

R E P O R T

BY

DIRECTOR OF RESEARCH

I. Research Programme.

ALTHOUGH Scotland is a comparatively small country a considerable range in soil and climatic conditions exists, and one of the functions of the plant breeder is to produce crop plants adapted as far as possible to one or another of these different sets of conditions. Some of the advantages accruing to the plant breeder through his being able to select and compare crop plants under different sets of field conditions were being realised at the Society's upland sub-station at Ainville, Kirknewton, Midlothian, which has been available for experimental work since 1926. Originally the ground at the sub-station was used only for potato breeding, but latterly more ground was obtained and the scope of the investigations was advantageously widened to include work with herbage plants and oats. The Society's tenure of this ground terminated, however, at November 1939 on the entry of a new tenant to Ainville Farm. The Board of Directors of the Society therefore decided that an endeavour should be made to obtain the use of another area of suitable ground in the Lothians or adjacent counties where the work conducted at Ainville Sub-station could be continued on similar lines. Towards the end of 1939 an arrangement was made with the Governors of the Edinburgh and East of Scotland College of Agriculture whereby the Society would obtain the

use of about 6 acres of land, lying at an elevation of about 600 feet above sea-level, at Boghall Experimental Farm for the erection of the necessary buildings and for plant-breeding experiments. Entry to the ground was obtained as from 28th November 1939, and the Society's greenhouses and other buildings at Ainville were subsequently dismantled and re-erected at Boghall. This work was almost completed by the end of March, and the experimental work has been continued with the minimum amount of interruption.

The investigations at Corstorphine were continued on numerous problems relating to the improvement of the more important Scottish crop plants such as Oats, Barley, Wheat, Beans, Potatoes, Herbage Plants, Swedes, and Kales. A review of the work for the year ended 31st March 1940 is given in these pages.

In view of the extended interest that is now being taken in grazing plants and grassland research, the report of the work with herbage plants includes some results obtained in the upland pasture investigations at Ainville which are of practical interest, especially at this time.

In the spring and early summer of 1939 there was a prolonged spell of dry weather which had an adverse effect on the cereal and root crop experiments. Rain came too late in the season to enable spring sown cereal plants, more especially those which ripen early, to grow to their maximum capacity. During the dry weather in spring, birds, chiefly rooks, were exceptionally troublesome, and they did much more damage than usual by uprooting many seedling plants. Comparisons of trial plots were therefore rendered less reliable.

GRAIN CROPS.

WILLIAM ROBB, *Director of Research.*
CHARLES A. LYALL, B.Sc.

Oats.

The problem of breeding highly productive oat varieties which will be resistant to lodging when grown on the more fertile soils and which possess other desirable characteristics that will meet the needs of growers, merits the expenditure of as much effort as possible. A promising line along which this

work has been proceeding has been the breeding from parent plants, which may transmit to some of their offspring a combination of such characters as relatively short straw and high productivity of grain. The shorter straw types undoubtedly tend to be less liable to lodge than those with longer straw. The Semi-dwarf oat has therefore been used as a parent, and the results so far obtained indicate that breeding with this oat deserves further exploitation on as large a scale as conditions will permit. The varieties Early Miller and Elder, the latter of which is known to be highly resistant to lodging but rather too late in ripening, have also been used as parents. For selection of plants resistant to lodging, unfixed hybrid progenies derived from the after-mentioned crosses were grown on an extensive scale—Early Miller \times Semi-dwarf, Elder \times Semi-dwarf, Elder \times Early Miller, Elder \times Marvellous, Early Miller \times Marvellous.

Among the shorter-strawed but fixed hybrid selections that are resistant to lodging, one derived from Potato oat \times Yelder has been favourably reported upon in trials in several different districts in Scotland. This selection ripens early and therefore does not suffer from the defect which has operated against a wider use being made of the Society's new oat variety Elder.

Comparisons were also made of several series of early maturing selections which may be adapted to poorer soils in upland areas. Amongst these there were selections from Elder \times Mulga, Sparrowbill \times Nidar, Victory \times Bathurst. Some of these early-ripening selections reach maturity at Corstorphine about ten days earlier than the varieties Potato and Sandy which are still extensively grown in certain areas in Scotland. A defect of many of the very early-ripening varieties is that they give too low a yield of grain. An effort is being made to see how far combination of high grain yield, early maturity, and hardiness for Scottish conditions can be secured.

Breeding to obtain resistance to sprouting of oat grain in the stook was carried a stage further. A large fourth-hybrid generation of plants derived from a cross between the variety Elder and the wild oat *A. fatua* was grown. Plants with the cultivated type of grain were selected, and grains from each were tested for germination immediately after harvest. All the plants possessing the desired characteristics of delayed germination, however, have rather small, thin grain, and it has therefore been decided that the size of the grain should

be increased. Some of the selected plants will be crossed with a larger grained variety, and the grain of the progeny plants subjected to germination tests as before.

Pure stocks of Early Miller and Bell oats were again grown at the Plant-Breeding Station and all the seed was readily sold to members at 30s. per hundredweight.

Replicated yield trials of about twenty-five unnamed new selections were carried out in accordance with the improved system referred to in the previous Annual Report. Several of the selections gave higher yields of grain than those produced by the varieties Eagle and Victory, but the differences could not be regarded as statistically significant. Further trials of the best of these will be made.

Barley.

From the fourth-generation hybrids of two crosses—viz., Kenia \times Spratt Archer and Kenia \times Plumage Archer—desirable types have been selected. These have the short, resilient straw and absence of 'neck' of the Kenia parent, and are rather earlier in ripening than Plumage Archer and Spratt Archer.

In 1937 Scots Common Barley was crossed with Plumage Archer in an attempt to obtain a Common type with the good quality grain and standing ability of Plumage Archer. From the progeny of this cross promising types with fairly short, stiff straw and very short 'necks' have been selected. The best types have long ears, slightly less lax than Scots Common types, and grain quality is definitely improved.

None of the accepted high-quality barleys gives grain of the highest grade under the conditions obtaining at the Scottish Plant-Breeding Station. The variety Primus, however, has given a good quality sample here over several seasons. This variety has been crossed with Kenia and with one of the Kenia \times Spratt Archer hybrids in an attempt to improve the Primus variety for conditions such as prevail at Corstorphine. Further crosses made during 1939 have included Golden Archer and *Ac 54* (a barley of Abyssinian origin). *Ac 54* is a two-row dense-eared barley with very short stiff straw and short neck. It is hoped to obtain short-strawed types with good grain quality. Attempts are being made to

improve the grain quality and yield of Scots bere by crossing, and if possible to produce forms less liable to 'neck.'

Wheat.

Work continues to be concerned chiefly with spring wheat. One winter wheat cross, however, was made in 1939—Wilhelmina \times W43(2)B(1) (a selection raised at the Station). In 1934 a Mesopotamian vulgare wheat was crossed with Sun III. This Mesopotamian wheat has one good quality—a large flinty grain which gives a uniform sample. W43(2)B(1) and other selections from the 1934 cross have large flinty grain and well-filled ears, but they have pubescent glumes and are bearded, as well as being weak strawed and late in ripening. The cross with Wilhelmina has been made with the hope of producing a good quality wheat which will yield well over a wide range of soils. Most British wheats of good baking quality only yield well under conditions of high fertility, owing to their small ears and high-tillering capacity.

With spring wheat the main objective is the production of early-ripening forms, resistant to lodging and resistant to loose smut. During the year a number of Australian wheats, resistant to loose smut in their native country, has been added to the collection of foreign spring wheats, which are being used as parents in this work. The resistance of these Australian varieties under Scottish conditions is being determined by artificial infection. A further number of crosses with smut-resistant varieties has been made during 1939.

Colchicine Treatment.

Further attempts have been made to induce polyploidy by treatment with colchicine. Previously wheat, oats, and barley have been treated with colchicine, but in 1939 attention was confined to several varieties of barley. Grain was soaked in solutions of colchicine as before, but in addition a new method of treatment was adopted. Briefly, this consisted of injecting a 0.4 per cent colchicine solution into the shoots of young barley seedlings by means of a hypodermic syringe. The object of this method of treatment was to bring the colchicine solution into contact with the tiller buds and to obviate the depressing effect of the colchicine on the root system. This treatment produced a number of plants with

tillers showing characteristic malformations, which may be indicative of an increased chromosome number. Grain from the ears produced by these abnormal tillers was sown this spring, and root-tip chromosome counts will be made.

Beans.

Field beans and soya beans were again grown on a small scale. It has been found that an appreciable amount of natural intercrossing has been taking place among the field beans, and this has necessitated taking some precautions to prevent its occurrence. The stocks of different varieties and the selections made from them are now being grown in plots isolated from each other as far as is practicable. It will be realised, however, that this severely limits the number of varieties and the amount of each that can be grown each season.

In an article in the 'Journal of the Ministry of Agriculture,' Vol. XLVI., No. 7, 1939, Principal William G. R. Paterson suggests that the introduction of an early-maturing, heavy-yielding field bean would be helpful to dairy farmers in the South-West of Scotland. The possibilities of producing a field bean of this type are being kept in view. In addition to the collection of varieties which have been grown for several years, a number of hybrid field beans have been secured, and observations on these are being made.

The soya beans, grown outside under garden conditions, in general produced better crops than they did in the preceding year, the weather conditions apparently being more suitable in 1939 for this bean. In some of the varieties the plants were much larger than they were in others. The largest plants were bushy and reached a height of about 27 inches. Many of the larger-growing varieties, however, produced no seed. Some of the smaller varieties produced a little seed, but not nearly enough to indicate they were worth trying on a field scale. In 1939 the leaves in almost all the varieties became distinctly mottled towards the end of August, resembling potato leaves showing symptoms of the virus disease known as mosaic.

POTATOES.

WILLIAM BLACK, B.Sc., Ph.D. (Boghall Sub-Station).

Much of the potato-breeding work of the past year has been directed towards the production of plants which possess

a high degree of resistance to blight (*Phytophthora infestans*). Over 4500 seedlings, bred from blight-resistant stock, were raised in 1939 and tested for their reaction to blight by means of a controlled glass-house method evolved for the purpose.

The majority of the seedlings were bred from the wild hexaploid species *S. demissum*, which possesses a very high degree of resistance to blight, and the group included various first, second, and third back-crossed generations. The proportion of blight-resistant plants in the progenies showed a general tendency to decrease with each successive back-cross to a cultivated variety, but the decrease was frequently small and presumably dependent upon the inherited resistance of the seedlings used as parents. The proportion of blight-resistant plants obtained in the various progenies ranged from 33½ per cent to over 80 per cent. The mode of inheritance of resistance to blight appears to be very complex, but no difficulty was experienced in retaining this resistant characteristic in combination with other desirable qualities. A number of third back-cross progenies contained over 60 per cent resistant plants.

Over 1200 plants were bred from the blight-resistant seedling Ref. No. 967c (38). This variety is a sixth-generation derivative of *S. demissum* and *S. edinense*, both of which remain unaffected by the common strain of blight. Progenies obtained by crossing 967c (38) with cultivated varieties were found to contain about 45 per cent resistant types. Selections made from them showed considerable promise as economic varieties, and these have been retained for further trial and multiplication. The varieties successfully used as pollen parents in this work were The Alness, Pepo, Shamrock, Katahdin, Liddesdale Lad, Flourball, and the seedling No. 121(2).

In the intercrossing of commercial types attention has been concentrated on the use of those which possess the valuable character of field immunity from viruses 'A' and 'X.' About 700 seedlings were raised in this group, and were derived from such varieties as Craigs Defiance, Epicure, and Liddesdale Lad, all of which possess this field immunity.

Investigations were continued on the possibility of utilising certain wild species, in addition to *S. demissum*, in the improvement of the potato. The species mainly concerned were *S. polyadenium* (diploid), *S. Rybinii* (diploid), *S. andigenum* (tetraploid), *S. fendleri* (tetraploid), *S. leptostigma* (tetraploid), and *S. edinense* (pentaploid). Various back-cross generations,

F₂ generations, and multiple hybrids have been raised, and work is in progress examining the many different and irregular chromosome complements which have resulted.

In collaboration with the Imperial Bureau of Plant-Breeding and Genetics, a collection of wild species, consisting of 235 samples from Mexico and South America, was grown and multiplied. The seedlings were examined morphologically and many were tested for their reaction to blight. Various chromosome counts were also made.

Large numbers of seedlings raised in previous years were grown in trial and multiplication plots at Ainville and Craigs House. Many of them had passed through the test for blight resistance in 1938, and their resistance had been confirmed in the field. The resistant types contained an encouraging proportion of forms worthy of trial as economic varieties, and several of them proved to be early in maturing. The majority of all the selections chosen for further trial in 1940 has proved to be resistant to blight.

The Potato Registration Trials carried out by the Department of Agriculture in 1939 contained a number of the Society's seedlings. These trials have been discontinued for the time being, but three seedlings were reported as showing considerable promise—viz., 373*a* (29), 586*b* (53), and 594 (87). No. 373*a* (29), as a second early, gave a heavy yield of tubers possessing good size, shape, and quality. It was, however, affected with blight. No. 586*b* (53) proved to be an attractive maincrop variety of very good quality, and it gave a heavy yield of tubers of good size and shape. No. 594 (87), a blight-resistant maincrop, gave a heavy yield of large tubers of good table quality. This variety remained quite unaffected by blight throughout the season.

The Potato Trials, arranged by the Ministry of Agriculture and Fisheries, at Ormskirk, contained samples of the Society's seedlings. The report received regarding the seedlings was encouraging and was also helpful in making comparisons. Further samples of seedlings have been forwarded for inclusion in the 1940 trials at Ormskirk.

The new variety, Craigs Defiance, was multiplied at Ainville in 1939, and a Stock Seed Certificate was granted by the Department of Agriculture for Scotland in respect of the crop. It was decided, however, not to release this variety until there was a larger quantity of it, and to multiply the stock

further in 1940. Arrangements were thereafter made with Miss Chisholm, Gibston, Huntly, whereby 4 tons of Craigs Defiance would be planted there and grown for the Society.

Samples of Craigs Defiance were distributed to certain centres in Scotland and England, where they will undergo comparative trials with standard named varieties in 1940.

A small multiplication plot of The Alness potato was grown at Ainville in 1939 and all the surplus crop was sold for seed.

HERBAGE PLANTS.

J. W. GREGOR, Ph.D., D.Sc., F.L.S.
J. M. S. LANG, B.S.A.

Renovation of Poor Pasture at Ainville Sub-Station.

In a previous report it was mentioned that pasture investigations had been started at Ainville in order to examine methods of reconditioning semi-derelict pastures by the employment of a grazing nurse crop, thus maintaining as continuously as possible the utility of the pasture as such. Unfortunately the studies there had to be terminated on the entry of a new tenant to the farm, who required the land which the Society had rented. Nevertheless a considerable amount of data had been collected relative to the aspects of the problem most intimately connected with plant breeding. Some of the observations have particular significance at the present time when the improvement of the poorest pasture becomes an important consideration in view of the appropriation of the better grasslands to meet the urgent need for an increased arable acreage. In this report it is proposed to discuss briefly only those observations which have a bearing on the choice of plants for pasture renovation under war-time conditions.

It is now generally agreed that the surest way of renovating poor pasture land is first to plough down the existing herbage, and the importance of having the herbage correctly ploughed under and the proper seed bed prepared to receive the new seeds mixture cannot be too strongly emphasised (for methods see 'News and Notes for Farmers,' No. 17; 'Ploughing and Cultivation'; and No. 19, 'Liming and Manuring,' issued by the Department of Agriculture for Scotland).

With regard to the choice of plants to sow, three questions arise: (1) What plants are likely to provide the grazing animal with food during the time the pasture species proper are establishing themselves? (2) Is short-term or long-term pasture required? And (3) if short-duration leys are desirable, can the commercial varieties of the potentially highly-productive grasses, such as Italian ryegrass, perennial ryegrass, cocksfoot, and timothy, be successfully employed?

(1) *Nurse Crops*.—At Ainville the inclusion of straw types of oats in the seeds mixture gave very satisfactory results, the plants being fit to graze approximately two or three weeks earlier than the customary nurse crop of rape. On better-class lands rape will almost certainly give more grazing than oats late in the season, but on poor land at Ainville the performance of rape was by no means remarkable. Oats in the early stages of growth cast relatively little shade, and thus favour the establishment of the more delicate grass and clover seedlings; nevertheless if grazing is delayed too long the spread of wild white clover is greatly retarded. Therefore the stage at which an oat nurse crop is first grazed is a very important factor in determining the subsequent quality of the pasture. For example, three series of plots sown on the same date, 20th May, were grazed for the first time on 13th July, 25th July, and 9th August respectively. These gave grass-clover ratios in the second year of 100:107, 100:78, and 100:20. Postponement of grazing thus progressively diminished the representation of wild white clover, and at the same time affected both the vegetative vigour and palatability of the associated grasses.

(2) *Short-term versus Long-term Pasture*.—This is a question which is particularly relevant at the present time, because, while the sowing of long-duration pastures would perhaps have been justified under the recent unsatisfactory economic conditions, the immediate need is for the highest possible production in the shortest possible time. Permanent pastures, generally speaking, are not productive in the early part of the year, and since maximum production can be obtained only by high yields throughout the entire season, the present need would seem to be for short leys capable of earlier growth. This implies the extension of the lowland system to upland districts.

(3) *Seeds Mixtures*.—The effect of a grazing nurse crop, in

contrast to a grain nurse crop, is to accelerate turf formation, and thus to favour the establishment of the rapid growing and most vigorous grass seedlings. For instance, in one series of plots a mixture of 16 lb. per acre of Ayrshire perennial, 18 lb. of Danish cocksfoot, 6 lb. of Stirlingshire timothy, and 1 lb. of wild white clover was sown. On the basis of viable seeds sown, the grass proportions in the resulting pasture ought theoretically to have been 20 per cent ryegrass, 46 per cent cocksfoot, and 34 per cent timothy; instead of which an analysis fifteen months later gave the establishment values 64 per cent ryegrass, 24 per cent cocksfoot, and 12 per cent timothy, demonstrating the aggressiveness of ryegrass at the expense of the weaker seedlings of both cocksfoot and timothy. The question therefore arises, would it not be more profitable to sow one grass species only in a pasture laid down under these conditions instead of a mixture of species? The results of the Ainville trials suggest that it would, for, apart altogether from the loss of the relatively costly seeds of cocksfoot and timothy, the yield of fodder in the second season from the mixture plots was actually less by 8 per cent than that from a series of plots containing only perennial ryegrass and wild white clover, and also less by 7 per cent than that from another series containing only cocksfoot and wild white clover. Moreover the mixture plots contained 25 per cent more weeds than the ryegrass plots, 4 per cent more than the cocksfoot plots, but 17 per cent less than plots of timothy. Nothing therefore has been gained by sowing a mixture of species.

In the presence of competitors such as ryegrass and cocksfoot, germinating under the conditions of a grazing nurse crop, the inclusion of bottom grasses is of doubtful value, and at Ainville it was found that in the absence of the slow-developing and comparatively low-yielding bottom grasses the requisite pasture density was readily obtained when the much more valuable wild white clover was encouraged to spread by grazing the nurse crop early. In fact the maintenance of Ayrshire perennial ryegrass and Danish cocksfoot at a satisfactory level of production was only obtainable by ensuring an abundant growth of wild white clover.

It has been shown that single species can give results as good as or better than a mixture of species. At the same time the highest yields from any species plots were obtained

from a mixture of varieties within that species. For instance, the highest seasonal yields of ryegrass were obtained from plots sown with a mixture of Ayrshire perennial and a late-flowering variety; and similarly a mixture of early and late cocksfoot varieties gave the best yields in the cocksfoot series. The use of late varieties tends to level out the production peaks and declines exhibited by early commercial varieties during a season's growth and to extend the grazing season at the end of the year. It is, for instance, the scarcity of late commercial varieties of perennial ryegrass that has led the plant breeder to re-explore the old pastures in search of suitable breeding material, and at the present time it is by the judicious use of mixtures of early commercial and these late varieties (not by the use of bred strains alone) that the most satisfactory results are likely to be obtained.

The following seeds mixtures (in rates per acre) gave good results on a moist mineral soil at 900 feet elevation:—

2 bushels Sandy oat.

2 bushels Grey winter oat.

20 lb. Ayrshire perennial ryegrass (or 10 lb. Ayrshire perennial ryegrass and 5 lb. Italian ryegrass).

20 lb. late-flowering perennial ryegrass.

1 lb. wild white clover.

The inclusion of Italian ryegrass in the alternative mixture adds to the bulk in the seeding year, but this mixture must be grazed early if the retarding of the spread of wild white is to be avoided. In the case of drier soils it may be an advantage to replace some or all of the perennial ryegrass by cocksfoot. At Ainville milking cows were used to graze the seeding year pasture, their daily grazing routine being: first, adjacent rough pasture; then the oat nurse crop for three hours; and finally, back to the rough pasture, which incidentally was greatly benefited by this treatment.

Conclusions.—(1) A straw type of oat such as Sandy made a satisfactory nurse crop for the pasture grasses and wild white clover, provided it was grazed at the correct time; (2) the rapid spread of wild white clover was essential to the success of the early commercial varieties of ryegrass and cocksfoot; (3) seedling competition under a grazing nurse crop was severe, and probably accounted for the fact that mixtures of ryegrass varieties or mixtures of cocksfoot varieties

gave better results than species mixtures; and (4) mixtures of early and late varieties of a species gave a greater seasonal production than that of either variety sown alone.

Breeding and Multiplication of New Varieties.

The chief objects of the breeding work are to produce improved strains of early and late perennial ryegrass and early cocksfoot, and a collection of seedling plants of these grasses was grown in nursery plots for comparison and selection. The studies on sea-plantain and ribgrass were also continued.

The further multiplication of varieties for long duration pasture—*e.g.*, Diploid Timothy *Cb* 191, has been suspended for the time being, and efforts are being concentrated on increasing the seed stocks of varieties which have proved their value in the grassland renovation trials and those which are likely to be suitable for the temporary pastures of the lowlands.

The undernoted varieties were multiplied:—

Perennial Ryegrass, Ca 434.—This is a relatively late variety, which has given satisfactory results when sown with Ayrshire perennial and wild white clover under a grazing nurse crop of oats. *Ca* 448.—This is an early variety derived from Devonshire material, which bulks well in nursery plots, and it merits promotion to the field-trial stage.

Cocksfoot, Cc 180—A multiplication of a reselected stock of this variety has been made, as the commercial stocks had become too impure.

Timothy, Cb 213.—This is a rust-resistant hexaploid variety suitable for sowing in lowland pastures, but also capable of giving good yields of leafy hay. *Cb* 224.—This is a strong stiff-strawed hexaploid hay variety.

ROOT CROPS.

(Swedes and Kales.)

V. M'M. DAVEY, B.Sc., Ph.D.
J. M. S. LANG, B.S.A.

The primary purpose of the experiments with swedes is the examination of various methods for the selection and com-

parison of individual plants intended for use in breeding with a view to obtaining improved strains or varieties. The object with kales is to devise a suitable method for propagating lines on a small scale with a view to combining those of similar appearance into strains of greater economic value.

Propagation.—About 190 samples of swede and 75 of kales were obtained by self-fertilisation or by hand-crossing, and four larger quantities were obtained by mass multiplication. Yields were somewhat below average, but sufficient seed was harvested for the continuance of the experiments. The plants selected for seeding in 1940 were badly damaged by frosts.

Kale Breeding.—Crops of marrow-stem and thousand-headed kales show considerable variation in their leaf and stem characters. Experiments have been in progress since 1936 to ascertain whether it is possible to isolate strains which would be of more uniform type and of equal or better feeding value. Lines of kales in the second generation of self-fertilisation were found, as was to be expected, to be relatively feeble and small plants, though there was considerable uniformity of type in some lines. F₁ hybrids from crosses made between the different lines were large plants and compared well with commercial crops. The hybrid strains were relatively uniform, and some of them appeared to be useful types. The object was to find which lines when combined by crossing would give good crops, so that those lines might be continued to form the basis of a compound strain. Reselections could also be made from the later hybrid generations. If possible, it is hoped to get similar but unrelated lines, so that the desired characters may be impressed on the resulting strain, together with the restored vigour due to outbreeding. A line of thousand-headed kale, T₁, has a very distinctive habit of growth; but though it is self-fertile, which is unusual in these kales, it is a relatively small cropper. Several lines have been started from unrelated plants of similar appearance to T₁, but the value of crossing T₁ with these is not yet known. Meanwhile the line T₁ has been closely examined, and is found to be varying for minor leaf characters and for production of side shoots and new leaves in the autumn. The most variation in leaf characters is found in the thousand-headed kales, and there are great differences between the dates when the side buds begin to develop. In marrow-stem kales there are differences in the surface of the stem and in the coarseness of

the leaf scars; the number of leaves borne at any one time is small, and attempts are being made to obtain leafier types. Some lines of marrow-stem kale with short stout stems were selected, but they appeared to be susceptible to rotting of the pith.

Observations were made on the resistance to frost of various strains of kales. Both marrow-stem and thousand-headed kales appeared to escape damage from the severe frosts in the beginning of January 1940, when the plants were covered with snow. Later frosts in February, without a snow covering, destroyed the crops, only 5 per cent appearing to be still viable. Under somewhat more sheltered conditions the marrow-stem plants kept for seeding were all destroyed, while the thousand-headed plants suffered very few losses. The unprotected stem and large pith of the marrow-stem appear to be sources of weakness.

Swede Pedigree Breeding.—Four acres were laid out in small and large observation plots and in yield trials. Comparative notes were made regarding the pedigree lines and inter-varietal crosses, and selections were made for propagation. Two yield trials were tested for dry-matter and bulb weight.

Yield Trials.—The effects of plant numbers have hitherto seriously limited the interpretation of results in the swede yield trials. It is well known that plants growing next gaps tend to be larger than average. Plots which contain large numbers of blanks may therefore have an increased bulb weight, and when one of the strains differs considerably from the others in plant numbers its yield may be misleading. The results of past yield trials have been examined by appropriate statistical methods, and the extent to which plant numbers affect determinations of yield has been ascertained. It was found that average bulb weight increased as the plant numbers decreased, but in three out of twenty-five trials this effect was absent. Dry-matter percentage appears to be so little affected by number of plants that it is not worth while to correct the results statistically; the unadjusted percentages for the strains in a trial usually show some differences which are highly significant. Dry-matter content of the bulb—*i.e.*, the amount of foodstuffs contained in a bulb of average size—is affected like the bulb weight, and the adjustment of the figures to allow for the effect of plant numbers improves the efficiency of the trial.

Finger-and-Toe Disease.—Seedling finger-and-toe resistance tests were carried out on more than 3000 plants. The young seedlings were pricked out into shallow boxes of partially burnt soil, and infection in the form of an aqueous extract of minced nodules was applied about the eighteenth day. It was found that the maggot of the cabbage root-fly is a serious hindrance to the efficiency of the test, since the attacked roots usually show no nodules. After a severe attack had been found in the first-sown trays, the practice of covering the surface of the soil with naphthalene every ten days was adopted. The latter sown seedlings were free or only occasionally attacked, but it remains to be seen whether the main attack in the spring can be successfully averted by this means. A second difficulty which has been experienced is the destruction of resistant seedlings at a later stage. The swede has never shown true immunity from the disease, and the utility of the seedling test depends on the assumption that a plant which is able to survive in the early stages of growth will not be seriously damaged in the later stages.

In the field an infected area was again sown out with various strains of swede. It was found that three strains derived from inter-varietal crossings had developed larger bulbs than the others, though none were free from the attacks of finger-and-toe disease. This apparent resistance may have been related to unevenness of infection in the plots, and the three strains are being mass-multiplied with a view to further testing.

CYTOLOGICAL WORK.

J. M. MAIN, B.Sc.

In the genus *Brassica* a beginning was made with an examination of the chromosome content of the available material in order to ascertain whether any outstanding differences in the chromosome number of the somatic tissues might prove of practical value in aiding the selection of plants for future breeding.

In the genus *Solanum*, *S. demissum*, a number of F₁ hybrids and back-crosses derived from *S. demissum* and cultivated varieties were examined. Chromosome counts have been made of various wild species of potato grown at the Plant-

Breeding Station, and the interspecific hybrids bred from them, particularly in cases where the chromosome numbers of the parent plants were different. Cytological studies have been made of a selection of unidentified wild potatoes which were received from Mexico and South America during the last two years.

VIRUS DISEASE RESEARCH.

Potatoes

GEORGE COCKERHAM, B.Sc., Ph.D.
C. H. CADMAN, B.Sc.

The classification of potato varieties according to their reactions to infection with each of the four potato viruses 'X,' 'A,' 'B,' and 'C' and the inheritance of the reactions indicative of 'field immunity' from these viruses have provided important lines of study during the year. In all, 2479 plants have been examined, of which 497 were named varieties and advanced seedlings and 1982 were seedlings in 33 selected progenies. The use of uncontaminated strains of viruses 'B' and 'C' in this work has brought to light many discrepancies in the literature bearing reference to the reactions of potato varieties to these viruses, and the new data have provided a basis of explanation for many of the anomalous results previously recorded. In consequence, progress with genetical studies has been advanced and a clearer understanding of the genetic constitution of the potato has been obtained. The available evidence clearly indicates an autotetraploid basis of inheritance in the potato. The factors controlling the lethal necrotic reactions of certain potato varieties to virus 'X' have been studied in greatest detail, and segregation ratios over a wide field of selfed and hybrid material have been obtained. Among the parent varieties which react with lethal necrosis upon infection with virus 'X,' one has been found to be duplex and the remainder simplex for the dominant 'necrotic' gene. The data are yet insufficient to indicate the detailed inheritance of reaction to viruses 'A,' 'B,' and 'C,' but there is strong indication that necrotic reactions to the three viruses are determined by different 'necrotic' genes all of which are dominant over their

'non-necrotic' allelomorphs. There is also indication of linkage relationships between some of the 'necrotic' genes. In further investigation of the genetics of 'field immune' characters 1414 seedlings are now undergoing examination. Close co-operation with the practical potato breeder in the use of suitable 'field immune' varieties as breeding material has been maintained throughout the year.

The classificatory work referred to above has proved very serviceable in aiding the development of less laborious and more certain technique for the analysis of material for virus content and also for the rapid identification of the causes of mosaic in field-grown stocks of known varieties. With detailed knowledge of the reaction behaviour of varieties it has been possible to identify viruses 'B' and 'C' as common causes of mosaic in certain varieties in the field and also to investigate the occurrence of virus 'Y' with greater ease. Analyses have confirmed the field observations. Analysis of material for virus content has been made also in respect of twenty-eight samples received from the Edinburgh and East of Scotland College of Agriculture from material used in biochemical investigation, ten samples of new stocks of Continental varieties, and ten samples which were tested for freedom from virus.

Investigations concerning the inheritance of resistance and susceptibility to virus 'Y' and the leaf-roll virus have been continued through the usual field trials, and, in addition, through the attempted infection of the more promising seedlings by infective aphides placed on the sprouts during germination. Several seedlings have remained uninfected under the more rigid conditions of test, and there is increasing evidence of the resistance to leaf-roll of two parental varieties and of the inheritance of this resistance in their progenies. The incidence of infection with both virus 'Y' and the leaf-roll virus in the field trials was greater in 1938 than in any previous year of trial.

Weekly estimates of aphid populations at the Plant-Breeding Station have recorded the earlier appearance of aphides than in previous years, together with exceptionally high total populations during July and August. A maximum total of 4262 aphides per 100 leaves was recorded on 2nd August, as compared with the previous maximum of 1474 aphides per 100 leaves in 1937. The possible bearing of size and

constitution of aphid populations upon the anomalous distribution of aphid-borne viruses has been referred to in a previous Report. With the valued co-operation of potato growers at several centres, preliminary investigation of this problem has been made during the year, but the abnormal infestations recorded in many instances have accentuated the differences between centres inspected. It is therefore desirable that this work should be continued over a further period. The influences of altitude, locality, and variety upon the size and constitution of aphid populations of potato crops have also been subjects of investigation in this field of study.

A portion of the land at Ainville Sub-Station was reserved for the maintenance of breeding stocks and the raising of new seedlings. Eleven progenies, all of which were derived from parents carrying the gene for lethal necrosis to virus 'X,' were raised during the year. A further eight progenies were raised and maintained in the glass-house for test in the early months of 1940. The breeding programme has been determined chiefly by the requirements for the further study of the inheritance of the genes controlling lethal reaction to viruses 'X,' 'A,' 'B,' and 'C.' Seed has been obtained from twelve self-fertilised named varieties, six self-fertilised F₁ plants, and thirty-eight hybridisations.

II. Publications and Lectures by Staff, for the Year ended 31st March 1940. Publications (P) and Lectures (L).

Director of Research :—

"Plant Breeding." Land Agents' Society (Scottish Branch), 10th May 1939. (L)

"The Scottish Society for Research in Plant Breeding and its Work." Scottish Farmer, June 1939. (P)

J. W. Gregor, Ph.D., D.Sc., F.L.S. :—

"Experimental Taxonomy: specific and infra-specific categories." British Association, 1939. (L)

"Experimental Taxonomy. IV. Population differentiation in North American and European Sea-Plantains allied to *Plantago maritima* L." *New Phytologist*, Vol. 38, No. 4, 1939. (P)

J. W. Gregor and J. M. S. Lang, B.S.A. :—

"Improvement of pasture: grazing nurse crops." *Scottish Farmer*, 23rd December 1939. (P)

"Further notes on pasture improvement." *Scottish Farmer*, 13th January 1940. (P)

J. S. L. Gilmour (Kew Gardens) and J. W. Gregor :—

"Demes: a suggested new terminology." *Nature*, Vol. 144, 19th August 1939. (P)

William Black, B.Sc., Ph.D. :—

"Potato breeding in the light of recent discoveries." *Roy. Caled. Hort. Soc.* 4th April 1939. (L)

V. M'M. Davey, B.Sc., Ph.D., and J. M. S. Lang :—

"Experimental Taxonomy. III. Correlation of Characters within a Population." *New Phytologist*, Vol. 38, No. 1, 1939. (P)

G. Cockerham, B.Sc., Ph.D. :—

"A Comparison of the Metabolism of Mosaic-Diseased Potatoes with that of Normal Potatoes." *Ann. Appl. Biology*, 26, pp. 417-439, 1939. (P)

III. Demonstrations.

A party of over sixty members who were attending the Seventh International Congress of Genetics in Edinburgh visited the Plant-Breeding Station on 28th August 1939. The visitors were received by Mr Fred Mills, Convener of the Research Committee, on behalf of the Directors of the Society, and afterwards the party was conducted round the experimental grounds by members of the Society's staff, who described various aspects of the work in progress. On various other occasions during the year visitors were conducted round the experimental plots.

IV. Acknowledgments.

Grateful acknowledgment is made to the undernoted departments, institutes, firms, and individuals for gifts of samples or other material for experiment :—

Aktieselskabet Dansk Frøavl's Kompagni og Markfrøkontoret (Trifolium), Copenhagen.

Bell, David, J.P., 15 Coburg Street, Leith.

Bolton, A. S., 201 Calder Road, Edinburgh.

Burr, W. M., The Banff and Moray Agricultural Co., Ltd., Elgin.

Cameron, Dr A. E., The University, Edinburgh.

Central Experiment Farm, Ottawa, per W. G. M'Gregor.

Department of Agriculture for Scotland, per T. Anderson, C. E. Foister, T. P. M'Intosh, and R. J. Scott.

Findlay, W. M., Agriculture Department, Marischal College, Aberdeen.

Gartons, Ltd., Warrington.

Henderson, R. M., & Co., Leith.

Hogg, Thomas (Alex. Cross Seed Co., Ltd.), 21 Hope Street, Glasgow.

Irvine, Charles, & Sons, Jedburgh.

Kay, William, 19 South St David Street, Edinburgh.

Morgan, George G., Ellisland, Hillview Terrace, Corstorphine, Edinburgh.

National Institute of Agricultural Botany, Cambridge, per S. F. Armstrong.

Neptune Mills, Ltd., Leith.

Royal Botanic Gardens, Kew.

Spence, Charles T., Tynefield, Prestonkirk, Dunbar.

United States Department of Agriculture, Washington, per J. W. Taylor and T. R. Stanton.

Watt, William, Cupar.

Wenholz, H., Department of Agriculture, Sydney, New South Wales, Australia.

Wilson, A. S. B., Boghall Experimental Farm, Biggar Road, Edinburgh.

Thanks are also due to members of the staffs of the three Scottish Agricultural Colleges who arranged and supervised the trials of certain of the Society's new varieties of oats and grasses.

WILLIAM ROBB,

Director of Research.

ESTABLISHMENT FOR 1939-40.

BOARD OF DIRECTORS.

Trustees.

H.M. SECRETARY OF STATE FOR SCOTLAND, Scottish Office,
Whitehall, London, S.W.
DAVID BELL, 15 Coburg Street, Leith.
JOHN FINLAYSON M'GILL, Kyle Street, Ayr.
SIR JOHN H. MILNE HOME, Irvine House, Canonbie.

Ordinary Directors.

1938.

A. Y. ALLISON, Turnhouse Farm,
Corstorphine.
W. J. CAMPBELL, 61 Fountainhall
Road, Edinburgh.
ROBERT HOWIE, The Grange, Kirk-
caldy.
WILLIAM KAY, 19 South St David
Street, Edinburgh.
ROBERT L. SCARLETT, Sweethope,
Musselburgh.
Professor ERNEST SHEARER, Agri-
cultural Department, The Univer-
sity, Edinburgh.

1939.

WILLIAM ALLISON, Almond Hill,
Kirkliston.
T. B. B. KERR, 63 Queen Street,
Glasgow.

IAN C. MENZIES, W.S., 22 Rutland
Street, Edinburgh.
FRANK G. MILNE (John Milne &
Sons), Montrose.
Professor Sir WILLIAM WRIGHT
SMITH, Inverleith House, Edin-
burgh.
JAMES WITHER, Awhirk, Stranraer.

1940.

DAVID BELL, Jun., 15 Coburg Street,
Leith.
JAMES H. ELDER, B.Sc., Cregganore,
North Berwick.
WM. HUGH HAMILTON, W.S.,
Cairns, Kirknewton.
A. D. C. MAIN, B.Sc., Windyedge,
Perth.
FRED MILLS (Roughhead & Park, Ltd.),
Haddington.
JAMES PATON, Kirkness, Glencairg.

Directors Co-opted.

Major R. F. BREBNER, The Leuchold, Dalmeny House, Edinburgh.
THOMAS HOGG, 21 Hope Street, Glasgow.
GEORGE G. MERCER, Southfield, Dalkeith.

Directors nominated by the Department of Agriculture for Scotland.

P. R. LAIRD, C.B.,
J. M. CAIE, M.A., B.L., B.Sc., } St Andrew's House, Edinburgh.
T. ANDERSON, M.A., B.Sc.,
ALEXANDER M'CALLUM, M.A., LL.B., 78 Craiglea Drive, Edinburgh.

Chairman of Directors—SIR JOHN H. MILNE HOME, Irvine House, Canonbie.
Vice-Chairman—DAVID BELL, 15 Coburg Street, Leith.
Director of Research—WILLIAM ROBB, N.D.A., F.R.S.E., Craigs House,
Corstorphine.
Chief Assistant—JAMES W. GREGOR, Ph.D., D.Sc., F.L.S., Craigs House,
Corstorphine.
Assistants—V. M'M. DAVEY, B.Sc., Ph.D., CHARLES A. LYALL, B.Sc.,
and JOHN M. MAIN, B.Sc., Craigs House, Corstorphine.
Assistant, Potato-Breeding Sub-Station—WILLIAM BLACK, B.Sc., Ph.D.,
Boghall.
Assistants, Virus Disease Scheme—GEORGE COCKERHAM, B.Sc., Ph.D., and
COLIN H. CADMAN, B.Sc., Craigs House, Corstorphine.
Temporary Assistant—J. M. S. LANG, B.S.A., Craigs House, Corstorphine.
Secretary—JOHN STIRTON, 8 Eglinton Crescent, Edinburgh.

COMMITTEES.

RESEARCH.

Fred Mills, *Convener*.
 William Allison.
 T. Anderson.
 David Bell.
 David Bell, Jun.
 Major R. F. Brebner.
 J. M. Caie.
 W. J. Campbell.
 James H. Eider.
 Wm. Hugh Hamilton.
 Thomas Hogg.
 Sir John H. Milne Home.
 Robert Howie.

William Kay.
 T. B. B. Kerr.
 P. R. Laird.
 Alexander M'Callum.
 J. F. M'Gill.
 A. D. C. Main.
 George G. Mercer.
 Frank G. Milne.
 James Paton.
 Robert L. Scarlett.
 Professor E. Shearer.
 Professor Sir William Wright Smith.
 James Wither.

MANAGEMENT.

William Allison, *Convener*.
 A. Y. Allison.
 David Bell.
 David Bell, Jun.
 Major R. F. Brebner.
 J. M. Caie.
 Thomas Hogg.
 Sir John H. Milne Home.
 Robert Howie.

T. B. B. Kerr.
 Alexander M'Callum.
 A. D. C. Main.
 Ian C. Menzies.
 George G. Mercer.
 Fred Mills.
 James Paton.
 James Wither.

FINANCE.

Alexander M'Callum, *Convener*.
 A. Y. Allison.
 William Allison.
 David Bell.
 J. M. Caie.
 W. J. Campbell.
 Wm. Hugh Hamilton.
 Sir John H. Milne Home.

P. R. Laird.
 Ian C. Menzies.
 George G. Mercer.
 Fred Mills.
 Robert L. Scarlett.
 Professor E. Shearer.
 Professor Sir William Wright Smith.

LIST OF MEMBERS.

- Adam, Robert M., Newhouse of Glamis, Glamis.
 Aiton, R. Scott, Legerwood, Earlstoun.
 Allison, Alex. Y., Turnhouse Farm, Corstorphine, Edinburgh.
 Allison, John M., Overton, Kirkliston.
 Allison, William, Almond Hill, Kirkliston.
 Allison, William, Campend, Dalkeith.
 Anderson, Thomas, M.A., B.Sc., Department of Agriculture for
 Scotland, Seed-Testing Station, East Craigs, Corstorphine,
 Edinburgh.
 Anderson, R. Gayler, 41 Mitchell Street, Leith.
 Austin, Robert (Charlton & Sons, Ltd.), 43 Whitesands, Dumfries.
- Baird, W. J., Deanscroft, Oakham, Rutland.
 Balfour, F. R. S., of Dawyck, Stobo, Peebles.
 Ballantyne, Sir Henry, Monkkrigg, Haddington.
 Bannatyne, John, Drumalbin, Biggar.
 Barnfather, William (Charles Sharpe & Co., Ltd.), Sleaford.
 Bell, David, J.P. (David Bell, Ltd.), 15 Coburg Street, Leith.
 Bell, David, junr. (David Bell, Ltd.), 15 Coburg Street, Leith.
 Bell, J. C. (David Bell, Ltd.), 15 Coburg Street, Leith.
 Berwick, P. W., Ardross, Elie.
 Biggar, J. M. R. (T. Biggar & Sons), Dalbeattie.
 Black, George, Penston, Macmerry, Haddington.
 Bone, Jack K., Monktonhill, Monkton, Ayr.
 Bowe, D. L., Skateraw, Dunbar.
 Brebner, Major R. F., The Leuchold, Dalmeny House, Edinburgh.
 Broadfoot, Abram, B.Sc., "Rhueval," Old Doune Road, Dunblane.
 Brough, John (Johnson & Darlings, Ltd.), Governor's Yard,
 Berwick-on-Tweed.
 Brown, James, 6 Meadowbank Avenue, Strathaven.
 Brown, James Hally (Brown & Polson, Ltd.), Paisley.
 Brown, Joseph, Merryton, Bentfield Drive, Prestwick.

- Bruce, William, M.A., B.Sc., Seton Mains, Longniddry.
 Burr, Wm. (The Banff and Moray Agric. Co., Ltd.), 100 High Street, Elgin.
 Butter, Colonel Charles A. J., of Faskally, Cluniemore, Pitlochry.
- Cadzow, James, Duncrahill, Pencaitland.
 Calder, Adam, Marigold, Duns.
 Calderwood, William, Clachan Farm, Roseneath.
 Campbell, Sir Archibald S. L., of Succoth, Bart., Garscube, Glasgow.
 Campbell, W. J., 61 Fountainhall Road, Edinburgh.
 Carruthers, Colonel F. J., of Dormont, Lockerbie.
 Chisholm, Miss E. M., Gibston, Huntly.
 Chisholm, William, Eastfield, Murthly.
 Clarkson, Alexander, Skirling Mill, Biggar.
 Colquhoun, Archibald (Charles Tennant & Co., of Carnoustie, Ltd.), Carnoustie.
 Cowan, Alex., Valleyfield, Penicuik.
 Cowper, H. S., Montrose.
 Crawford, James B., Caigton, Castle-Douglas.
 Crawford, Robert, Drumbeg, Turnberry.
 Cross, Donald, Otterden, Maybole.
 Cruickshank, James, Roselea House, Cruden Bay.
 Cunningham, Howard U. (Scottish Agricultural Industries, Ltd.), Council Chambers, Charlotte Street, Leith.
 Cunningham, Thomas (of John G. Cunningham), 26 Murrayfield Avenue, Edinburgh.
 Currie, William, Greenhill, Deskford, Cullen.
- Dale, John R., Auldhamo, North Berwick.
 Davidson, George (The Highland Agricultural Co., Ltd.), Falcon Square, Inverness.
 Deans, John H., Pitcox, Dunbar.
 Dewar, Andrew (Joseph Gartshore & Sons), Stirling.
 Dickie, John, Kettle Farm, Kingskettle.
 Dickson, William C., Glassingall, Dunblane.
 Dods, Archibald, Carrington Mains, Gorebridge.
 Donald, John (Wotherspoon, Donald & Geo. Graham, Ltd.), 11 Braemar Street, Langside, Glasgow.
 Douglas, A. (A. & W. Douglas), Dalkeith Mills, Dalkeith.
 Drummond, Professor Montagu, Botany Department, The University, Manchester.
 Dudgeon, G. E., Kildalloig, Campbeltown.
 Dudgeon, John G., Easter Dalmeny, South Queensferry.

- Dun, John (John Dun & Co., Ltd.), Valley Mill, Galashiels.
 Duncan, John, Castlehill, Maybole.
 Duncan, William Watson (Drummond Bros.), Central Station
 Buildings, Leith.
 Durie, John, Greendykes, Macmerry.
 Durno, James, Crichtie, Inverurie.
 Duthie, Edwin C. (Ben Reid & Co.), 20 Hadden Street, Aberdeen.
- Easton, A. L. (R. Smith & Son), West Mills, Mid-Calder.
 Elder, Archibald J. (Hugh Elder & Son), City Mills, Dunfermline.
 Elder, James H., B.Sc., Cregganore, North Berwick.
 Elliot, Captain Thomas, Thirlestane, Lauder.
 Elliot, Thomas (R. M. Henderson & Co.), 65 Albert Street, Edin-
 burgh.
- Fairlie, John M., Kirkton, Monikie, near Dundee.
 Findlay, Robert, Easter Cadder, Kirkintilloch.
 Ferguson, Hugh, B.Sc., El Banga, Abidiya, Northern Province,
 The Sudan.
 Fleming, G. J., 30 Royal Circus, Edinburgh.
 Fleming, William, Cove Villa, Annan.
 Fletcher, Captain Andrew M. Talbot, of Saltoun, Pencaitland.
 Forbes, Robert, Balglassie, Forfar.
 Forrest, Robert Jack, Whitemire, Edrom.
 Fraser, Samuel (Alex. Cross Seed Co., Ltd.), 21 Hope Street,
 Glasgow.
- Garden, W. J. (R. Garden, Ltd.), 18 Bridge Street, Kirkwall.
 Gardner, Andrew, 30 Melville Street, Glasgow, S.1.
 Garvie, R., Hillocks of Gourdie, Blairgowrie.
 Gebbie, Alexander (Scottish Co-operative Wholesale Society,
 Ltd.), Shieldhall, Govan, Glasgow.
 Gibb, John, Fliskmillan, Newburgh.
 Gibb, William P., Pitteuchar, Markinch.
 Gill, William Hope, Brucefield, Portmahomack, Fearn.
 Gladstone, James, Formall, Alyth.
 Glendinning, George E., Woodhall House, Juniper Green.
 Gossip, Wm. M., 22 Hamilton Street, Inverness.
 Graham, Alexander (Wotherspoon, Donald & Geo. Graham,
 Ltd.), 65 Stonelaw Drive, Rutherglen.
 Graham, William (W. & A. Graham (Glasgow), Ltd.), 183-185
 Hunter Street, Glasgow, C.4.
 Grant, James (John Grant & Sons, Ltd.), Kingennie House,
 Kingennie, Angus.
 Gray, James, 74 Osborne Street, Glasgow.

- Gregor, David Clunie, Innerwick, Dunbar, East Lothian.
 Greig, Sir Robert B., M.C., LL.D., Shaws, Barnton, Edinburgh.
 Hamilton, Colonel Claud L. C., Rozelle, Ayr.
 Hamilton, Robert C., Kilnknowe, Galashiels.
 Hamilton, W. H., Cairns, Kirknewton.
 Hannah, John M., Girvan Mains, Girvan.
 Harper, Thomas, Charlotte Street, Stranraer.
 Henderson, John, Annandale Estates Office, Moffat.
 Highet, John J. I. (J. J. Inglis & Sons), Alloway Street, Ayr.
 Hill, William James, 19 St Vincent Place, Glasgow, C.1.
 Hogg, Robert N., Oxenfoord Mains, Dalkeith.
 Hogg, Thomas (A. Cross Seed Co., Ltd.), 21 Hope Street, Glasgow.
 Hogg, William, Meigle, Clovenfords.
 Home, John Gavin Milne, Irvine House, Canonbie.
 Home, Sir John H. Milne, Irvine House, Canonbie.
 Hope, Sir Harry, Kinnettles, Forfar.
 Hope, William W., Braehead, St Boswells.
 Houldsworth, Lieut.-Colonel W. T. R., of Kirkbride, Maybole.
 Howie, Alex., Ardgaith, Glencarse.
 Howie, Robert, Drumfork Farm, Helensburgh.
 Howie, Robert, The Grange, Kirkcaldy.
 Howie, Thomas, Balhelvie, Newburgh, Fife.
 Hunter, A. Thornton (Alexander Jack & Sons, Ltd.), Maybole.
 Hutchison, A. (R. Hutchison & Co.), Kirkcaldy.
 Hutchison, Thomas (Barclay, Ross & Hutchison), 67 Green,
 Aberdeen.
 Inglis, Wm. (J. Inglis & Sons), Leith.
 Irvine, Charles, sen. (C. Irvine & Sons), 1 Market Place, Jedburgh.
 Jamieson, William (Jamieson Bros.), 60 High Street, Annan.
 Johnston, W. L., Oxnam Neuk, Jedburgh.
 Kay, William, 19 South St David Street, Edinburgh.
 Keith, Major James, Pitmedden, Udney.
 Kerr, H. R. (Forage Supply Co., Ltd.), Springfield Mills, Leith.
 Kerr, T. B. B., 63 Queen Street, Glasgow.
 Kirkwood, John, B.Sc., Scorrieholm, Lesmahagow.
 Laing, Robert Paterson (Thomas Bernard & Co., Ltd.), Seafield,
 Leith.
 Laird, W. P. (Laird & Sinclair, Ltd.), 22 City Square, Dundee.
 Lindsay, Adam (Robert Inch & Son, Ltd.), 46 Timber Bush,
 Leith.

Linlithgow, The Marquess of, Hopetoun House, South Queensferry.
 Lithgow, Colonel Sir James, Bart., M.C., of Ormsary, Ardrishaig.
 Lumsden, James R., Arden, Dumbartonshire.
 Lyburn, R., 8-10 Germiston Street, Glasgow.
 Lyon, Arthur J. (Pringle & Alexander), 17 Waterloo Street,
 Glasgow.

M'Alister, A. W., Potato Merchant, Dumfries.
 M'Arthur, A. (J. & A. M'Arthur), 204 Hunter Street, Glasgow.
 M'Arthur, Norman (The Fife Coal Co., Ltd.), Leven.
 Macaulay, Thomas, Fernlea, East Kilbride, Lanarkshire.
 M'Cormick, Thomas (Edward Webb & Sons (Stourbridge), Ltd.),
 Wordsley, Stourbridge.
 M'Corquodale, A. C., Meddat, Kildary.
 Macdonald, T. Martin, of Barguilean, Taynuilt.
 M'Gill, J. Becket (M'Gill & Smith, Ltd.), Ayr.
 M'Gill, John F. (M'Gill & Smith, Ltd.), Ayr.
 MacGregor, James (James MacGregor, Ltd.), Garrion Grain Mills,
 Wishaw.
 M'Intosh, T. P., Ph.D., Department of Agriculture for Scotland,
 29 St Andrew Square, Edinburgh.
 M'Kerrow, George E., Addinston, Lauder.
 Mackie, Maitland, North Ythsie, Tarves.
 M'Laren, J. T., 7 Park Place, Stirling.
 Maclellan, George, Redheugh, Gorebridge.
 Maclellan, George, 35 Charlotte Street, Leith.
 M'Morran, Thomas W., Larriston, Newcastleton.
 M'Nab, J. B., Keithock, Brechin.
 Macpherson, D. J. R., B.Sc. (Scottish Agricultural Industries,
 Ltd.), Blaikie's Quay, Aberdeen.
 Main, Alexander D. C., B.Sc., Windyedge, Perth.
 Marshall, H. B., Rachan, Broughton.
 Marshall, Mark, Laverockhill Farm, Torrance of Campsie.
 Marshall, Robert C., Burntshields, Kilbarchan.
 Mather, Matthew, Silverknowes, Davidson's Mains.
 Meiklejohn, John A., 86 St Vincent Street, Glasgow, C.2.
 Menzies, Ian C., W.S., 22 Rutland Street, Edinburgh.
 Menzies, J. C. (Scottish Agricultural Industries, Ltd.), Council
 Chambers, Charlotte Street, Leith.
 Mercer, George G., Southfield, Dalkeith.
 Middleton, Sir Thomas H., Whyte House, Strawberry Vale,
 Twickenham.
 Miller, Hugh, West Fortune, Drem.
 Miller, John R., Midkelton, Castle Douglas.

- Miller, Robert, Ferrygate, North Berwick.
 Mills, Fred (Roughead & Park, Ltd.), Haddington.
 Miln, David L., F.L.S., Abbot's Bank, Westminster Avenue,
 Chester.
 Miln, Thomas Edward (Gartons, Ltd.), Warrington.
 Milne, Frank G., Southesk Granaries, Montrose.
 Mitchell, Lieut.-Colonel A., Tulliallan, Kincardine, Fife.
 Mitchell, James, B.Sc., East Craigs, Corstorphine, Edinburgh.
 Montgomerie, A. W., Westburn Farm, Cambuslang.
 Montgomery, Andrew Mitchell, Netherhall, Castle Douglas.
 Montrose, Duchess of, Brodick Castle, Isle of Arran.
 Morris, Robert (Robert Morris & Son, Ltd.), Woodside, Coupar-
 Angus.
 Morrison, John A., West Fenton, Drem.
 Motherwell, Andrew (A. Motherwell, Ltd.), Gorbals, Glasgow.
 Muir, Sir A. Kay, Bart., of Blair Drummond, Perthshire.
 Murdoch, Alexander, East Hallside, Cambuslang.
 Murray, James C. (Lothian Coal Co., Ltd.), Newbattle Collieries,
 Newtongrange.
 Nagel, F. J. (Peter Lawson & Sons, Ltd.), 1A George IV.
 Bridge, Edinburgh.
 Nelson, Alexander, Ph.D., Royal Botanic Garden, Edinburgh.
 Nelson, John M., Pleasants, Dunbar.
 Paterson, Principal William G. R., West of Scotland Agricultural
 College, Glasgow.
 Paton, James, Kirkness, Glencairn.
 Paul, Andrew (Paul & Weir), 14-16 Caithness Street, Garscube,
 Glasgow.
 Pollok, Mrs Gladys M., Ronachan, Clachan.
 Porter, A. Gordon, Turfachie, Cortachy, Kirriemuir.
 Proctor, W., Canterland, Laurencekirk.
 Rae, W. A., Douglasfield, Murthly, Perth.
 Reid, A. T., Auchterarder House, Auchterarder.
 Reid, W. J., Fordhouse of Dun, Montrose.
 Reynard, James N., Manuel House, Linlithgow.
 Riddel, Andrew M. (W. Drummond & Sons, Ltd.), Stirling.
 Riddell, John (Andrew Riddell & Co.), 5 Grassmarket, Edinburgh.
 Rintoul, William, Pratis, Leven.
 Robertson, A., 125 Willowbrae Road, Edinburgh.
 Robertson, Peter D., of Castlecraig, Nigg.
 Robertson, Wilson Mathieson, Saughton Mains, Corstorphine.
 Robinson, R. G. (R. G. Robinson Ltd.), P.O. Box 4, Papanui,
 Christchurch, New Zealand.

- Roger, John M., Balgove, St Andrews.
 Ross-Taylor, Sir Joshua, Mungoswalls, Duns.
 Rowallan, Lord, M.C., Rowallan, Kilmarnock.
 Runcieman, William, Castleton, King-Edward.
- Salmon, A. B. (Barclay, Ross & Hutchison), 67 Green, Aberdeen.
 Sanderson, D. H. (Scottish Agricultural Industries, Ltd.), 10
 Bridge End, Berwick-on-Tweed.
 Scarlett, Robert L., Sweethope, Musselburgh.
 Scott, D., Ferneyhill, Kelso.
 Scott, James, Fearn.
 Shearer, A. (Macfarlan, Shearer & Co.), Greenock.
 Shearer, Professor Ernest, The University, Edinburgh.
 Shields, G. Bertram, 48 Ravelston Garden, Edinburgh.
 Simpson, Alistair M., City Mills, Perth.
 Simpson, Major J., Glencarse House, Glencarse.
 Simpson, Mark T., Crowhill, Innerwick, Dunbar.
 Simpson, R. C., Shiel Lodge, Gullane.
 Simpson, William D., Highfield, North Berwick.
 Smart, Thomas, Kames, Duns.
 Smith, Mrs Ida F., Whitcheater, Duns.
 Smith, Stanley B., Crosston, Dunnichen, Angus.
 Smith, Professor Sir William Wright, Inverleith House, Arboretum
 Road, Edinburgh.
 Speirs, A. A. Hagart, of Elderslie, Houston House, Houston.
 Spence, Charles T., Potato Grower, Dunbar.
 Stanhope, John M. Spencer, of Glenure, Argyll.
 Steel, John K., Whitehill, Dailly.
 Steele, J. Norman H., 61 Harrison Road, Edinburgh.
 Stevens, Alexander B., Queenstonbank, North Berwick.
 Stevenson, Allan, Parkhill, Mauchline.
 Stevenson, Allan, Luffnees Mains, Aberlady.
 Stevenson, A. Harvey, Saltcoats, Gullane.
 Stewart, Sir Hugh Shaw, Bart., K.C.B., Ardgowan, Inverkip.
 Stirling, Hugh B., Allanbank, Edrom.
 Stirling, Major John, of Fairburn, Muir of Ord.
 Stirling, John W., P.O. Box 245, Nairobi, Kenya.
 Stodart, Charles, Leaston, Humbie.
 Stratton, David Thomas, Braehead House, Kilmarnock.
- Tait, Charles William (J. & W. Tait), Kirkwall.
 Tait, John, Choicelee, Duns.
 Temperley, Eric (W. A. Temperley & Co., Ltd.), 2 St Nicholas
 Buildings, Newcastle-upon-Tyne.

- Thomson, Henry, Newark, St Monance.
 Thomson, John (Thomson Bros.), 106 Taylor Street, Glasgow.
 Thomson, Moffat S., of Lambden, Greenlaw.
 Thomson, T. (J. Donaldson & Co.), 24 St Giles Street, Edinburgh.
 Thyne, James C. (Thyne & Son), 65 Trades Lane, Dundee.
 Turnbull, Alan T., Smithston, Gartly.
 Tweedie, R. W., Phantassie, Prestonkirk.
- Wallace, Falconer L., of Candacraig, Strathdon.
 Watson, D. King, Newtown of Stracathro, Brechin.
 Watson, Professor J. A. S., School of Rural Economy, Oxford.
 Waugh, John F. (J. & A. Waugh), 18 Hailes Grove, Colinton,
 Edinburgh.
 Whitburgh, Lord, Whitburgh, Ford.
 White, George L., Halkerston, Gorebridge.
 Wilson, Emma, Lady, Kippen House, Dunning.
 Wilson, Philip, Corn Factor, Duns.
 Wither, James, Awhirk, Stranraer.
 Wright, William J., The Heugh, North Berwick.
 Wyllie, J. G. C. (Dan Wyllie & Co.), 199 High Street, Ayr.
- Young, James G., Cadboll, Fearn.
 Young, T. M., Edinburgh Co-operative Farming Society, Ltd.,
 92 Fountainbridge, Edinburgh.
 Younger, H. G. (W. Younger & Co., Ltd.), Abbey Breweries,
 Edinburgh.
 Yule, J. B., Upper Pirriesmill, Huntly.