SCOTTISH PLANT BREEDING STATION
PENTLANDFIELD, ROSLIN, MIDLOTHIAN

REPORT

TO THE

ANNUAL GENERAL MEETING

OF

THE SCOTTISH SOCIETY FOR RESEARCH IN PLANT BREEDING

23rd JULY 1970

BY THE

BOARD OF DIRECTORS

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1. REPORT BY THE DIRECTOR

General

The Station received in April 1969 a Visiting Group appointed by the Agricultural Research Council. The Group was under the chairmanship of Prof. O. V. S. Heath and comprised Prof. J. L. Jinks, Mr J. S. Martin, Prof. N. F. Robertson and Prof. Watkin Williams. It was accompanied by members of the ARC Secretariat and by representatives of the DAFS. The Group spent two days at the Station and its report was accepted by Council in June 1969. The Group broadly endorsed the Director's thesis that the Station stood in pressing need of more and better resources in laboratories, glass-houses, equipment and land; it also made a number of concrete recommendations for new staff appointments and supported our policy of extensive collaboration with Universities, sister Institutes and industrial research laboratories. The Group's report was welcomed by the Board of Directors of the Society at its meeting in November 1969 as offering strong support for the policies and programmes of the Station.

Further progress has been made in improving the physical resources of the Station. Work began on the laboratory west wing in December 1969; the two workers' cottages at Bilston are nearly complete; the covered yard is in use and now contains a workshop, an oven room and threshing room. As to equipment, a new seeder and a new combine have been acquired, new seed cleaning equipment is installed, the chemistry laboratory is now set up to determine *in vitro* digestibilities and three growth cabinets should be in place by the end of March. A new small two-wheel tractor designed to draw the Scottish Plot Seeder has been built and modifications of the Mk. I Seeder are in hand. Further progress has been made in improving the very bad land and all 28 acres of rotational land have now been ashed. The amelioration of structure achieved by this programme is very evident, both to inspection and in crop growth.

The search for a farm has continued during the year. We saw one excellent place in East Lothian but failed to secure it. Our needs are rather closely circumscribed as to area, location, altitude and quality of land and this means that suitable farms rarely appear upon the market. When they do, there is generally keen competition for them and prices are high. There has lately, however, been an indication that land prices are easing, we must hope to our advantage.

It is a cardinal item of Station policy to develop collaboration with sister Institutes, Universities, industrial laboratories and official bodies that have interests in common with our own. Collaborators are listed on page 29 of this report and many are mentioned in context. Three specific points of collaboration deserve comment here. We are grateful to the Home-Grown Cereals Authority for continued financial support of and interest in our high diastase barley work. During the year a joint research project with the Stirling University Department of Technological Economics was started; the object is to analyse in depth the economics of potato breeding and a research student, under an S.R.C. grant, is in post. A joint project with the Scottish Colleges was also set up with the object of determining the agronomic requirements and possible economic place of new Brassica allopolyploids; this we have long recognized as an important and wide-ranging practical enquiry that lay far beyond our own resources.

Late in 1969 there began a series of meetings and discussions initiated by the Agricultural Research Council on plant breeding policy in the official stations. These were stimulated by awareness that commercial plant breeding in Britain is now well established and growing fast in response to the Plant Varieties and Seeds Act (1964). The broad economic and agricultural context in which the official stations are working is therefore changing; hence the accepted need for some review of official policy. The conclusions arrived at by the Council were embodied in a statement issued on 23rd February 1970 as follows:—

> The Agricultural Research Council has reviewed its policy regarding the support of plant breeding at State-aided research institutes, in the light of developments, especially in the private sector, that have occurred since the passage of the Plant Varieties and Seeds Act, 1964.
>
> The Council is of the opinion that the total plant breeding resources of the country could with advantage be increased. It therefore welcomes the expanding efforts in the private sector and wishes to encourage and extend collaboration between private and State-financed organisations and their scientific staffs. The Council hopes that this collaboration, although having to some extent a competitive background, will be constructive, and profitable to all concerned.
>
> The Council however believes that the present situation does not call for any major change from its past policy, which has been to encourage the State-aided institutes to develop improved techniques and to establish their validity by the tests of practical breeding; and to breed new crop plants and new varieties to provide, as far as possible, for needs of farmers, growers and processors that might otherwise not be satisfied from British sources. The Council also has in mind the importance of the State-supported institutes as training grounds for plant breeders.
>
> For these reasons the Council believes that it would not be in the national interest to reduce the overall effort devoted to the breeding of

new plant varieties by the institutes under its aegis. It recognises, nevertheless, that policies with regard to particular crops must be flexible, and breeding programmes more selective; and that it will be necessary from time to time to change priorities, both to anticipate the changing needs of the agricultural and food industries and to take account of new scientific discoveries.

Finally, it should be noted that the Council will continue to give full support to research in all scientific disciplines relevant to plant breeding.

Potato Investigations

On completion of the official trials of five seedlings it was decided to relinquish Rights over one of them and to apply jointly with NSDO for Grant of Rights over the remaining four, which then had to be named before 31st March 1970. Full details of the parentage, appearance and performance of these varieties will be published in a forthcoming issue of the Plant Varieties and Seeds Gazette. Notes on the four varieties follow. Names are not given because they are still subject to official approval.

Seedling No. 4232a(3)

This clone, an early maincrop, is superior to Majestic and equal to Pentland Crown in yield but, lacking Pentland's Crown notable resistance to virus, is considered unlikely to replace Pentland Crown for general purposes. The tubers are a more regular oval and 2 per cent higher in dry matter than those of Pentland Crown. It has been rated "very promising for the production of frozen potato chips" after a combined field and processing trial by a commercial firm at present using Pentland Crown for this purpose. Further combined trials, extended to include the production of instant potato powder, are being arranged.

Seedling No. 4634a(1)

This clone is a first early, resistant to pathotype A of potato cyst eelworm and so in the same category as Pentland Javelin and Pentland Lustre; it outyielded these varieties in widespread NAAS trials. The tubers are coarse by comparison with other Pentland varieties; indeed they are similar to (but not as coarse as) those of Epicure, which remains the most widely grown first early in Ayrshire, largely because no newer variety has consistently out-yielded it at first lift under the conditions peculiar to the Ayrshire foreshore. Seedling 4634a(1) was acclimatised in Ayrshire in 1969 and goes forward to the final stage of the West of Scotland College's trial in 1970; commercial trials will probably follow.

Seedling No. 4851(5)

This clone, an early maincrop, is equal to Majestic but inferior to Pentland Crown in yield. It has tubers of high dry matter (about 23 per cent), rough-skinned, white-fleshed and likely to prove suitable for abrasive peeling; its crisping quality has been better than the standard variety Record in two years out of three in laboratory tests, but this needs further evaluation on an industrial scale.

Seedling No. 5015(1)

This seedling, a first early, is a specialised canning variety and the first of its kind. The produce of a half-acre crop certified grade A at Blythbank has been distributed between five Scottish seed growers, each of whom proposes to enter a crop of at least half an acre for Grade A certification in 1970, in contract with NSDO. The Station is indebted to Norfolk Canners Ltd., who first commended the canning quality of 5015(1) as one of a batch of 15 seedlings sent to them for test in 1966, following the first attempt to select potential canning varieties at Blythbank in the previous year. The suitability of the variety for canning was confirmed in collaboration with the National Fruit and Vegetable Preservation Research Association at Chipping Campden and in several commercial trials, the latter ensuring that an initial market for the variety already existed before it came to be released. The variety is currently undergoing trials in France, Cyprus and The Netherlands.

Reference was made in the last report to the need for selecting potatoes in what may be called " realistic " growing conditions. With generous collaboration from the National Agricultural Advisory Service, this has now proved possible and a new testing routine for advanced selections established. Each year some 20 or 30 second earlies and early maincrops will be grown and selected at several Experimental Husbandry Farms with the objective of picking the one or two potential varieties that may be expected to emerge. In 1969, 7 second earlies and 13 maincrops were considered. These were grown with 8 control varieties on three Experimental Husbandry Farms—namely, Terrington, Lincs., on silt; Arthur Rickwood, near Ely, on fen peat; Gleadthorpe, Notts., on sand under irrigation; and also on East Lothian loam. Each variety was represented by four randomised, open-ended 3-tuber plots at each centre. The plots were inspected during the growing season by Station staff, who also took part in the harvest and evaluated the material, first of all on the ground, using a 1-5 general merit scale. This was done under code, which ensured that no preconceived ideas about the relative merits of trial or control varieties entered into the reckoning; in practice it turned out to be surprisingly difficult to pick out the plots of most of the control varieties with any certainty.

On summing the scores from all centres, Seedling 4232a(3) ranked 3rd, Pentland Crown 4th, Seedling 4851(5) 6th, King Edward 17th and Majestic 22nd out of the 28 varieties. King Edward produced much of its crop in the form of small secondary tubers (a well-known fault of the variety under dry conditions) and Majestic yielded relatively poorly at all three English centres, besides being severely scabbed at Gleadthorpe; had these been new seedlings, neither would have had the least chance of being retained.

All but two of the trial varieties that ranked lower than Pentland Crown were discarded. Of the two that were retained, one was kept as a very heavy yielder that seemed to have processing potential and the other as a gangrene-resistant parent. Of the three new seedlings that ranked with or above Pentland Crown, two had markedly undesirable features and the third was kept for further trial as a high-yielding second early of excellent quality. Viewed broadly, the trials were highly satisfactory in that they permitted a comparatively objective evaluation of potential new varieties; they also showed how hard it will be to better Pentland Crown in the early maincrop category.

The programme of reorganising the Blythbank routine was successfully continued during the year. Planting was completed between 21st-30th April, rather earlier than usual (fortunately as it turned out because, after three wet weeks at the beginning of May, the growing season and conditions at harvest were exceptionally good). With the prospect of time in hand at harvest some of the material was allowed to grow on to near maincrop maturity with the result that the maincrops substantially out-yielded earlies for the first time in three years. Very high mean yields of up to 5 kg. (11 lbs.) per plant were recorded in 3-tuber plots. The crop as a whole covered 5·1 ha (12·5 acres), excluding material grown for the P.B.I., Cambridge.

Among the changes initiated in 1969 were the randomisation, replication and mechanical harvesting of 3-tuber plots, followed by weighing in the field and the storing of the whole produce of selected 3-tuber plots for further assessment during the winter. Handling in the store is largely mechanised. Every progeny destined to be grown at Blythbank was blight-tested by inoculating samples of detached leaflets from the seedling glasshouses. These and several other changes should be completed in 1970, to be followed by computerisation in 1971, ready for the evaluation of about 300 pilot progenies which should be reaching the stage of 3-tuber plots in 1972. These will be related progenies resulting from test crosses made in 1969 using a combination of well-tried parents and new parents drawn from the virus-resistance breeding programme, the Andigena selection experiment and the breeding of eelworm resistant material stemming from *Solanum vernei*. This means that the commercial breeding programme will become more experimental and the outcome in terms of potential new varieties may be disappointing at first. The long-term aim, however, is ambitious: it is to broaden the genetic base of the breeding population so as to generate self-sustaining progress by use of initially diverse material. Plans call for sequences of test crosses, coupled with progeny evaluation over a three-year period, and systematic feedback of processed information.

Further studies of blackleg (which had proved so troublesome at Blythbank in 1967 and 1968) led to the conclusion that the biggest single factor sustaining the disease was the intensive effort being made to control it by roguing. Blackleg is contagious and cannot be controlled in the same way as the insect-transmitted severe virus diseases; at least this is true at Blythbank under conditions of high fertility giving heavy, tangled, easily damaged foliage. Under the revised procedure planned for Blythbank in 1970, the blackleg problem is expected to subside.

Strips of King Edward and Pentland Dell were grown on the windward side of the plots at Blythbank and were sprayed with spores of an indigenous culture of blight race 1, 2, 3, 4 shortly after blight had first appeared naturally. By harvest, 88 per cent of the plots were showing blight, so the danger of selecting potentially susceptible hypersensitive clones was not great. Observation of blight in the field is regarded as complementary to laboratory tests and essential to the selection procedure because of a suspicion that field-resistant varieties may sometimes be rather prone to tuber blight; the reason seems to be that the period of possible tuber infection, when blight is sporulating on the foliage, is longer than in varieties which are cut down quickly by blight.

In the laboratory tests of resistance to blight, particular attention was paid to stem and petiole resistance in whole-plant tests of advanced clones. In addition, seedling progenies which had given the most resistant leaflet samples were retested as whole plants grown from cuttings and scored for stem resistance. A very striking feature of some of these progenies (especially those descended from *S. vernei*) was that the upper surfaces of the leaflets were often much more resistant to infection than the under surfaces. This also proved to be a feature of Roslin Eburu, which has earned a good reputation for field resistance in Kenya, so adaxial resistance may turn out to be of practical value. This will be checked in the field since the progenies which showed this kind of resistance were in any case destined for commercial selection at Blythbank. Tests of resistance to tuber blight were carried out, as usual, by artificial inoculation and, again, the results will have to be checked in the field, where the amount of tuber blight that develops is probably influenced by the extent to which tubers are clustered or dispersed (and so more or less deeply buried in the drill).

Studies of mixtures of blight races led to an interesting and probably rather important discovery. Using *R*-gene specificities as markers, mixtures yielded complex races that displayed the sum of the " parental " specificities. This is strong evidence of somatic hybridisation but there is yet no evidence of genetic recombination. It seems certain that this is not only a phenomenon of great intrinsic interest but also a partial explanation, at least, of an old mystery: how complex races arise in the field.

In the scab-test plot at Archerfield, the four new Pentland varieties all showed greater resistance than the susceptible Redskin. Seedlings 4634a(1) and 5015(1) were particularly resistant. Most of the 105 advanced clones under test also showed better resistance than Redskin and 20 were better even than the rather resistant Ackersegen. In general, results agreed well with those obtained by the NAAS from the Wirral, Cheshire. Very few of the clones in regional trials were as severely scabbed as Majestic at Gleadthorpe E.H.F., a tribute to the effectiveness of their previous testing at Archerfield.

The latent tuber diseases have received a good deal of attention during the year. Thus the same 105 clones were screened for resistance to gangrene and a considerable range of response was evident; 69 were more resistant than Majestic, 32 of them being better than Arran Consul, which is very resistant. Advanced selections from the 1969 crop are now being screened for resistance to skinspot. Evidence of variation in susceptibility to blackleg was obtained by smearing 50 tubers of each clone with a sludge made by pulping tubers from blacklegged plants before planting them in a trough under glass. Whether a workable routine test can be developed is yet uncertain.

Three of the seedlings which were included as possible P.V.R. candidates in the regional trials were products of the special programme of breeding for resistance to virus. Although all were eventually discarded, the fact that they were even considered is a good indication of the quality of the virus-resistant parents now being fed into the general breeding programme. Six such parents were used in 1969; they combined leafroll resistance, built up over the years, with comprehensive Y resistance derived from *S. microdontum*, *S. stoloniferum* or *S. demissum*. Some 11,000 seedlings were screened for resistance to viruses X and Y. In replicated trials at the P.B.I., Cambridge, 129 clones plus controls were exposed to leafroll and Y infection; 12 survived selection by commercial standards and some of the others may yet be used as parents. Of the four newly named varieties, Seedling 5015(1) was comparable with Pentland Crown in its specific resistance to virus Y and moderate resistance to leafroll; the three others showed no special resistance to viruses. From the experimental work with virus Y, one strain emerged with the virulence required for discriminating between comprehensive and specific resistance.

Work with pathotypes of potato cyst eelworm was reduced to the minimum required for identifying specific resistance in the commercial breeding material.

Attention is now concentrated on the less extreme polygenic resistance from *S. vernei* which is almost equally effective against all pathotypes and is therefore likely to be permanent and more valuable in the long run. The first wave of test progenies having *vernei* resistance yielded 6,002 selections which are due to go out to Blythbank in 1970. Crosses of parents derived from *S. vernei* with Maris Piper produced outstandingly attractive material in the glasshouse and gave another 3,459 selections for the field.

The Andigena selection experiment moved a year nearer to the goal of a population indistinguishable from Tuberosum in all essential commercial characteristics. As usual, the year's populations for selection at Pentlandfield and at Rosewarne, Cornwall, were raised from seed obtained as a result of natural selfing plus cross pollination by bumble bees in a field-grown population of élite clones which is added to and reselected each year. The material now coming forward is designated Neo-Tuberosum, a self-explanatory name in the context of the experiment.

Eight advanced Neo-Tuberosum selections, which were brought into the general breeding programme for test-crossing with four other groups of parents, proved exceptionally easy to cross and enough seed for a standard-sized pilot progeny was obtained from 78 of the possible 112 crosses involving them. These Neo-Tuberosum × Tuberosum crosses represent the first step in the station policy of broadening the genetic base of potato breeding. Whether they have direct commercial potentiality or will find use principally as parents, time alone will show. Conclusions will start to emerge in four years' time.

In a population study, Neo-Tuberosum and Tuberosum seedlings were similar in yield when similar in maturity; but, in general, Neo-Tuberosum was later maturing and "stemmier" than Tuberosum, producing taller, more numerous stems and more abundant tubers. The internodes in Neo-Tuberosum were longer and, although leaf lengths were similar, Neo-Tuberosum had more lateral leaflets.

On a basis of a 40-plant sample, 70 per cent of the current Neo-Tuberosum population is immune to wart disease. A sample of tubers was sent to Mexico for planting and assessment of resistance to blight at the Rockefeller Centre in Toluca Valley. Seed samples were sent to Brazil and the U.S.A. In general, it seems clear that the Neo-Tuberosum potatoes have yield potential, blight resistance and cooking quality but are still a little on the late side; from the breeding viewpoint, this last characteristic may not matter.

Progenies obtained by intercrossing or selfing 33 clones of Chilean Tuberosum were raised in preparation for a project along the lines of the Andigena selection experiment.

It is now clear that the glasshouse which was being used for the production of potato dihaploids and for crossing dihaploids did not provide suitable conditions for making difficult crosses involving rather weak plants of low fertility, which is what dihaploids tend to be. Similar trial crosses in one of the older glasshouses were much more successful, so some reorganisation will be required for 1970 before an adequate annual production of dihaploids can be hoped for.

Mass selection at the diploid level in the field, aimed at improving a population derived from Phureja and Stenotomum cultivars has had the effect of increasing yield and tuber size. Yields of over 2 kg per plant were recorded at Pentlandfield under conditions of very moderate soil fertility. Progress is thus at least as good as in the Andigena experiment and perhaps rather better.

As part of the ordinary process of maintaining the Commonwealth Potato Collection, 525 progenies were grown for seed renewal, which was accomplished in 225 cases. The remaining unseeded progenies, mostly tetraploids, will now be grown from tubers for another attempt at reseeding. Again, some improvement of conditions for pollination is necessary.

An Inventory of the Collection was compiled and published in March 1969, listing seed-lines descended from 1,344 accessions of wild and cultivated potatoes of Latin American origin. Eighty new accessions were received in tuber form and will be maintained under quarantine until seed from them becomes available for addition to the Collection; then the original accessions will be destroyed. Some 133 Chilean tetraploids which will not flower in the quarantine house may have to be returned to South America for seeding out of doors.

Forage crops investigations

Cereals. Oat breeding continued along familiar lines, utilising three main selection centres; these are located in East Lothian, Inverness-shire and Argyll, with the addition of a highly alkaline site in East Lothian for the selection of resistance to Grey Speck (manganese deficiency), a long-term selection experiment on the Island of Tiree for the same purpose, and a site in Midlothian for the evaluation of material selected for resistance to the oat stem eelworm (*Ditylenchus dipsaci*).

Several pedigree selections are approaching the commercial level and have been passed to the Field and Works Department for final yield evaluation. Their number includes two promising general purpose selections Aa 743 and Aa 744, three more selections in the same category and ten eelworm resisters. The eelworm resistant E 284 is being multiplied with a view to submission for Rights.

In 1969 the first evaluation of selections of unknown parentage derived from hybrid bulk (*i.e.,* composite cross populations) took place, some 600 F8 lines being tested. Those with undesirable morphological characters were eliminated and the survivors go into replicated trial in 1970.

The selection Aa 737 has been registered for Plant Variety Rights under the name Pentland Provender. It is an early variety with straw of average strength and of average height. It performs well in late upland districts and on light land subject to summer drought. A description follows:—

'PENTLAND PROVENDER' SPRING OAT

Origin	Elder × [{(Castleton × Beselers) × (Victory × Black Mesdag)} × Marvellous].
Breeder	The Scottish Plant Breeding Station, Pentlandfield, Roslin, Midlothian.
Young plant	Habit of early growth erect to semi-erect; margins of leaf blades glabrous; lowermost leaf sheaths glabrous.
Flowering culm	Uppermost nodes sparsely hairy.
Panicle	Equilateral; open; size medium large to large; glumes at flowering moderately to strongly glaucous.
Spikelets	Attitude at flowering pendulous.
Grain	White; lemma non-glaucous, matt; callus hairs usually absent; rachilla glabrous.

The work on high diastase barley progressed very satisfactorily during the year. The ultimate objective is to replace by home-grown barley the large imports of barley with high diastatic power used by distillers of grain whisky. In this we have been helped by continued support by the Home-Grown Cereals Authority; valuable co-operation has also been received from the Glenochil Research Station of Scottish Grain Distillers Ltd. The Preece method of estimating diastatic power (D.P.) is now operated as a routine for assessing grain produced in the Station experiments. The method involves micro-malting, digestion of starch and titration with Fehling's solution. It is very time-consuming and suitable only for limited numbers of samples. A simpler technique, to distinguish single grains of high D.P. from those with low, has been devised, the "halo" test (see Frontispiece). After germination on filter paper, individual grains or endosperms are extracted in a specified way and the extract is applied to a tiny disc of filter paper with a capillary pipette. The disc is placed on starch-agar gel and, after incubation, staining with iodine indicates the area (halo) where the starch has been digested. The width of the halo measures the D.P. The method is now being applied to a composite cross bulk in order to test its utility in selection.

A further procedure, one which gives a semi-quantitative estimate of D.P. but also promises to be very valuable for genetical work, uses agar-gel electrophoresis (see Frontispiece). This technique separates the so-called iso-enzymes of both alpha- and beta-amylase. Incubation with starch and staining with iodine displays their position and intensity as clear bands against a blue background. The method gives the same ranking of samples in D.P. as the micro-malting procedure. It also brings to light varietal differences in iso-enzymes; of some twenty varieties so far studied, six have a faster-moving band of beta-amylase and one (an accession of *Hordeum spontaneum*) lacks one of the alpha-amylase bands. The part played by hormones from the embryo can be studied by detaching it from the endosperm at an early stage and then treating the endosperm with dilute solution of the hormone. By this method it has been shown that gibberellic acid (GA_3) mainly stimulates the second alpha-amylase band. The variety Ymer, usually having a low D.P., has a weak alpha-2 band, but when the endosperm is treated with GA_3 at 10^{-6} to 10^{-4} molar the alpha-2 band is strongly expressed. A beginning has been made with embryo transplants to learn more about the functions of embryo and endosperm. This analysis of the diastatic system is intended to provide a rational biochemical basis for designing crosses and selection procedures and for screening composite cross bulks and induced mutants; it also has relevance to malting practices and is of considerable scientific interest.

Work has also been started on inhibitors of germination in order to develop another method of screening heterogeneous populations. The idea is to define conditions under which only grains resistant to the inhibitor will germinate. If the control system resembles those analysed for several genes in micro-organisms, a proportion of inhibitor-resistant mutants should turn out to be of "controlling genes" and should be dominant in expression. To produce a range of mutations, Ymer barley has been treated with a chemical mutagen, ethylmethane sulphonate.

The diastase variety trials started in 1968 were continued in 1969 at 16 sites in the eastern half of Scotland from Berwickshire to Moray. Analysis of the 1968 trials was completed: that of the 1969 trials continues. Broadly the same picture emerged in both years: malt with a high D.P. can be produced from varieties chosen purely for this property, but their yields are far too low. The high-yielding varieties which were included in the trials were consistently lower in D.P., in general too low to be acceptable for diastatic malt. The well-known correlation between D.P. and nitrogen content was amply confirmed, but it only explained about one-third of the variation between varieties.

The same poor yield from varieties of known high D.P. was also observed in another barley trial. Twenty-five varieties were grown in two lattice square experiments at Dunbar, one with and one without nitrogenous top dressing. The varieties Akka, Berac and Zephyr showed some potential as parents in breeding for high diastase. Akka, an early, two-row variety, has a rather low yield but produced grain with a high nitrogen content and a D.P. averaging well over 300 degrees Lintner in the green malt; samples of Akka received from Rothwell Plant Breeders ran up to 2·45 per cent N and 450°L. for the D.P. of green malt. Berac and Zephyr, with satisfactory yields, gave D.P.s over 250°L. at moderate nitrogen contents around 1·5 per cent. In this trial there was again a significant association between nitrogen content and D.P., but with less than half the variation in D.P. among varieties accounted for by nitrogen content.

A 14 × 14 set of diallel crosses, with 10 of the parents crossed reciprocally, has been virtually completed. The object is to develop breeding stocks and to provide material for biometrical studies of D.P. and of agronomic features. The wide range of flowering times and the difficulty of obtaining pollen in mid-winter have made this a formidable undertaking.

Two factorial fertiliser trials with Ymer barley were conducted to try to find out why barley yields at Pentlandfield were so low. In one, three levels of nitrogen in the seed bed, combined with three levels of top dressing were applied; in the other all combinations of N, P and K at three levels of each were used. Both experiments implicated low levels of N as limiting yields and showed that, with adequate N, yields of 5 tonnes per hectare (about 2 tons per acre) are possible.

A glasshouse disease of barley which has been a nuisance in the winter was investigated. The first symptoms are leaf-tip scorch and brown flecks; in severe cases the plant dies. An organism forming naked spore-clusters in the roots was found and is believed to be a chytrid fungus; it closely resembles *Polymixa graminis,* reported to attack wheat in Canada. There is some evidence of seed-borne infection. No control is known but it was found that the disease was less severe in plants grown in peat and sand compost than in peat, loam and sand and there are varietal differences in susceptibility. It is possible that a virus is transmitted by the fungus (as with *Spongospora* in potatoes and *Olpidium* in lettuce) but we have at present no evidence on this.

The high amylose gene (which doubles the proportion of amylose in the starch) was further investigated. In particular, an attempt is being made, by linkage tests, to locate its position on the chromosome map of barley. Joint segregation with single markers on each of chromosomes 4, 5 and 7 showed no association in F_2. F_1 plants have been raised from crosses with isogenic lines of Bonus barley providing markers for all seven chromosomes and also from crosses with lines carrying different reciprocal translocations. These valuable tester stocks were developed by Swedish barley geneticists. Special interest attaches to the cross with a waxy-starch line in which the starch lacks amylose.

The back-crossing programme aimed at transferring the high amylose gene into a range of varieties continues but made disappointing progress. It has been necessary to curtail the list of varieties. Difficulty in obtaining pollen for winter crossing work has been an adverse factor.

How important economically is barley mildew in Scotland? The answer to this question is important for the barley breeder. Two series of trials run in collaboration with the Edinburgh School of Agriculture at sites throughout Scotland have provided useful information on the point. The Station planted 16 trials with small plots and a further 13, with larger plots, were sown by the Scottish colleges and two commercial firms. The varieties used were Golden Promise (susceptible), Ymer (field resistant) and Julia (with race-specific resistance). They were sown in replicated trials with and without a heavy seed-dressing of the systemic fungicide Milstem. Percentage mildew infection was scored (at stage 11·1 in most cases) and yields of grain were recorded. Mildew levels in general were slight to moderate. The heavy dressing with Milstem gave effective control in both series and the varieties behaved more or less as expected in the untreated plots, with Julia the most resistant and Golden Promise the least. Appreciable scores for mildew on Julia at some sites showed that a biotype of mildew virulent on the variety is present in Scotland. Neither series of trials showed any effect of the fungicide on the yield of either Ymer or Julia but there was a small gain with Golden Promise. Larger gains have been reported from similar trials in England; as far as they go, the Scottish results are consistent with the widely held view that, in Scotland, mildew comes too late to have much effect on yields. But the need to continue the trials is evident, especially as the situation may change if the area sown with Golden Promise continues to increase; it is believed to be already the most popular single variety, used for about half the crops sown in 1969.

A multiplication plot of the high-amylose variant of Glacier was used to test the effects on yield of spraying with Milstem, Benlate or Calixin. The mean of all fungicide treatments was non-significantly higher than the control and the Benlate plots had a strikingly brighter appearance at maturity.

A beginning has been made with the descriptions of some 950 entries in the museum collection. Two-row and six-row forms collected in South America by a St Andrews University expedition were grown in ear rows.

Grasses. The project aimed at incorporating the early growth, characteristic of certain exotic species of Poa, in a form adapted to Scottish hill conditions has made excellent progress. *Poa ampla,* a non-rhizomatous species from the north-east of Washington State, has been successfully hybridised with *Poa pratensis* from Scottish pastures. The number of hybrids is small because of the difficulties inherent in making a cross between highly apomictic species, but at least twenty strong hybrids are available for study and evaluation. A further lot of possible hybrids has been isolated from multiple seedlings which were detected amongst the thousands of predominantly apomictic progeny of the cross. The first seedling produced in a multiple is normally maternal but the second and third seedlings can be the result of sexual fertilisation or, alternatively, may possess half or double the chromosome complement of the mother plant. A few chromosome counts suggest that all possibilities have been realised and some fifty interesting plants are recognised as differing from the original mother parent, thus giving a reasonable nucleus of breeding material.

Two additional species with a capacity for early spring growth similar to that shown by *P. ampla*—namely, *P. iberica* and *P. longifolia*—have also been successfully crossed with *P. pratensis*, though there is some doubt about the hardiness of some of these hybrids.

Work on the cocksfoot composite cross aimed at producing an improved version of Scotia Cocksfoot continued. Field notes were taken on winter survival, spring growth, ear emergence, habit, flag-leaf dimensions, leaf flexibility and aftermath habit. Seed was harvested from all plants and 80 of the most attractive were selected. Material for *in vitro* digestibility determinations was harvested from two different plantings.

The large-scale cocksfoot composite mentioned in the last report was also continued. Of the 484 populations, 469 remain as separate maternal lines. The rest were either removed because they were diploid or lost by winter killing. In the second cycle, as in the first, seed was harvested separately from spaced plants, to moderate the effects of natural selection until extensive crossing should have had a chance to occur. For more intensive study, an incomplete diallel cross involving 18 contrasting populations was planted in four replications. The spacing used (22 × 22 cm. or 9 × 9 ins.) allows identification of individuals but is believed to be close enough to approximate in performance to a sward. Of the 324 (18 × 18) possible progenies which would occur in a complete diallel with parents and reciprocals, there were planted 266 representing either parent populations or reciprocal crosses; an additional 74 represent either crosses available in one direction only or duplicate crosses made with different individuals. In the seedling year, one harvest and one set of tiller counts were made.

Catapodium rigidum was found to be self-compatible and so has been deleted from the list of candidates for growth chamber studies.

Brassicas. The allopolyploid Raphanobrassica studied by Karpechenko many years ago was vigorous and seed fertile. It has therefore come as an unwelcome surprise that the many new Raphanobrassicas made at Pentlandfield in recent years turn out to be remarkably weak or infertile. Of about 200 plants raised from crossing tetraploid radish with tetraploid kale about a fifth were dwarf or stunted. Many plants failed to produce pollen and in some even the pistillate parts of the flowers were reduced or vestigial. Of the plants with apparently good pollen 62 were selfed in the bud stage; 38 gave no seed; and only 357 seeds were obtained from the rest, two-thirds from only two plants derived from one cross. The average fertility was only 7 seeds per 100 pollinations.

Ten times as many aborted seeds were harvested, mostly from well-developed siliquae. Hand crossing was hardly more successful, yielding 8 seeds per 100 pollinations in 39 crosses. Again there were ten times as many aborted seeds. The sterility appears to be due to endosperm failure rather than failure to fertilise.

Cytological examination showed 27 plants out of 34 to be euploid (2n = 36), 6 aneuploid (2n = 35 to 38) and 1 diploid (2n = 18). Meiosis was generally regular in the euploid plants, with 18 bivalents found in 94 per cent of the pollen mother cells examined. Aneuploidy showed no evident relation with either vigour or fertility.

Mr D. Harberd of Leeds University has collaborated in a successful synthesis of *B. napus*. The Station provided him with seed of tetraploid *B. campestris* (2n = 40, aaaa) in the form of F_1 hybrids of ssp. *oleifera* with ssp. *nipposinica* and *pekinensis* and also with cuttings of tetraploid F_1 hybrids of *B. oleracea* (2n = 36, cccc), thousand-head kale × curly kale. Mr Harberd used a new and simplified technique for embryo culture to raise interspecific hybrids of constitution aacc, 2n = 38; they are synthetic *B. napus*. He obtained seven hybrids at a far higher rate than can be obtained without embyro culture. At the Station four of the hybrids were self-pollinated (two euploids and two aneuploids); the heterozygosity built into them by the use of heterozygous parents was reflected in wide variation in the selfed progenies in the field. Selections have been made for further inbreeding. A slowly rotating drum has been constructed to allow the use of Mr Harberd's technique at the Station.

A late-flowering diploid and an autotetraploid fodder radish were evaluated in trials in East Lothian, at the Welsh Plant Breeding Station and at the Grassland Research Institute. Complete results are not yet to hand.

The work on matromorphs mentioned in the last report was continued. Matromorphs are supposedly homozygous maternal plants which offer an attractively rapid means of isolating inbred lines. By pollinating various kales by *B. campestris* in 1968, 54 seeds were obtained. Of the resulting seedlings, 4 died before flowering, 3 were interspecific hybrids, 4 failed to flower, 15 flowered but gave little or no seed from bud selfing and 28 gave adequate numbers of seeds to raise progenies for further study. One of these segregated for purple pigmentation and it looks as though its immediate parent was the result of accidental pollination of curled kale by purple sprouting broccoli. This left 27 progenies, representing half of the original seeds; the evidence obtained so far is consistent with the idea that their immediate parents were homozygous but is not really adequate to prove it. Further crosses were made in 1969 and gave an even lower rate of success than those made in 1968. It is becoming clear that, unless some means can be found of drastically increasing the frequency of matromorphs, then the phenomenon will have only theoretical interest. To be useful in practical breeding the yield of matromorphs per 1,000 pollinations would have to be increased at least tenfold.

Some effort was made to identify pollinators that would facilitate the production of matromorphs. A range of Cruciferous crops and weeds was used to pollinate buds of *B. oleracea*; styles were fixed after 48 hours and examined for pollen tube growth. Some, such as *Eruca sativa,* could be eliminated as potential producers of matromorphs because their pollen did not grow. In two cases (with *B. campestris* and *B. tournefortii* as pollinators) coiling of the tubes on the stigma was observed. From pollinated buds left to maturity, seed was obtained only when *B. carinata* was the pollinator: it was not viable.

A 5 × 5 diallel set of crosses was made using matromorphic plants (from marrow-stem kale) resulting from the 1968 pollinations by *B. campestris*. One plant proved to be female sterile, although it functioned as a pollen parent; it has been propagated vegetatively for further study. The 10 F_1 progenies will be assessed in the field in 1970; if the matromorphs really are homozygous, this test should permit some assessment of the value of the method for speeding up practical breeding.

The matromorph method is also being tested in swedes. Maternal-type plants produced when swede hybrids were pollinated with radish pollen were self-fertilised in the greenhouse or in the field.

The main objective of the breeding work with swedes is to produce a variety with the high yield of dry matter and the uniformity of Pentland Harvester but without its susceptibility to "raan" (internal browning). To produce F_3 seed of seven crosses that have Pentland Harvester as one parent, 40 F_2 plants of each were selfed in the field. A further nine F_2 families were grown at Myles Farm, Tranent, by courtesy of Mr Dykes, and from these selected roots, free of "raan", were stored for planting in 1970 to produce F_3 seed. The swede matromorphs derive from F_1 plants of these sixteen crosses and comparison of the two types of progeny should provide evidence to test the hypothesis that the matromorphs were homozygous.

2. GRASS BREEDING

J. L. Fyfe

Introduction

The high proportion (about two-thirds) of British agricultural land devoted to the production and utilisation of grass is a measure both of the importance of grass in British agriculture and of the suitability of the British climate for grass. Ever since the agricultural revolution, forward-looking agriculturalists and seed merchants have given attention to the genetical improvement of grass seed. It is widely accepted that credit for a giant step forward is owed to the vision, energy and ability of R. G. Stapledon. He saw the need for supplies of grass seed of quality that was high in both analytical and genetical characteristics: that is, seed that was pure, highly viable and genetically capable of producing long-lived and productive swards. It needed a large research station to carry this work forward on a scientific basis and to determine how best to use the products. Led by Stapledon, the Welsh Plant Breeding Station produced varieties of all the major grasses and, for many years now, farmers have been able to buy certified seed of these varieties, confident that it will perform according to specification.

Given this success and given the importance of the grass crop, it could be argued that all the official plant breeding stations should make grass breeding as important a part of their work as it has been made at Aberystwyth. Against this view a number of arguments could be advanced: the present level of grass management leaves much of the potential of existing varieties unused; grass breeding is particularly difficult and a comparable effort on other crops might produce more useful results; new varieties are, in any case, being provided in abundance (the NIAB Recommended List names about sixty); and so on. It may be helpful for members of the Society to have an account of "the present state of the art"; hence the present review.

Peculiarities and objectives

To understand the peculiarities of grass breeding it is useful to compare and contrast it with the breeding of our common cereals—wheat, barley and oats. Starting with the most obvious difference, in cereals the useful product harvested is also the planting material for the next generation, but this is not so for grasses; in the early generations of a breeding programme the cereal breeder need not separate the two functions of harvesting and seed production whereas the grass breeder must do so. On the other hand, if the cereal breeder wants tests of quality in early generations he must sacrifice some seed, but not so the grass breeder. The tillering habit associated with the long life of most grasses makes them easier than cereals to multiply clonally, but speeding up sexual generations is much easier with cereals. At a later stage in the breeding programme, when selections have to be compared over several seasons, the long life of grasses leads to complexities in experimental design if the effects of season are to be distinguished from effects of age. Another very important difference is in the breeding system. Unlike the cereals, none of our major agricultural grasses is automatically self-fertilising. The grasses are outbred and the grass breeder faces the same dilemma as the animal breeder: too intense selection may involve too much inbreeding, with decline in performance. By contrast, the cereal breeder's normal aim is a single, completely inbred line. A further complication with some grasses (*e.g.*, cocksfoot, timothy) is that their mode of inheritance is not the straightforward diploid type found in cereals; it involves autopolyploidy (as in the potatoes) and is of a different order of complexity. The differences mentioned so far tend, on balance, to make grass breeding more difficult than cereal breeding. There are even more important differences in the way the crops are used; contrast, in particular, the multiplicity of ways of growing and utilising grass and the relative simplicity of handling and using cereals. A single variety, such as S.23 perennial ryegrass, may be sown broadcast or drilled; under a cereal cover crop or direct; pure, in a simple mixture or in a complex mixture of species; it may or may not be the only variety of its species sown; it may receive annual dressings of nitrogen up to some 600 kg/ha of N or it may have to depend on clover in the mixture for its nitrogen. Utilisation may be by grazing, continuous or rotational, or by mowing. If mown, it may be for feeding fresh, for dried grass, for unwilted silage, for wilted silage, or for low or high quality hay; the extent to which it has to provide for production as well as maintenance varies from nil upwards, both in time and place. Disease problems are usually much more clearly defined in cereals than in grasses; although an accurate estimate of yield reduction or loss of quality through disease is rarely easy, it is far more difficult with grasses than with cereals. Finally, the economic value of grass is hard to define because the cash return comes not from the crop itself but from the animals fed on it; the cash value of cereals is much more easily assessed.

A plant breeding programme must be aimed at objectives that are both useful and attainable. Over half a century ago Stapledon seized on the simple fact that if a farmer wants to use grass he must be able to rely on the grass being still there when he wants it. Much of the seed then being sold lacked that reliability; it lacked persistency, which could therefore be set up as an objective to be attained by a combination of plant breeding, seed certification and seed testing. By the second world war the objective had been attained. This was a solid achievement; its importance is not diminished by the failure of experimental results to substantiate some of the larger claims made for bred varieties of grasses. In particular there is no evidence from grazing experiments that leafiness gives the bred varieties a higher nutritive value; considering their advantage in persistency, the wonder is that they have not actually suffered a diminution in nutritive value.

Since Stapledon, nobody has propounded a grass-breeding objective comparable in importance and attainability with his. Indeed, many hold that the next major advance in grassland husbandry will not involve breeding but will be an efficient system of production and utilisation. In turn, if such a single system began to replace the present multiplicity of systems, grass breeders' objectives would become much clearer. Until this happens the outstanding fact confronting grass breeders is how little of the potential of existing varieties is exploited. Again, the comparison with cereals, in terms of tons of dry matter per acre usefully consumed, is instructive. A superbly managed grass crop probably represents five or six times as much as the national average in terms of consumption per acre: the best cereal yields are hardly double the national average. This implies that, if a grass breeder decides to breed varieties to suit the management imposed by the small minority, who exploit their grass as intensively as the average cereal grower exploits his cereals, then he is banking on the minority's methods becoming much more widely adopted. The breeder would thus have more confidence about attaining his objective (especially if the system he were breeding for involved no grazing), but less confidence in its usefulness.

At the other end of the spectrum lie the vast acreages of upland rough grazings, where conventional methods of reclamation are prohibitively costly. The invention of a cheap but effective way of replacing the native vegetation by sown species would set enormously attractive objectives before grass (not to mention legume) breeders. At present, the balance of opinion seems to favour increasing the productivity and utilisation of the native vegetation and it would be hard to justify a major breeding programme based on an assumption that this opinion is wrong. The needs of upland districts are very much to the fore in the Station's work on both cocksfoot and smooth-stalk meadow grass, but with more conventional farming techniques in mind.

For these two extremes, representing the practical minimum and maximum of stress for grass, investigation of the biological problems involved is undoubtedly justified and is, in fact, in progress at the Welsh Plant Breeding Station. But, until the technological outlook becomes clearer, the detailed objectives of individual grass breeding programmes can hardly be stated. Grass breeders are therefore left with the aim, broadly speaking, of dotting the " i "s —and crossing the" t "s that is, of seeking minor (though useful) objectives.

Sometimes a clear request comes from the farming side as, for example, the demand for an Italian ryegrass able to survive two winters in the West of Scotland. If one grants that such a variety would have some value that Scotia perennial ryegrass lacks (and this is by no means obvious) there should be no great technical difficulty in breeding it. But then another question arises: should not an objective so purely commercial be left to the commercial breeders already active in the field ? For an official station, the attraction of Italian ryegrass is that extreme perenniality is not an objective and so it can serve as a useful grass for studying breeding techniques; an experiment does not have to last half a working lifetime. But the selection criteria used in such work have to be realistic and so useful varieties may emerge as one kind of product.

Grass breeding methods

There has been a great deal of refinement of plant breeding theory since Stapledon's time, but no basically new grass-breeding technique has emerged. The theory of population genetics has advanced and can now provide a rational basis for choice of technique, but the techniques remain, in essence, the same. They need only be mentioned here, rather than reviewed. One still has to start with collection and some evaluation of existing ecotypes and cultivars. Selection may stop there or it may proceed, with varying degrees of genetical refinement, such as recurrent mass selection, maternal line selection, progeny testing by the polycross method or by systematic mating patterns. The outcome is usually a " synthetic variety ", which is the progeny of an assemblage of interbreeding lines or clones that have been tested for " general combining ability "—the capacity to do well in combination with a range of other parents.

Some thirty-five years ago the value of the alkaloid, colchicine, for doubling chromosome numbers was discovered. It was quickly realised that herbage plants were particularly suitable material for exploiting chromosome doubling, which increases cell size, allows extra hybrid vigour to be bred into a synthetic but reduces seed fertility. Some success with Italian ryegrass has been achieved in the form of the Dutch tetraploids, which have $2 \times 2 \times 7 = 28$ chromosomes. More may yet be achieved in the area of short-rotation ryegrass. Here a double bonus is feasible, at least in theory: both the extra vigour possible with autopolyploids and the considerable suppression of segregation, which should make it easier to avoid reversion of perennial-Italian crosses. Colchicine also helps in work on " new " allopolyploids, such as fescue-ryegrass hybrids. These have frequently looked very impressive in breeders' plots but cytological instability has so far stopped them reaching the market. Perhaps more subtle forms of chromosome manipulation (as practised with wheat) will be needed to combine the desirable features of the two genera in one grass.

The most important advance in technique for grass breeders has come in the field of assessment. Nutritional chemists have provided laboratory (*in vitro*) techniques for measuring digestibility, capable of being applied at an early stage of breeding because they require only small amounts of plant material. The breeder can now evaluate his trials in terms of digestible organic dry matter. Other analytical methods have also been developed or improved and a degree of automation can often be incorporated to increase the number of samples analysed per man per week. This all helps grass breeders towards a rational assessment of their material, but also highlights the difficulty of defining objectives, arising from the diversity of management and utilisation of grass. When conservation is the intended use, maximum yield of digestible energy is probably the best objective, in the sense that nobody can demonstrate that any other objective is better. The factors affecting intake by ruminants are not yet well enough understood for the breeder to select with confidence in this direction. No doubt this will come.

A departure from what by now may be called traditional methods of breeding is being tried at the Scottish Plant Breeding Station. A very wide range (nearly 500) of cocksfoot ecotypes and cultivars, instead of being compared and evaluated, are being combined into a composite cross. There is evidence from American work with cereals (see our *Annual Report*, 47, p. 22) that the operation of what one might call semi-natural selection on a population so constituted can produce striking results. The principle of the method is to produce a vast range of combinations of genetic factors and allow selection and recombination to operate over many generations. Lines extracted from later generations of a composite cross have been reported to show co-adaptation; some mixtures of pairs of lines give higher yields than pairs of varieties selected independently of each other and a bigger advantage over the average of the two lines grown pure. This property is obviously of interest to the grass breeder; so is the related property of giving rise to a mixture which could persist through generations of seed multiplication in relatively stable proportions. It is logical to try the technique with grasses. The work is long-term and it will be some years before clear-cut results are available.

" Hybrid varieties " are much in the minds of breeders these days. These are controlled hybrids of seed-propagated plants produced by crossing two, three or four more or less inbred parental lines together in various ways. The method has been successfully applied to maize, onions, beets and brassicas, and is on the way to application in the small grain cereals (see our *Annual Report*, 47, p. 25). Attractions of hybrid varieties include uniformity and constancy—*i.e.*, they are readily and precisely reproducible. With our common grasses there is no bonus to be claimed from hybrid vigour, since they are not inbred in the first place. If grass breeders are ever required to produce varieties for a precisely defined and highly productive system, hybrid varieties may be needed. It is obviously easier to find a particular cross which would fit the system outstandingly well than to find several parents all of whose offspring are in general outstandingly good. The relative ease of vegetative propagation (the preferred method of propagation with some tropical agricultural grasses) makes the mass reproduction of a cross technically feasible. Virus diseases would be a serious menace to this method of seed production, however, and it would be safer, if possible, to follow up with a similar cross based on inbred lines.

Finally, there is an attractive, though yet remote, possibility of making a fundamental change in the genetic structure of some of our grasses. The possibility has emerged from physiological studies. Grasses characteristic of temperate regions make very poor use of the most intensive illumination to which they are subject in summer. If one plots their photosynthetic assimilation against light intensity, it is found to level off long before the intensity of full summer sunlight is reached. Tropical grasses are much better able to make use of high light intensities. If this ability could be transferred to a temperate grass, like ryegrass, a radical increase in yield potential might become attainable. At present no method of making the transfer is known. Somatic cell hybridization, though not yet achieved in higher plants, might provide a method. Very recently, however, a method whereby plants having this property of utilising high light intensity can be automatically selected from a mixture with plants lacking the property has been announced. The method makes use of the odd fact that plants with the "temperate" type of photosynthesis cannot utilise very low concentrations of carbon dioxide, while the "tropical" type can. In an airtight system with both types present and light supplied, the CO_2 concentration is reduced by photosynthesis below the threshold value for the "temperate" type. The "tropical" type survives on the CO_2 produced by the respiration of the "temperate" types, but the latter starve.

Conclusions

As the proportion of grass seed sold under variety names has increased, so has the number of varieties bred by commercial firms. The advent of Plant Variety Rights is clearly tending to accelerate this trend. In the absence of standard systems of management and hence of agreed criteria of worth, any given grass variety is very difficult to assess; in such circumstances it is impossible to justify a short list of recommended varieties or to counter persuasive publicity with hard facts. The conclusion is indicated that, for a good many years to come, the flow of commercially bred varieties is unlikely to dry up. We must expect to remain for a long time in the situation of having, for any one grass species, a plethora of good varieties, all much of a muchness, between many of which rational choice is hardly possible. In these circumstances an official station has to consider carefully whether it should set itself as a main target a further contribution to the plethora. The answer must vary with the grass and the connected scientific circumstances. For the perennial ryegrasses there is already a big commercial effort and a strong combined genetical/breeding attack at Aberystwyth; anything the SPBS could do would be puny by comparison and there is no point in doing it. The case for breeding Italian ryegrass is stronger, as indicated in our *Annual Report*, 45, p. 12. The cocksfoots are a different matter; they are in a decline but informed opinion gives them great potential; and they lend themselves well to a combined genetic/breeding attack of a somewhat speculative nature. It is speculative in the sense that we are not certain whether high-yielding cocksfoot of high digestibility can be bred nor, if bred, whether it would have a place. But it seems certain that breeding is essential if cocksfoot is ever to have a place. Our work on Poa is likewise speculative, in the sense that success is uncertain and the market unknown. But, if animal production in the harder environments is to increase (as many think it must) then new grasses for those environments will be wanted. The economic potential is great and the scientific interest—of combining genetically awkward species from different continents—is considerable.

3. VARIETIES BRED BY THE STATION

The following varieties are on the market:—

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

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

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

4. COLLABORATORS

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

(*a*) Official bodies:—

Animal Breeding Research Organisation, Edinburgh.
Animal Diseases Research Association, Edinburgh.
Department of Agriculture and Fisheries for Scotland, Scientific Services, Edinburgh.
Edinburgh Regional Computing Centre.
Forestry Commission, Research Branch, Edinburgh.
Fruit and Vegetable Preservation Research Association, Chipping Campden.
Grassland Research Institute, Hurley.
Home-Grown Cereals Authority, London.
M.A.F.F., Plant Pathology Laboratory, Harpenden.
Ministry of Agriculture, N.I., Plant Breeding Station, Loughgall.
National Agricultural Advisory Service.
National Institute of Agricultural Botany, Cambridge.
National Institute of Agricultural Engineering (Scottish Station), Edinburgh.
National Seed Development Organisation, Cambridge.
National Vegetable Research Station, Wellesbourne.
Plant Breeding Institute, Cambridge.
Potato Marketing Board, London.
Rowett Research Institute, Aberdeen.
Scottish Horticultural Research Institute, Dundee.
States of Jersey, Department of Agriculture.
Welsh Plant Breeding Station, Aberystwyth.

(*b*) Universities and Colleges:—

A.R.C. Unit of Statistics, University of Edinburgh.
Department of Botany, University of Edinburgh.

Department of Brewing and Biochemistry, Heriot-Watt University, Edinburgh.
Edinburgh School of Agriculture.
North of Scotland College of Agriculture, Aberdeen.
School of Agricultural Sciences, University of Leeds.
West of Scotland College of Agriculture, Glasgow.

(*c*) Industrial Collaborators:—

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Campbell's Soups Ltd.
Distillers Co. Ltd., Menstrie.
Gordon-Innes Ltd., Huntly, Aberdeenshire.
Robert Kilgour & Co. Ltd., Kirkcaldy.
Lincolnshire Canners Ltd., King's Lynn, Norfolk.
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Plant Protection Limited.
Ross Foods Ltd., North Walsham, Norfolk.
Rothwell Plant Breeders Ltd., Caistor, Lincs.
Scottish Agricultural Industries Ltd., Edinburgh.

(*d*) Individual:—

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R. &. G. Brown, Crowfoot Bank, Swinton, Duns, Berwickshire.
H. Calder, Billie Mains, Chirnside, Duns, Berwickshire.
G. Clapperton, Sheriffhall Mains, Dalkeith, Midlothian.
A. G. Dewar, Hedderwick Hill, East Lothian.
G. F. Duncan, Waterton, Duffus, Moray.
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J. S. Graham, Queenston Bank, North Berwick, East Lothian.
G. B. R. Gray, Smeaton, East Linton, East Lothian.
M. J. Hamilton, Muirhouse, Edinburgh.
J. Howie, Newton, Wormit, Fife.
H. Jerrard, Woollands, Cockburnspath, Berwickshire.
Sir David Lowe, Elvingston, East Lothian.
A. Macintyre, South Ledaig, Argyll.

D. C. MacKessack Leitch, Inchstelly, Alves, Elgin, Moray.
P. McGowan, Wheatlands, Kirkliston, West Lothian.
R. Miller, Tullochgorum, Inverness-shire.
R. C. Smith, Whitsome, West Newton, Berwickshire.
W. M. Stephen, Rothills, Duffus, Moray.
J. Stewart, Caberston, Walkerburn, Peeblesshire.
G. A. Storrar, Rossie, Auchtermuchty, Fife.
H. Thomson, Newark, St Monance, Fife.
A. R. Wilson, Brightmony, Auldearn, Nairn.

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Trustees

H.M. SECRETARY OF STATE FOR SCOTLAND, Scottish Office, St Andrew's House, Edinburgh.
W. ANDREW BIGGAR, O.B.E., M.C., B.Sc., F.R.Ag.S., Magdalene Hall, St Boswells.
JAMES GRAY, O.B.E., T.D. (James Gray & Co. (Stirling) Ltd.), Stirling.
Sir JAMES DENBY ROBERTS, Bt., O.B.E., M.A., J.P., Strathallan Castle, Auchterarder.
ROBERT L. SCARLETT, C.B.E., C.D.A., S.H.M., V.M.H., Sweethope, Musselburgh.

Chairman of Directors

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

Vice-Chairman

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

Ordinary Directors

1967

ROBERT ALLISON, Turnhouse, Corstorphine, Edinburgh 12.
.... Vacancy.
G. B. R. GRAY, Smeaton, East Linton.
JOHN MARSHALL, C.B.E., Dalreoch, Dunning. (deceased.)
P. P. WADE, Whitegates, Bardon Mill, Hexham, Northumberland.
JOHN WATSON (McGill & Smith Ltd.), 67 Kyle Street, Ayr.

1968

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

1969

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

Directors Co-opted

A. MANTON BAXTER (Baxter & Guion Ltd.), Museum Buildings, Priestgate, Peterborough.
J. LESLIE DAWSON, B.Sc., (S.A.I. Ltd.), West Mains of Ingliston, Newbridge, Midlothian.
G. A. STORRAR, M.C., B.Sc., J.P., Rossie, Auchtermuchty.

Directors nominated by the Secretary of State for Scotland

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

Standing Committee—Finance

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

Research Committees

Forage Crops

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

Potatoes

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

Election of Directors

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

ROBERT ALLISON, Turnhouse, Corstorphine, Edinburgh 12.
G. B. R. GRAY, Smeaton, East Linton.
P. P. WADE, Whitegates, Bardon Mill, Hexham, Northumberland.
JOHN WATSON (McGill & Smith Ltd.), 67 Kyle Street, Ayr.

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

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

Meetings

The Board of Directors met four times: on 24th July 1969; 4th November 1969; 26th March 1970; and 4th June 1970.

The Finance Committee met on 26th March 1970 and 4th June 1970.

Research Committee Meetings were held as follows: Potatoes on 22nd August 1969, 9th October 1969 and 8th January 1970; Forage Crops on 23rd October 1969.

7. ADMINISTRATION

Finance

The abstract of audited accounts set out on pages 42–48 reveals the Society's financial position at 31st March 1970. The Scottish Plant Breeding Station research programme was supported by a grant of £145,500 from Department of Agriculture and Fisheries for Scotland and other income amounting to £979, 19s. 10d. In addition, for alterations to the covered yard and workshops, the Department allowed expenditure of £1,944, 8s. 3d. from unspent balances of grants from previous years. From the Department's research grant for the year, £323, 5s. 8d. remained unspent.

The Department also provided capital grants during the year: £8,773, 9s. 8d. for capital works and £13,415, 11s. 8d. for capital equipment.

The Home Grown Cereals Authority supported a barley breeding project by means of a grant of £3,150, 18s.

Membership

At 31st March 1970 the total membership was 331, comprising 172 life members and 159 annual members. Sixteen new members were elected during the year and 38 members died or resigned.

Distribution of Membership as at 31st March 1970

Aberdeen	12	Fife	21	Renfrew	1
Angus	26	Inverness	6	Ross and Cromarty	8
Argyll	2	Kincardine	2	Roxburgh	11
Ayr	8	Kinross	2	Selkirk	3
Banff	2	Kirkcudbright	2	Stirling	3
Berwick	15	Lanark	17	Sutherland	..
Bute	..	Midlothian	57	West Lothian	6
Caithness	4	Moray	6	Wigtown	3
Clackmannan	2	Nairn	1	England	29
Dumfries	6	Orkney	3	Ireland	1
Dunbarton	3	Peebles	..	Wales	..
East Lothian	40	Perth	22	Abroad	8

Board of Directors

The Board of Directors learned with great regret of the deaths of two members during the year. Both had been members of the Society for twenty years or more and both had rendered sterling service to the Board and its committees. Mr R. H. Watherston, C.B.E., of Crichton Mains, Ford, died on 9th February 1970 and Mr John Marshall, C.B.E., of Dalreoch, Dunning, died on 22nd March 1970. They will be sorely missed.

The Board of Directors welcomed Mr E. F. Sherriff to the Board, on election, and warmly congratulated Mr John Arbuckle on the award of the O.B.E. Mr Arbuckle joined the Society in 1942 and has served for many years on the Board. He is presently Convener of the Potatoes Research Committee.

Staff

The following new appointments were made during the year:—

Scientific	R. J. Killick, B.Sc., Ph.D. (Potatoes).
Experimental	F. G. Cook, B.Sc. (Potatoes).
	R. J. Crawfurd, B.Sc. (Field and Works).
	R. J. Giles, B.Sc. (Forages).
	Miss R. J. Smelt, B.Sc. (Potatoes).
Assistants	D. C. Bignell (temporary).
	R. Borzucki.
	Mrs A. Clark.
	D. Fleming.
	M. Macaulay.
	G. J. McLean.
	Miss M. I. Munro.
	Miss H. Pollock.
	Mrs M. Sinclair.
Technical	A. E. Hamilton.
Administration	Miss I. M. N. Hayes.
	Mrs D. C. Murray.

The following resignations took effect:—

Miss E. A. R. Bogle.
Mrs M. Cadden (Miss Blackhall).
Miss R. A. Llewellyn.
Miss M. Orr.
G. N. Price, B.Sc.
A. Smith.
Miss M. Thomson.
Miss R. Pendrich.

Staff made three visits abroad during the year. Dr J. F. Malcolmson, at the invitation of the New Zealand Government, spent six months in New Zealand, November 1969 to April 1970, working in the Crop Research Division of the Department of Scientific and Industrial Research at Christchurch. Dr F. J. W. England visited grass breeding establishments in Holland for one week in July 1969; he travelled with the aid of a grant from the British Grassland Society, for which grateful acknowledgment is made. Dr J. M. Dunnett attended a meeting in Paris, 3rd to 5th June 1969, as U.K. representative to an O.E.C.D. committee appointed to consider the possibility of establishing an European Potato Introduction Station.

Members of staff attended sundry scientific meetings in the United Kingdom and gave three lectures or seminars to various audiences in meetings or at Universities. Dr Dunnett was appointed Honorary Fellow of Edinburgh University. The Director and Mr J. L. Fyfe again lectured in the University, the former to the fourth year Botany Class, the latter to the Diploma Class in Genetics. Mr Fyfe was appointed external examiner in Agricultural Botany at Aberystwyth and the Director again served as external examiner to the M.Sc. course in Applied Genetics at Birmingham University.

The Director also gave eight lectures to various audiences in research stations and Universities during the year. In November 1969 he visited the West Indies as Consultant to the West Indies Central Sugar Cane Breeding Station. He continued to serve on several committees within or directly connected with the work of the Agricultural Research Service. He was elected to the Council of the Institute of Biology and served as Chairman of Council of the Scottish Branch of the Institute. In March 1970 he was elected a Fellow of the Royal Society of Edinburgh. In November 1969 he attended a Senior Management Seminar run by the Civil Service Department at Sunningdale, Berkshire; the theme was "Appraisal of Research and Development Programmes".

The Station received many visitors during the year, among them parties of students, farmers and advisers, as well as individual scientists and technologists from home and abroad. We were pleased to see them all. Among the individual visitors we were glad to welcome The Hon. J. J. Astor, then, in July 1969, newly appointed Chairman of the Agricultural Research Council.

Acknowledgments

Acknowledgment of financial assistance from the Department of Agriculture and Fisheries for Scotland and of practical help in various forms from Universities, Colleges, Institutes, Companies and individuals has been made elsewhere in this Report. To all, whether named individually or not, who have thus supported the work of the Station, we offer our warmest thanks.

8. PUBLICATIONS

ALLISON, M. J. (1969). Mutagen specificity at the ad-3A and inositol loci in *Neurospora crassa*. *Mutation Research*, **7**, 141-154.

ALLISON, M. J. (1969). An effect of genetic background on dose-response curves in *Neurospora crassa*. *Mutation Research*, **7**, 297-306.

ANON (1969). Commonwealth Potato Collection. Inventory of seed stocks, 1968. Published by the *Scottish Plant Breeding Station*.

BORRILL, M., and CARROLL, C. P. (1969). A Chromosome Atlas of the Genus *Dactylis* (Part II). *Cytologia*, **34**, 4-17.

MACKAY, G. R. (1969). Possibilities from the use of matromorphy. *In:* Dixon, G. E. (Ed.), *Proceedings Brassica Meeting of Eucarpia*, 1968, Horticultural Section, 4-6 September 1968. Wellesbourne, England.

MCNAUGHTON, I. H. (1969). The synthesis of new crop plants from inter-specific and inter-generic crosses of *Brassica* and *Raphanus*. *Ibid.*

MALCOLMSON, JEAN F. (1969). Races of *Phytophthora infestans* occurring in Great Britain. *Trans. Br. mycol. Soc.*, **53**, 417-423.

MALCOLMSON, JEAN F. (1969). Factors involved in resistance to blight (*Phytophthora infestans* (Mont.) de Bary) in potatoes and assessment of resistance using detached leaves. *Ann. appl. Biol.*, **64**, 461-468.

MALCOLMSON, JEAN F. (1969). Vegetative hybridity in *Phytophthora infestans*. *Nature*, **225**, 971-972.

SIMMONDS, N. W. (1969). Variegated mutant plastid chimeras of potatoes. *Heredity*, **24**, 303-306.

SIMMONDS, N. W. (1969). Genetics of spectacle in diploid potatoes. *Heredity*, **24**, 487-90.

SIMMONDS, N. W. (1969). Genetical bases of plant breeding. *J. Rubb. Res. Inst., Malaya*, **21**, 1-10.

WATSON, PATRICIA J. (1969). Evolution in closely adjacent plant populations. VI. An entomophilous species *Potentilla erecta* in two contrasting habitats. *Heredity*, **24**, 407-422.

9. ABSTRACT OF ACCOUNTS

ABSTRACT OF ACCOUNTS

For year ended 31st March, 1970

INCOME

1969		
£437	Dividends and Interest	£233 3 3
469	Sales of Produce and Stock on Hand	431 6 7
67	Sale of Van	105 12 0
79	Subscriptions—Annual *Note.*—Annual Subscriptions amounting to £5 10 0 are in arrear.	72 13 0
45	Rent of Cottages	137 5 0
£1,097	*Total Ordinary Income*	£979 19 10
	Grant received from the Department of Agriculture and Fisheries for Scotland:—	
132,650	Maintenance for year 1969-70	145,500 0 0
£133,747	*Total Income*	£146,479 19 10
	Balance at 1st April 1969:—	
6,021	Department of Agriculture and Fisheries for Scotland—Maintenance Grant	9,185 10 5
£139,768		£155,665 10 3

EXPENDITURE

1969				
	Salaries:—			
£66,579	Scientific and Technical Staff	£72,419 6 4		
7,439	Administrative and Clerical Staff	8,173 3 1		
1,418	Pension Supplementation	1,576 3 1		
£75,436			£82,168 12 6	
6,117	Superannuation Contributions		7,457 6 3	
12,780	Wages		15,552 16 1	
3,640	National Insurance and Graduated Contributions		4,314 18 2	
4,102	Apparatus and Equipment		6,693 13 3	
3,063	Chemicals and Materials		5,793 11 4	
1,768	Travelling and Subsistence		2,318 14 6	
2,113	Rates, Taxes and Insurance		2,936 19 5	
5,807	Power, Heat and Light		5,464 6 1	
523	Library Books and Periodicals		562 5 10	
843	Printing and Binding		720 12 11	
1,413	Stationery, Postages, Telephones and Office Expenses		1,760 8 11	
2,316	Vehicles: Purchase		—	
1,325	Maintenance		1,907 12 3	
179	Audit and Legal Expenses		231 17 9	
924	Property Repairs		1,259 15 9	
221	Trial Centres		347 0 0	
1,054	Edinburgh Centre of Rural Economy—Contribution towards upkeep		1,233 0 0	
422	Repairs and Servicing		913 11 6	
675	Seed Testing, Plant Variety Trial Fees		450 14 0	
234	Transport		138 12 10	
1,439	Land Improvement		1,271 12 0	
652	Advertising		931 4 8	
287	Furniture		494 14 4	
513	Miscellaneous		526 16 9	
2,236	Property Alterations		1,944 8 3	
501	I. B. M. Computer Rentals		705 17 1	
£130,583	*Total Ordinary Expenditure*		£148,101 2 5	
	Balance at 31st March 1970:—			
9,185	Department of Agriculture and Fisheries for Scotland—Maintenance Grant		7,564 7 10	
£139,768			£155,665 10 3	

BALANCE SHEET

as at 31st March 1970

I Funds:—		
Balance as at 31st March 1969	£233,302 11 5	
Grant received from DAFS, Capital Works .	8,773 9 8	
" " " " , " Equipment .	13,415 11 8	
Gain on realisation of Investments . . .	1,770 0 8	£257,261 13 5
II Current Liabilities:—		
Accounts outstanding due by Society . .	£764 17 11	
Subscriptions paid in advance	3 10 0	
Dept. of Agriculture and Fisheries for Scotland Balance of Maintenance Grant . . .	7,564 7 10	£8,332 15 9
		£265,594 9 2

	Cost	*Amounts charged to Revenue*	*Net*
I Fixed Assets:—			
Heritable Property . .	£233,244 4 8	}	£255,471 19 1
Capital Equipment . .	22,227 14 5	}	
Implements and Tools . .	16,388 13 5	£16,388 13 5	...
Vehicles	4,679 1 3	4,679 1 3	...
Laboratory Apparatus . .	18,885 12 2	18,885 12 2	...
Furniture and Fittings . .	7,078 8 8	7,078 8 8	...
Library Books . . .	5,826 0 0	5,826 0 0	...
	£308,329 14 7	£52,857 15 6	£255,471 19 1

II Current Assets:—		
Stocks on Hand as valued by Directors . .	£36 0 0	
Accounts Outstanding, due to Society . .	747 0 0	
Income Tax Recoverable	26 5 1	
H.G.C.A. Grant due to Society . . .	645 19 6	
Cash and Bank Balances.	8,667 5 6	10,122 10 1
		£265,594 9 2

Edinburgh, *14th May. 1970.*—The undersigned, having had access to all the Bo[illegible]s of the Society, and having examined the foregoing Statement of Accounts and verified the same with the Accounts and Vouchers relating thereto, now sign th[illegible]d to be correct, duly vouched, and in accordance with law.

16 Alva Street.

BROWN, MACDONALD & FLEMING, *Auditors.*

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

LIFE MEMBERSHIP SUBSCRIPTIONS AND DONATIONS ACCOUNT

Dividends and Interest	£499 13 3
Donations	50 0 0
Life Subscriptions	105 0 0
Fee (The Grower)	26 5 0
Malayan Rubber	500 0 0
Balance at 1st April 1969	9,117 9 8
	£10,298 7 11

W. J. REID AND JAMES MUNRO BEQUESTS

Dividends and Interest	£115 15 9
Balance at 1st April 1969	1,834 19 9
	£1,950 15 6

DR. WILSON MEMORIAL FUND

Dividends and Interest	£26 9 1
Balance at 1st April 1969	505 18 4
	£532 7 5

HOME GROWN CEREALS AUTHORITY

Grant received	£3,150 18 0
Balance due to Society at 31st March 1970	645 19 6
	£3,796 17 6

Travel Grant		£20 0 0
Loss on Sale of Investments		94 4 2
Hospitality		34 0 0
Balance at 31st March 1970, consisting of:—		
Investments (see Appendix), at cost	£8,987 13 3	
Recoverable Income Tax	174 5 10	
Deposit Receipt	400 0 0	
Cash in Bank of Scotland Current Account	94 1 1	
Cash in Bank of Scotland Savings Account	464 3 7	
Cash in hand	30 0 0	
		10,150 3 9
		£10,298 7 11

Hospitality		£40 8 0
Balance at 31st March 1970, consisting of:—		
Investments (see Appendix), at cost	£1,699 2 10	
Recoverable Income Tax	43 15 6	
Cash in Bank of Scotland Current Account	102 9 2	
Cash in Bank of Scotland Savings Account	65 0 0	
		1,910 7 6
		£1,950 15 6

Balance at 31st March 1970, consisting of:—		
Investments (see Appendix), at cost	£464 0 1	
Recoverable Income Tax	8 15 5	
Deposit Receipt	55 0 0	
Cash in Bank of Scotland Current Account	3 4 10	
Cash in Bank of Scotland Savings Account	1 7 1	
		£532 7 5
		£532 7 5

Balance brought forward from previous year	£615 9 0
Salaries	2,273 5 5
Superannuation contribution	255 13 11
National Insurance and Graduated Contribution	129 10 2
Apparatus and Equipment	485 9 0
Conference Fee	37 10 0
	£3,796 17 6

APPENDIX

LIST OF INVESTMENTS

Life Membership Subscriptions and Donations Funds

Nominal Value		*Market Value at 31/3/70*
£240 0 0	Courage, Barclay & Simonds Ordinary 10s. Shares	£696
220 0 0	Electrical & Musical Industries 440 Ordinary 10s. Stock Units	1,072
416 8 1	6½ per cent Funding Stock 1985-87	329
82 15 0	Guardian Royal Exchange Assurance Co. 331 Ordinary 5s. Shares	488
345 0 0	Imperial Chemical Industries Ordinary £1 Stock Units	906
247 10 0	National Commercial Banking Group Ltd. 990 Ordinary 5s. shares	743
86 5 0	"Shell" Transport & Trading Co. 345 Ordinary 5s. Shares	1,203
1,153 0 0	Stirling County Council 7¾ per cent Loan 1977-79	1,003
2,359 6 11	Treasury 8¾ per cent Loan 1997	2,336
760 0 0	Treasury 8½ per cent Loan 1980-82	741
		£9,517

W. J. Reid and James Munro Bequests

£1,359 5 9	6½ per cent Funding Stock 1985-87	£1,074
80 0 0	Imperial Chemical Industries 80 Ordinary £1 Stock Units	210
208 0 0	Stirling County Council 7¾ per cent Loan 1977-79	181
		£1,465

Dr Wilson Memorial Fund

£276 12 0	6½ per cent Funding Stock 1985-87	£218
26 15 0	Guardian Royal Exchange Assurance 107 Ordinary 5s. Shares	158
		£376

10. LIST OF MEMBERS

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

Aberdeen

Chisholm, Miss E. M. Gibston, Huntly.
Dempster, D. G., Aberdeen University Farms, Tillycorthie, Udny.
Durno, James, C.B.E., Uppermill, Tarves.
Ellis, John, Crookmore, Alford.
Gill, A. J. (James Gill & Sons, Ltd.), 6 Exchange Street, Aberdeen.
Howie, Andrew, B.Sc.(Agric.), N.D.A., N.D.D. (North of Scotland College of Agriculture), 41½ Union Street, Aberdeen.
Lee, E. M., Haddo, Methlick.
Mackie, Maitland, O.B.E., LL.D., North Ythsie, Tarves.
Salmon, A. B., 20 Harlow Road, Aberdeen.
Scott, C. D., Waterside, Newburgh.
Shackleton, J. F. (Benjamin Reid & Co.), 20 Hadden Street, Aberdeen.
Turnbull, A. T., Smithston, Gartley.

Angus

Adam, Andrew, Newhouse of Glamis, Glamis, Forfar.
Arbuckle, Wm. S., N.D.A., Old Downie, Carnoustie.
Archie, Alex. R., South Leckaway, Forfar.
Barr, John M. (Pattullo, Barr & Co., Ltd.), West Dock Street, Dundee.
Barron, J. R., Findowrie Farm, Brechin.
Batchelor, D. Hill, 4 Baltic Street, Montrose.
Black, David, 16 Railway Road, Montrose.
Braes, Robert, West Ballochy, Montrose.
Fairlie, Denis W. W., Kirkton, Monikie, Dundee.
Forster, E. A., Mains of Benholm, Benholm, Montrose.
Galloway, George L., East Balmirmer, Arbroath.
Henderson, Frank M., 7 Bingham Terrace, Dundee.
Inverarity, J. A., Cransley, Liff, by Dundee.
McLeish, Allister (Geo. Ogilvie (Montrose) Ltd.), Panmure Buildings, Ferry Road, Montrose.
Mackie, George Y., Ballinshoe, Kirriemuir.
Milne, Alex. S., Timaru, Trinity, Brechin.
Murray, Joseph, N.D.A., N.D.D., Balruddery Farm, Invergowrie (*last known address*).
Murray, T. P. Douglas, 26 Swan Street, Brechin.
Porter, A. Gordon, J.P., East Scryne, Carnoustie.
Rankin, G. M. Westdrums, Brechin.
Renwick, J. H., Border, Arbroath.
Smith, Stanley B., Crosston, Dunnichen.
Thomson, J. G., Kinpurnie Farm, Newtyle.
Wallace, D., Pitpointie, Auchterhouse, Dundee.
Warnock, John, Shandon, Rosehill, Montrose.
Young, Charles, B.Sc., Shielhill, Dundee.

Argyll

Ferguson, Hugh, B.Sc., Beach Hill, Campbeltown.
Pollock, Mrs Gladys M., Ronachan, Clachan.

Ayrshire

Atkinson, James, 37 St Andrew Street, Kilmarnock.
Hannah, John J. M., 3 Cairn Crescent, Alloway, Ayr
Harvey, N. P., Oakvilla, Dalrymple, Ayr.
McGill, J. Becket F., 52 Carcluie Crescent, Ayr.
Rowallan, Lord, M.C., Rowallan, Kilmarnock.
Stevenson, Robert H. U., Corseclays, Ballantrae, Girvan.
Stewart, John, Dalquharran, Dailly, by Girvan.
Watson, John (McGill & Smith Ltd.), 67 Kyle Street, Ayr.

Banff

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

Berwick

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

Caithness

Bruce, James S., 26 Union Street, Wick (*last known address*).
Campbell, A. D., Sibster, Halkirk.
Morris, John, Borlum, Reay, Thurso.
Sinclair, Hon. Robin McDonald, East Mains, Thurso.

Clackmannan

Fisher, John, Jellyholm, Alloa.
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