Whether *all* useful innovations are so transferred and whether, having been transferred, they then diffuse through the industry as quickly as they might are questions that need—and deserve—much study.

Acknowledgments

I am indebted to numerous colleagues in Scottish institutes and elsewhere for information and helpful criticism. But I alone am responsible for the general argument and the conclusions stated in this paper, and neither the Department of Agriculture and Fisheries for Scotland nor the Agricultural Research Council are in any way committed to my opinions. I am well aware that this is a confused and confusing subject upon which several different points of view are possible.

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3. PLANTS FOR ANIMALS

K. L. Blaxter

The following is a summary of the second SSRPB lecture planned, at the time of writing, to be held at the Bush at 16.00 hrs on Thursday, 13th April 1972.

In considering how those concerned with the feeding of animals might specify what attributes of crop plants merit improvement, two opposite views emerge. One view is that, since we know what nutrients animals need and the limitations of individual crops as sources of these nutrients, effort should be expended in overcoming these nutritional limitations. The other view is that, since different crops have different nutritional attributes, effort should be placed on the improvement of yield, it being left to nutritionists to combine different crop products and mineral and organic supplements to produce optimal diets. The problems of decision about the relative emphasis to be placed on nutritional quality, on yield and on cultural characteristics in plant improvement programmes are then discussed using the barley crop and the grass crop as examples. With barley grain, which is never given without supplementation, a case can be made for an increase in protein content where the crop is destined for ruminant feeding. It is more difficult, in the context of non-ruminant feeding, to justify a breeding programme designed to increase the energy value or to change the amino acid composition of the grain. With the grass crop, evidence suggests that, in any breeding programme, changes in nutritive value will be extremely difficult to monitor. The overall value of a specific variety of grass to an individual animal depends on its nutritive value per unit weight and the amount of it consumed voluntarily. These two attributes are positively correlated as the grass grows, flowers and matures and its nutritive value per unit weight declines. Comparison between species commonly used in the UK as pasture species at any one botanically defined stage of growth show differences in their worth assessed in this way, but usually these differences are small relative to the changes taking place on maturation. This suggests that work on the improvement of existing forages might well concentrate on delaying maturation and thus the decline in nutritive value per unit weight with the progress of the season. Yield under continuous or sporadic defoliation must, however, be preserved or increased.

4. VARIETIES BRED BY THE STATION

The following varieties are on the market:—

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

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

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

5. 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 Ely E.H.F.; Rosewarne E.H.S.; Shardlow Hall; Woodthorne).
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Animal Diseases Research Association, Edinburgh.
Campden Food Preservation Research Association, Chipping Campden.
Canada Department of Agriculture, St John's West, Newfoundland.
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Potato Marketing Board, London.
Rowett Research Institute, Aberdeen.
Scottish Horticultural Research Institute, Dundee.
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ROBERT BROWN.
J. D. G. DAVIDSON.
H. F. D. ELDER.
G. B. R. GRAY.
JAMES GRAY (*Vice-Chairman*).
Sir DAVID LOWE.
ROBERT L. SCARLETT.
M. A. H. TINCKER.

Research Committees

Forage Crops

H. F. D. ELDER, *Convener.*
J. G. M. BREMNER.
G. CLAPPERTON.
J. L. DAWSON.
H. P. DONALD.
J. W. GRANT.
G. B. R. GRAY.
JAMES GRAY (*Vice-Chairman*).
M. JOUGHIN.
Sir DAVID LOWE.
A. K. M. MEIKLEJOHN.
J. STEWART.
J. WATSON.
CHAIRMAN (*ex officio*).

Potatoes

W. H. M. GILL, *Convener.*
R. ALLISON.
A. MANTON BAXTER.
H. P. DONALD.
Mrs B. A. GORDON.
Sir DAVID LOWE.
J. E. RENNIE.
E. F. SHERRIFF.
G. A. STORRAR.
D. W. WILLIAMS.
CHAIRMAN (*ex officio*).
VICE-CHAIRMAN (*ex officio*).

Farm Advisory

G. CLAPPERTON, *Convener.*
R. ALLISON.
G. B. R. GRAY.
A. K. M. MEIKLEJOHN.
J. E. RENNIE.
CHAIRMAN (*ex officio*).
VICE-CHAIRMAN (*ex officio*).

8. ADMINISTRATION

Finance

The abstract of audited accounts on pages 53 to 60 reveals the Society's financial position at 31st March 1972. The cost of the research programme at the Scottish Plant Breeding Station was met by a maintenance grant of £244,600 from the Department of Agriculture and Fisheries for Scotland. The Department also provided a grant of £10,875·88 for improvements to buildings at The Murrays farm. Other income amounted to £431·03. The unspent balance of maintenance grant for the year amounted to £1,751·06, which has been added to unspent balances from previous years, bringing these to £6,758·91.

Capital expenditure amounted to £82,234·41, against which the Department provided grants of £68,243·20 for continuing and new capital works and £13,991·21 for equipment.

The Home Grown Cereals Authority made a final contribution of £2,073·64 towards a barley breeding project.

Membership

At 31st March 1972 the total membership was 323, comprising 118 life members and 205 annual members. Twenty-two new members were elected during the year and ten died or resigned.

Board of Directors

The Board elected Mr James Gray, O.B.E., T.D., to the office of Vice-Chairman.

The Board warmly welcomed on election for the first time: Mrs B. A. Gordon, B.Sc., Mr James D. G. Davidson, M.V.O., M.I.Ex., and Mr M. Joughin, C.B.E., J.P.

The Board warmly congratulated Mr G. A. Storrar on his appointment as Honorary Sheriff of the County of Fife.

Election of Directors

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

John Arbuckle, O.B.E., Logie, Newburgh, Fife, KY14 6HL.
George Clapperton, Sheriffhall Mains, Dalkeith.
Professor H. P. Donald, Ph.D., D.Sc., F.R.S.E., Animal Breeding Research Organisation, King's Buildings, West Mains Road, Edinburgh EH9 3JQ.
J. W. Grant, B.Sc., North of Scotland College of Agriculture, Drummondhill, Stratherrick Road, Inverness.
A. K. M. Meiklejohn, B.Sc., Edinburgh School of Agriculture, West Mains Road, Edinburgh EH9 3JG.
E. F. Sherriff (Sheriff & Sons Ltd.), Burleigh Mead, Great North Road, Hatfield, Herts.

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

Hugh C. Drummond, The Curragh, Girvan, Ayrshire.
H. F. D. Elder (Wm. Dods & Son), Haddington.
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.
Douglas Morrison, B.Sc.(Agr.), Dip. Agric., M.S., School of Agriculture, 581 King Street, Aberdeen.

Meetings

The Board met five times: on 15th April 1971; 4th June 1971; 22nd July 1971; 11th November 1971; and 10th February 1972 (special meeting).

Research Committee Meetings were held as follows: Potatoes on 8th October 1971; Forages on 20th January 1972.

The Finance Committee met on 4th June 1971, and the Farm Advisory Committee on 6th May, 21st July, 13th August and 15th December 1971.

Fiftieth Annual General Meeting

MINUTE OF PROCEEDINGS at the FIFTIETH 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, 22nd July 1971.

Sir James D. Roberts, Bt., O.B.E., M.A., J.P., Strathallan Castle, Auchterarder, presided.

Minute. The Minute of the 49th Annual General Meeting, held at the Scottish Plant Breeding Station on Thursday, 23rd July 1970, having been submitted and approved, was signed.

Apologies. Apologies for absence were intimated by the Secretary.

Annual Report and Accounts. The 50th Annual Report of the Directors, embodying the audited accounts for the year ended 31st March 1971, which had been distributed to members with the Notice of Meeting, was submitted by the Chairman.

After a brief speech, the Chairman moved and Mr J. Arbuckle, Logie, Newburgh, seconded the adoption of the Report and Accounts and the motion was carried unanimously.

Election of the Board of Directors. Moved by Mr George Clapperton, Sheriffhall Mains, Dalkeith, and seconded by Mr G. A. Storrar, Rossie, Auchtermuchty, a motion was unanimously adopted to elect to the Board of Directors the following members:—

Robert Allison, Turnhouse, Corstorphine, Edinburgh 12.
James D. G. Davidson, M.V.O., M.I.Ex., Royal Highland and Agricultural Society, Ingliston, Newbridge, Midlothian.
G. B. R. Gray, Smeaton, East Linton, East Lothian.
Mrs B. A. Gordon, B.Sc.(Agric.), Rosefarm, Cromarty.
M. Joughin, C.B.E., J.P., Wester Manbeen, Elgin, Morayshire.
J. Watson (McGill & Smith), 67 Kyle Street, Ayr.

Appointment of Auditors. On the motion of the Chairman and seconded by Mr James Gray, Stirling, Messrs Brown MacDonald & Fleming, Chartered Accountants, were appointed Auditors of the Society.

This concluded the business of the Meeting.

Staff

The following new appointments were made during the year:—

Scientific Officers	R. P. Ellis, B.Sc., Ph.D. A. S. Peddie, S.D.A., D.C.P. W. G. Rogers, B.Sc.
Assistant S.O.	J. M. Chalmers T. R. Crawford E. S. Ellis B. H. Gordon (temporary) Miss B. C. Graham, B.Sc. R. W. Hutchison D. D. Mathieson D. T. Miller P. W. T. Nairn L. G. Newman A. Nicholson Miss E. A. Purves D. Stewart J. S. Swanston, B.Sc. Miss D. Watt G. R. Young
Laboratory Attendants	Mrs I. Macanulty Mrs M. Stewart
Administration	Mrs J. B. P. Stevenson Mrs I. M. Walley

The following staff left employment:—

Mrs M. S. Cochrane (LA)
R. J. Crawfurd, B.Sc. (SO)
E. S. Ellis (ASO)
Mrs T. Jones (*née* Wright) (ASO)
D. J. Liston (ASO)
Mrs G. Macdonald, H.N.C., L.I.Biol. (SO)
A. A. Mitchell (temporary) (ASO)

G. J. McLean (ASO)
Miss S. P. McLean (31/3/71) (ASO)
Mrs A. R. V. Ross (LA)
Mrs M. Sinclair (ASO)
D. Stewart (ASO)
Miss S. M. Taylor (Admin.)

Retirement:—

Miss P. J. Watson, M.A., Ph.D. (PSO)

Miss P. J. Watson retired after 24 years' service to the Station and Society on 30th September 1971 with the good wishes alike of the Board and her colleagues. She made valuable contributions to the work on genecology and grass breeding.

Members of staff made four visits abroad during the year with the aid of grants from the ARC. In August 1971 Dr Hayter and Mr Riggs visited Swedish barley workers at Svalöf and Weibullsholm. Mr Carroll visited potato workers at Wageningen and the Max Planck Institute, Cologne, in March-April 1971; his purpose was to discuss work on the utilisation of dihaploids and diploids in potato breeding. Dr Davidson attended the Virology Section meeting of the European Association for Potato Research held at Wageningen in June 1971.

Members of staff presented several papers or seminars to scientific meetings and university audiences during the year. Mr Fyfe lectured on plant breeding to the M.Sc. class of the Department of Genetics, University of Edinburgh. Dr Holden attended a Senior Management Seminar at the Civil Service College, Edinburgh, in October 1971; the theme was "Techniques of Economic Appraisal". Miss Piggott attended a Management Studies Seminar run in November 1971 by the Scottish Office Treasury Unit.

A Staff Association was formed during the year, and Dr England and Miss Hayes were elected Chairman and Secretary respectively. Dr Hayter became Station First Aid Officer and Dr Malcolmson was appointed Training Officer in succession to Dr Watson on her retirement. Dr Holden was appointed Information Officer and attended an ARC public relations seminar held in February 1972; the intention is that all press contacts shall be canalised through him.

The Director again lectured to the fourth-year Botany Class in the University of Edinburgh; he also gave a radio interview and miscellaneous lectures to various university audiences during the year. One of these, on 3rd November 1971, under the title "The Place of Plant Breeding", was the first Blackman Lecture in the University of Oxford. The lecture has been instituted in honour of Professor G. E. Blackman, F.R.S., who recently retired from the Chair of Agriculture in the University. In November-December 1971 he visited Barbados in connection with sugar cane breeding, but resigned from his consultancy in rubber breeding, due to the mounting pressure of other duties. He continued to serve on an ever more demanding series of ARC and computing committees and was appointed a member of the newly-formed Scottish Agricultural Development Council.

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

9. PUBLICATIONS

Banks, W., Greenwood, C. T., and Walker, J. T. (1971). Studies on the Starches of Barley Genotypes: A comparison of the starches from normal and high-amylose barley. *Die Stärke*, **23**, 12–15.

Fell, B. F., Kay, M., Ørskov, E. R., Boyne, R. and Walker, J. T. (1972). The role of ingested animal hairs and plant spicules in the pathogenesis of rumenitis. *Res. vet. Sci.*, **13**, 30–36.

Killick, R. J. (1971). The biometrical genetics of autotetraploids. I. Generations derived from a cross between two pure lines. *Heredity*, **27**, 331–346.

Mackay, G. R. (1971). The Brassica Forages 1970-? *J. Univ. of Newcastle upon Tyne Agricultural Society*, **24**, 16–20.

Mackay, G. R. (1972). On the genetic status of maternals induced by pollinations of *Brassica oleracea* L. with *Brassica campestris* L. *Euphytica*, **21**, 71–77.

McNaughton, I. H. (1971). Wide hybridization as an approach to Brassica improvement. In: *The future of Brassica crops. Occ. Publ. Rowett Res. Inst.*, **2**, 39–47.

McNaughton, I. H., and Thow, R. F. (1972). Swedes and Turnips. *Fld. Crop Abstr.*, **25**, 1–12.

Simmonds, N. W. (1971). The breeding system of *Chenopodium quinoa*. I. Male Sterility. *Heredity*, **27**, 73–82.

Simmonds, N. W. (1971). The potential of potatoes in the tropics. *Trop. Agric., Trin.*, **48**, 291–299.

Simmonds, N. W. (1971). The Scottish Plant Breeding Station. *Scott. Agric.*, **50**, 113–118.

10. ABSTRACT OF ACCOUNTS

ABSTRACT OF ACCOUNTS

For Year ended 31st March 1972

INCOME

1971		£
£36	Dividends and Interest	..
544	Sales of Produce and Stock on Hand	142·32
67	Subscriptions—Annual	135·35
	Note.—Annual Subscriptions amounting to £21·00 are in arrear	
143	Rent of Cottages	153·36
£790	*Total Ordinary Income*	£431·03
	Grant received from the Department of Agriculture and Fisheries for Scotland—	
190,550	Maintenance	244,600·00
£191,340	*Total Income*	£245,031·03
2,500	The Murrays: Improvements	10,875·88
	Balance at 1st April 1971—	
	Department of Agriculture and Fisheries for Scotland—	
7,565	Maintenance Grant	5,007·85
£201,405		£260,914·76

EXPENDITURE

1971			
	Salaries:—		
£91,453	Scientific and Technical Staff	£118,576·58	
9,695	Administrative and Clerical Staff	11,662·34	
1,589	Pension Supplementation	2,854·42	
£102,737			£133,093·34
8,000	Superannuation Contribution		9,441·69
21,177	Wages		27,647·77
5,623	National Insurance and Graduated Contributions		7,457·09
10,538	Apparatus and Equipment		11,249·94
7,392	Chemicals and Materials		10,175·88
2,861	Travelling and Subsistence		3,436·18
2,992	Rates		4,252·77
7,148	Power, Heat and Light		8,774·01
691	Library Books and Periodicals		724·32
875	Printing and Binding		1,232·39
2,125	Stationery, Postages, Telephone and Office Expenses		2,735·41
1,925	Vehicles—Purchase £1,098·77; Maintenance 2,550·87		3,649·64
250	Audit and Legal Expenses		250·00
1,613	Property Repairs and Improvements		5,013·93
271	Trial Centres		153·00
2,419	Edinburgh Centre of Rural Economy—Contribution towards upkeep		1,963·00
1,561	Repairs, Servicing and Upkeep		1,449·07
823	Seed Testing Fees		712·35
214	Transport		108·02
—	Staff Training		269·83
1,094	Advertising		1,053·13
680	Furniture & Fittings		2,081·34
282	Miscellaneous		830·84
981	Rentals		742·13
9,625	The Murrays—Net Cost		4,782·90
£193,897	*Total Ordinary Expenditure*		£243,279·97
2,500	The Murrays: Improvements		10,875·88
	Balance at 31st March 1972—		
	Department of Agriculture and Fisheries for Scotland—		
5,008	Maintenance Grant		6,758·91
£201,405			£260,914·76

BALANCE SHEET

as at 31st March 1972

I. Funds:—		
Balance at 31st March 1971	£328,094·37	
Grant received from D.A.F.S. Capital—Works	68,243·20	
Equipment	13,991·21	
		£410,328·78
II. Current Liabilities:—		
Accounts outstanding due by Society	£5,631·35	
Subscriptions paid in advance	3·00	
Department of Agriculture and Fisheries for Scotland— Balance of Maintenance Grant	6,758·91	
		12,393·26
		£422,722·04

	Cost	Amounts charged to Revenue	Nett
I. Fixed Assets:—			
Heritable Property	£367,189·90	}	£409,755·21
Capital Equipment	42,565·31	}	
Implements and Tools	20,873·71	£20,873·71	..
Vehicles	5,937·83	5,937·83	..
Laboratory Apparatus	33,614·09	33,614·09	..
Furniture and Fittings	10,649·45	10,649·45	..
Library Books	7,241·00	7,241·00	..
	£488,071·29	£78,316·08	£409,755 21

II. Current Assets:—		
Stocks on Hand as valued by Directors	£166·00	
Accounts outstanding due to Society	2,428·75	
Cash and Bank Balance	10,372·08	
		12,966·83
		£422,722·04

Edinburgh, *23rd May, 1972.*—The undersigned, having had access to all the Boo[illegible]nts of the Society, and having examined the foregoing Statement of Accounts and verified the same with the Accounts and Vouchers relating thereto, now sign the[illegible]nd to be correct, duly vouched, and in accordance with law.

16 Alva Street.

Messrs BROWN, MACDONALD & FLEMING, *Auditors.*

JOHN ARBUCKLE, *Convener, Finance Committee.*

LIFE MEMBERSHIP SUBSCRIPTIONS AND DONATIONS ACCOUNT

Dividends and Interest	£675·44
Malayan Rubber	250·00
Donations	55·00
Life Subscriptions	315·00
Balance at 1st April 1971	11,227·25
	£12,522·69

W. J. REID AND JAMES MUNRO BEQUESTS

Dividends and Interest	£116·88
Balance at 1st April 1971	2,029·91
	£2,146·79

DR. WILSON MEMORIAL FUND

Dividends and Interest	£31·06
Balance at 1st April 1971	558·82
	£589·88

HOME GROWN CEREALS AUTHORITY

Grant received	£2,073·64
	£2,073·64

Travel Grants Andes Expedition	£10·00		
Nepal ,,	20·00		
			£30·00
50th Anniversary Celebrations			137·45
Hospitality			184·57
Insurance			7·25
Balance at 31st March 1972, consisting of:—			
Investments (see Appendix), at Cost		£11,564·95	
Recoverable Income Tax		229·26	
Cash in Bank—Current Account		369·21	
			12,163·42
			£12,522·69

Balance at 31st March 1972, consisting of:—		
Investments (see Appendix), at Cost	£1,990·24	
Recoverable Income Tax	39·28	
Cash in Bank—Current Account	117·27	
		£2,146·79
		£2,146·79

Balance at 31st March 1972, consisting of:—		
Investments (see Appendix), at Cost	£566·41	
Recoverable Income Tax	8·99	
Cash in Bank—Current Account	14·48	
		£589·88
		£589·88

Balance brought forward from previous year	£762·84
Salaries	979·49
Superannuation Contribution	110·44
National Insurance and Graduated Contributions	39·72
Apparatus and Equipment	181·15
	£2,073·64

APPENDIX

LIST OF INVESTMENTS

Life Membership Subscriptions and Donations Funds

Nominal Value		*Market Value at 31/3/72*
£710·00	Claverhouse Investment Trust Ltd. 1,420 Ordinary 50p shares .	£1,321
264·00	Courage, Barclay & Simonds 1,056 Ordinary 25p shares . .	1,774
1,581·40	6½% Funding Stock 1985-87	1,407
82·75	Guardian Royal Exchange Association 331 Ordinary 25p shares .	993
345·00	Imperial Chemical Industries 345 Ordinary £1 Stock Units . .	914
28·50	London and Manchester Assurance Co. Ltd. 570 Ordinary 5p shares	1,066
247·50	National Commercial Banking Group Ltd. 990 Ordinary 25p shares	2,277
86·25	Shell Transport & Trading Co. Ltd. 345 Ordinary 25p shares .	1,052
1,153·00	Stirling County Council 7¾% Loan 1977-79	1,188
2,359·35	Treasury 8¾% Loan 1997.	2,395
760·00	Treasury 8½% Loan 1980-82	813
£7,617·75		£15,200

W. J. Reid and James Munro Bequests

£200·00	English & International Trust Ltd. 7% Convertible Stock 1986 .	£280
1,359·29	6½% Funding Stock 1985-87	1,210
80·00	Imperial Chemical Industries 80 Ordinary £1 Stock Units . .	212
208·00	Stirling County Council 7¾% Loan 1977-79.	214
£1,847·29		£1,916

Dr Wilson Memorial Fund

£70·00	English & International Trust Ltd. 7% Convertible Stock 1986 .	£98
276·60	6½% Funding Stock 1985-87	£246
26·75	Guardian Royal Exchange Assurance 107 Ordinary 25p shares .	321
£373·35		£665

11. INSTITUTES FOR AGRICULTURAL RESEARCH IN GREAT BRITAIN

The research programmes of all the research Institutes supported from public funds are co-ordinated by the Agricultural Research Council. The following is a list of Institutes. Most of them publish reports annually and details can be obtained from the Secretaries of the Institutes concerned.

ARC Institutes:

Animal Breeding Research Organisation	King's Buildings, West Mains Road, Edinburgh EH9 3JQ
Institute of Animal Physiology	Babraham, Cambridge CB2 4AT
Institute for Research on Animal Diseases	Compton, Newbury, Berks.
Food Research Institute	Colney Lane, Norwich NOR 70F
Letcombe Laboratory	Letcombe Regis, Wantage, Berks.
Meat Research Institute	Langford, Bristol BS18 7DY
Poultry Research Centre	King's Buildings, West Mains Road, Edinburgh EH9 3JS
Weed Research Organisation	Begbroke Hill, Sandy Lane, Yarnton, Oxford OX5 1PF

State-aided Institutes in England and Wales:

Animal Virus Research Institute	Pirbright, Woking, Surrey
East Malling Research Station	East Malling, Maidstone, Kent
Glasshouse Crops Research Institute	Worthing Road, Rustington, 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.
National Institute for Research in Dairying	Shinfield, Reading, Berks. RG2 9AT
National Vegetable Research Station	Wellesbourne, Warwick
Plant Breeding Institute	Maris Lane, Trumpington, Cambridge CB2 2LQ
Rothamsted Experimental Station	Harpenden, Herts.
Welsh Plant Breeding Station	Plas Gogerddan, Aberystwyth, Cardiganshire SY23 3EB
Wye College, Department of Hop Research	Ashford, Kent

State-aided Institutes in Scotland:

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

SCOTTISH SOCIETY FOR RESEARCH IN PLANT BREEDING

APPLICATION FOR MEMBERSHIP

The subscription is one pound for the year 1st April to 31st March or part of the year. Advance subscriptions will be accepted. Donors of £10 or over become life members without further payment. Applications should be addressed to:

The Secretary,
Scottish Plant Breeding Station,
Pentlandfield,
ROSLIN, Midlothian,
EH25 9RF.

I desire to be enrolled a member of the Society and enclose the sum of

....

Name: ....
(including Honours, Degrees, etc.)

Address: ....

....

....

Signature:.. *Date:*..........................

A banker's order form is attached and applicants for membership are reminded of the convenience, both to themselves and to the Society, of paying a subscription thus.

BANKER'S ORDER

To: .... Bank

.... Branch

.... Address

....

Date..

Please pay to the **Bank of Scotland, South Morningside Branch, Edinburgh,** Code 80 02 95 A/C ref. 295 764316 for the credit of Scottish Society for Research in Plant Breeding, the sum of .... now, and on each 1st April following until further notice.

Signed ....

Name ....

Address ....

....

Please complete and return to **The Secretary, Scottish Plant Breeding Station, Pentlandfield, ROSLIN, Midlothian EH25 9RF.**

A note on the Scottish Plant Breeding Station

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

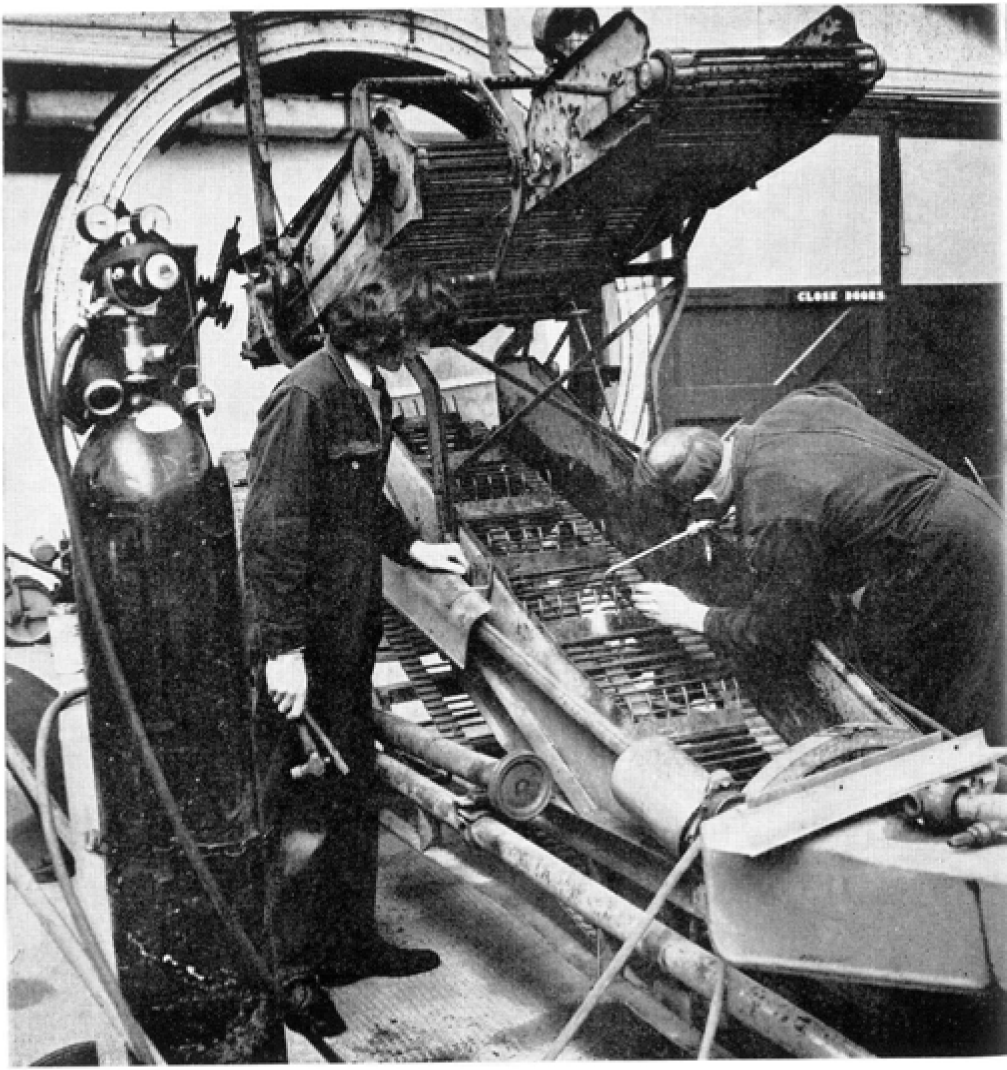
Interested persons are invited to submit the sub-adjacent membership form. Members receive the Annual Report and are eligible to participate in the affairs of the Society.

Address: Scottish Plant Breeding Station, Pentlandfield, ROSLIN, Midlothian EH25 9RF, Scotland.

Telephone: 031-445 2171.

Location: See map on back cover.

Printed by William Blackwood & Sons Ltd., Edinburgh



At work on the prototype of the single-plant potato harvester developed at the Scottish Plant Breeding Station. The combs on the elevator belt are a key feature.

(Photograph by John Porteous)