

1947

SCOTTISH SOCIETY FOR RESEARCH IN  
PLANT-BREEDING,

REPORT.

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THE Directors of the Scottish Society for Research in Plant-Breeding have pleasure in submitting the Twenty-sixth Annual Report to members of the Society.

Reference was made in the previous Annual Report to the improbability of the Society obtaining suitable additional land in the vicinity of Craigs House for the expansion of its work. The Directors of the Society were advised by the Department of Agriculture for Scotland to defer making further inquiries about land in view of a scheme which was being considered for further developing the facilities for agricultural education and research in the vicinity of the Edinburgh and East of Scotland College of Agriculture farm at Boghall, near Edinburgh. The University of Edinburgh has purchased the estates of Bush and Dryden, which are adjacent to Boghall, and together comprise about 1000 acres. Progress is being made in planning the details for developing the estates to the fullest advantage. This Society is one of the research organisations in Scotland which will be afforded the opportunity of obtaining the use of land on the estates for experimental work, but no definite arrangement with the University has yet been made. Entry to the land will not be available until November 1948, and in the interval more information regarding

conditions of tenancy, types of soil, &c., will be obtained by the Society. While land may be available immediately after the date of entry, it is probable that the erection of permanent buildings for experimental work will not be possible for a year or two afterwards. It is obvious that while land may be available it will be impracticable to transfer the Plant-Breeding work wholly from Craigs House to a new centre until suitable laboratory and office accommodation for the staff is available on the new site. While the complete transference of the Plant-Breeding Station to a new site will therefore be delayed for a few years, the land and buildings at Craigs House will be used to full capacity, and preparations for expansion and transference will be advanced as far as possible. It is not expected that this unavoidable delay will seriously handicap the development of the Society's programme.

During the past year the experimental work at the Station has increased and more experimental material is becoming available. There has been an increase in the number of experimental plots and new herbage experiments at Dundonnell, Wester Ross, have been laid down. An account of the work at the Plant-Breeding Station, Corstorphine, at the Sub-Station, Boghall, and at Dundonnell is given in the Report by the Director of Research on pages 5 to 31.

The Directors wish to take this opportunity of expressing their thanks to Messrs David Bell, Ltd., Leith, for their valued assistance in cleaning and storing bulk quantities of cereal and grass seeds for the Society. Facilities are not available at the Plant-Breeding Station for undertaking the cleaning and storing of commercial quantities of seeds.

#### **Staff.**

Mr C. A. Lyall, B.Sc., Assistant in the Cereal-Breeding Section, was released from H.M. Forces towards the end of 1946, and resumed his duties at the Plant-Breeding Station in December of that year. In January 1947 he accepted the offer of an appointment to the staff of the Botany Depart-

ment, University of Edinburgh, and resigned his post at the Plant-Breeding Station as from 1st February 1947.

Mr Donald Cameron, B.Sc., who had been engaged in March 1946 as a temporary worker in the Cereal-Breeding Section, has been appointed to the permanent staff.

Miss Patricia J. Watson, M.A., has been appointed as from 1st January 1947 to a temporary post on the Society's staff for work in connection with the selection and comparison of certain herbage plants.

By arrangement with the British Council, who have granted a Scholarship for one year to Mr Nelson Ramos Nobrega, S. Paulo, Brazil, facilities have been given to Mr Nobrega to work in the Potato Virus Disease Section at the Scottish Plant-Breeding Station, and he has been pursuing his studies there since October 1946.

The Directors have pleasure in recording that Dr William Black was recently awarded the Makdougall-Brisbane Prize (1944-46) by the Royal Society of Edinburgh for his work, published in the *Proceedings R.S.E.* within the period, dealing with genetical investigations on the potato, with their practical applications.

### Membership.

The Directors regret to report that in the past year five members died and four members resigned. They are pleased to record, however, that thirty new members were elected during the year; five of these became life members. At 31st March 1947 the membership numbered 365, and consisted of 155 life members and 210 annual members (17 at the 5s. rate and 193 at the 10s. rate of subscription). A list of members appears on pages 34 to 44 hereof.

Donors of £10 and over are entitled to become life members without further payment. Donors of £5 may become members of the Society by payment of an annual subscription of 5s., and others by payment of an annual subscription of 10s.

**List of Varieties of Crop Plants raised or selected  
by the Society and introduced into Commerce.**

		Date of Registration.
<i>Oats</i> —		
Elder	} Registered by the Department of Agriculture for Scotland as new varieties.	{ 1930 1932 1934
Bell		
Early Miller		
<i>Wheat</i> —		
Scottish Iron III.		
<i>Barley</i> —		
Craigs Triumph.		
<i>Potatoes</i> —		
The Alness	} Registered by the Department of Agriculture for Scotland as new varieties.	{ 1934 1939
Craigs Defiance		
<i>Grasses</i> —		
"Scotia" Cocksfoot, Ref. No. <i>Cc</i> 196.		
"Scotia" Timothy, Ref. No. <i>Cb</i> 224.		
Perennial Ryegrass, Ref. No. <i>Ca</i> 448.		



FIG. 1.

Plot of *Aa* 698 Oats. At Plant-Breeding Station. 1946.

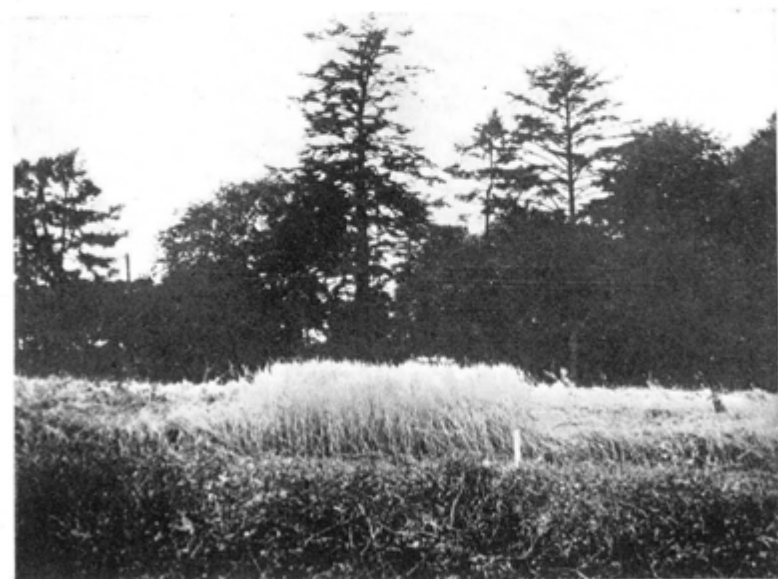


FIG. 2.

Part of Oat Trial Plots, Craibstone, 1946. *Aa* 708 standing, other varieties lodged. (Photograph supplied by Mr W. M. Findlay, Craibstone.)



FIG. 3.

The Ryegrass and Cocksfoot plots at Dundonnell Experimental Centre. In the foreground a manured plot of *Agrostis*, which previously had been used as part of a 'rough' complement.



FIG. 4.

Loading herbage samples from Dundonnell Ryegrass plots for analyses in Edinburgh.

# R E P O R T

BY

DIRECTOR OF RESEARCH

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## I. Research Programme.

### GRAIN CROPS.

WILLIAM ROBB, *Director of Research.*

C. A. LYALL, B.Sc. (Resigned 31st January 1947.)

DONALD CAMERON, B.Sc.

#### *Oats.*

The practical problems confronting the oat breeder in Scotland are mainly to increase the strength of the oat straw to resist lodging and to combine as far as possible any improvement effected in this direction with high-yielding and early- or medium-early-ripening capacity, good quality grain, and adaptability for certain soils and areas. With these objectives in view, the pedigree method of breeding has been largely practised, but, in addition, multiple crossing is now being tried with a view to seeing what results are obtained by this method. In continuing the breeding work a large collection of hybrids (about 15,000 plants) selected from the previous year's crop was grown as spaced plants, and at the end of the season selections were again made for further breeding. Some promising selections which seemed to be uniform in type were also selected and marked for multiplication and preliminary trial.

During the war years it was not possible to have comparative trials of the new selections raised at the Station conducted on as reliable and extensive a scale as was desired. In 1946, however, it was possible to lay down more systematic trials, and thirteen hybrid selections with one standard named variety (Star) grown as a control were included in small replicated initial trial plots, and comparison was made of yields of grain, period of maturity, and resistance to lodging. Six varieties gave yields of grain not significantly different from that of Star; six were earlier in ripening and ten were more resistant to lodging. The more promising selections in this trial will be included with some more new varieties in comparative trials at the Station in 1947.

*Regional Trials.*—Various hybrid selections in the later trial stages were included in outside trials. The weather conditions at harvest in many areas were not propitious, and in some instances only reports of general observations are available, but, nevertheless, such information is often useful. The varieties *Aa 676* and *Aa 708* again gave promising results in various trials, particularly as regards strength of straw and ripening period, and reference will be made mainly to them.

The National Institute of Agricultural Botany again kindly agreed to include a few of the Society's new varieties in field trials in various parts of England, and the following extracts have been taken from the report received regarding trials at Nafferton, Northumberland, and Askham Bryan, York.

At Nafferton the varieties *Aa 676* and *Aa 708* were included in a replicated full-scale trial with Victory and Early Miller. Taking Victory as a control, the following are the yields of dry grain from the various lots:—

Victory . . . .	100 (16.86 cwt. dry grain per acre.)
Early Miller . .	94
<i>Aa 676</i> . . . .	112
<i>Aa 708</i> . . . .	149

The trial gave a Standard Error of 2.51 per cent and a Significant Difference of 7.19 per cent.

It was emphasised that these represent only one season's results and that harvest conditions were exceptionally bad. The outstanding feature of the whole trial, however, was the



very stout, stiff straw of *Aa 708*, which stood remarkably well for such adverse conditions. *Aa 676* also stood up fairly well and was a marked improvement over both Early Miller and Victory. Both varieties were ripe about the same time as Early Miller and about eight days earlier than Victory. Tillering capacity, however, was considerably below average. Comparative husk contents were as follows:—

		Weight of 1000 grains.
Victory . . .	26.4 per cent of husk .	39.22 gm.
Early Miller . . .	25.6 per cent of husk .	40.68 gm.
<i>Aa 676</i> . . .	28.0 per cent of husk .	36.28 gm.
<i>Aa 708</i> . . .	28.0 per cent of husk .	38.46 gm.

At Askham Bryan the variety *Aa 712* was included in a trial with Victory as a control, and yields of dry grain were as follows:—

Victory . . .	100 (22.13 cwt. dry grain per acre.)
<i>Aa 712</i> . . .	95

It was mentioned that this trial also represented only one season's results and that the crop was harvested under adverse conditions. There was no lodging, but the straw of *Aa 712* was shorter and stiffer than that of Victory. Both varieties ripened about the same time. Tillering capacity appeared to be average. Comparative husk contents were as follows:—

		Weight of 1000 grains.
Victory . . .	26.2 per cent of husk .	39.54 gm.
<i>Aa 712</i> . . .	26.9 per cent of husk .	37.50 gm.

The two varieties—viz., *Aa 676* and *Aa 708*—were included in field trials in Northumberland carried out by the staff of the National Agricultural Advisory Service, Northern Province. The report received regarding these varieties states:—

“*Aa 676* was sown in a trial on some very fit, first-class medium loam in the Tyne Valley. In early July I noted that this variety was slightly later in shooting than the other varieties (Sun, Yelder, Star, and Spitfire). *Aa 676* had very thick, stout straw and a particularly broad flag, and at the time of harvesting was the only variety which stood to my

satisfaction, all the rest being lodged to a varying degree. Owing to the season and lodging, &c., yield results could not be taken.

"*Aa 708* was grown in a trial on fit, medium-heavy land near the coast, east of Alnwick, alongside such varieties as Black Supreme, Marvellous, Star, and Onward. Like the other varieties, 708 had some mildew on it. It had short very stout straw and broad flag, &c., and was the last variety to lodge, and even then it only lodged to a very small degree. The plant stand of this variety was particularly thick. Again it was impossible to get yield results." The recorder stated that he was very impressed by both of these varieties.

*Craibstone, Aberdeen.*—The following varieties were included in Standing Power Trials here: *Aa 708*, *Aa 712*, and *Aa 713*. *Aa 708* showed a high degree of resistance to lodging (see illustration, fig. 2); some other varieties as a result of the very adverse weather were badly broken down. *Aa 713* stood fairly well, but in *Aa 712* the straw was weak and it showed little resistance.

*Boghall Experimental Farm, Edinburgh.*—Three of the Society's unnamed selections—viz., *Aa 705*, *Aa 707*, and *Aa 708*—were included in trials here. The control varieties were Victory and Yielder, and each variety was replicated four times. All three of the Society's varieties ripened earlier than Victory—the earliest one, *Aa 707*, being about ten days ahead—and they had shorter and stronger straw. They and Yielder gave significantly lower yields of grain than Victory; in two, *Aa 705* and *Aa 708*, the yields were lower, but not significantly lower than that of Yielder, but in the remaining three the yields were significantly lower.

*Auchincruive, Ayrshire.*—Five unnamed selections—*Aa 705*, *Aa 706*, *Aa 707*, *Aa 708*, and *Aa 713*—were compared with Victory and Yielder in trials at the West of Scotland Agricultural College Farm. *Aa 708* was the best of the five; it was second in order of ripening, Yielder being first and Victory fourth. There was a moderate amount of lodging in Victory and a very slight amount in Yielder, but in *Aa 706* and *Aa 708* there was no lodging. All five selections and Yielder gave significantly lower yields of grain than Victory; *Aa 708* gave a yield of grain slightly but not significantly lower than that of Yielder, while, in the other four, yields of grain were significantly lower than that of Yielder.

In making comparisons of hybrid oat selections note is made of the type of grain and, if other characteristics are satisfactory, preference is given to those having a well-filled, thin-skinned grain likely to be suited for milling. With a view to getting a report on the milling quality of some of the new varieties showing promise in the early trial stages, samples of grain from a number of them were submitted to Dr James Sword, Scottish Co-operative Wholesale Society's Cereal Laboratories, Regent Mills, Glasgow, for examination, and he has kindly given permission to quote the undernoted extracts from his report.

TABLE I.

"The following Table gives the percentage of groat and the weight per 1000 grains in the samples as received.

Ref. No.	Groat %	Weight per 1000 grains in grammes	Oatmeal content %
480 (3) E (5) A . . . . .	76.0	35.5	65.0
<i>Aa</i> 713 . . . . .	75.05	34.0	64.5
<i>Aa</i> 712 (a) . . . . .	73.4	27.3	62.2
<i>Aa</i> 712 (b) . . . . .	72.9	27.4	61.9
<i>Aa</i> 698 (a) . . . . .	72.7	36.3	62.7
<i>Aa</i> 698 (b) . . . . .	72.7	34.2	62.5
<i>Aa</i> 708 . . . . .	72.1	29.5	60.9
<i>Aa</i> 676 . . . . .	71.7	28.2	60.6

"These are all acceptable oats for milling. They have the advantage of having been carefully cleaned and dressed, which has reduced the percentage of 'useless for milling' material to a minimum, but, in addition, they have also thin husks with a corresponding high percentage of groat, without which no amount of dressing can give an oat a high oatmeal content."

It has been regarded as an important part of the cereal work at the Station to maintain as representative a collection as possible of named varieties of oats as a source of genetic material and also for reference. There are in the collection over 160 varieties, and during the war years it was not possible

to grow them all each year. The entire collection, however, has been sown in 1947, and it is intended to take notes of the botanical characters of the varieties during the growing season and in due course to make a classification of them.

Elite stocks of Early Miller (6 acres) and Bell oats (1 acre) were maintained. Harvesting of the crops was difficult because of the very unfavourable weather, but very little of the crop was lost, and all the best quality grain, except that required at the Station, was sold for seed.

### *Barley.*

Craigs Triumph barley continues to be grown successfully in parts of the north-east of Scotland, and, incidentally, it may be mentioned it was reported in the press that grain of this variety was awarded 1st, 2nd, and 3rd prizes in the class for barley at Aberdeen Spring Show, 1947. An elite stock of Craigs Triumph barley has been maintained at the Station, and all the surplus grain from the 1946 crop (2 acres) was sold for seed. A reference collection of named varieties of barley was also grown in small plots.

There appears to be a need in Scotland for a barley specially suited for the production of pearl barley. The grain desired for this purpose should possess a white endosperm and a shallow furrow. Two samples of grain of Craigs Triumph barley, both grown in 1945—one at Corstorphine and the other in south-east England—were submitted to Dr Sword for examination, and he has reported as follows :—

“The sample grown in England was altogether superior for pearl barley, particularly in the colour of the endosperm, which was white through and through. The sample grown at Corstorphine was steely grey and very hard. The samples were of particular interest in as much as they showed the difference which might be found in the same variety grown in the same year, but in different parts of the country.”

### *Wheat.*

A reference collection containing examples of the more commonly grown winter wheats and spring wheats was grown for general observation and demonstration. Seeds of various

crosses between wheat and some of the wheat grasses (*Agropyron*) have been obtained from abroad and they were sown in small plots. Very few of these crosses have so far shown promise as being suitable for cultivation here. Some of the plants sown last spring which produced shoots were cut back in the autumn and several of them are surviving, thus indicating that they possess the perennial habit of their wheat-grass parents.

### *Legumes.*

A large number of ordinary field bean plants were successfully seeded, the plants being "bagged" at the flowering period to prevent natural intercrossing. A few lines which seemed to be breeding true are being multiplied in isolation for subsequent trials. Several white-flowered plants appeared in the field crop and as they may prove useful for inheritance studies they have been isolated for breeding purposes.

Seeds of several German strains of Sweet Lupin were obtained by Dr William Black when he visited Germany, and these were grown for observation. A certain amount of variation, morphological and chemical, was noted. The plants grew to a height of about two feet and produced some seed, but they did not ripen satisfactorily before they had to be harvested in October. Seeds from several sweet-seeded plants have been sown this season.

### POTATOES.

*(Breeding—Boghall Sub-Station.)*

WILLIAM BLACK, B.Sc., Ph.D.  
J. C. HAIGH, B.Sc., Ph.D., A.R.C.S.

In breeding to produce improved varieties of potato special attention has been directed towards the raising of types resistant to the more important diseases, e.g. blight, leaf-roll and the various mosaics, and the combining of those qualities with the essential features of successful commercial varieties. The collection of parental material suitable for this work has been increased with the addition of specimens from Australia, Canada and Germany.

The most widespread mosaic virus—viz., X—now offers comparatively little difficulty to the breeder, since field-immune commercial varieties are available and the number of field-immune seedlings which have been bred in recent years is extensive. Field immunity from virus X is inherited as a simple dominant, and, consequently, if so desired it would be quite a practical proposition to prohibit the introduction into commerce of all varieties which are susceptible to virus X and thereby overcome the difficulties caused by this contact-transmissible virus. Since field immunity from Virus A is closely linked with field immunity from X, the solution of the virus X problem would at least greatly diminish the incidence of virus A.

The problem of virus Y, as shown in the Virus Disease section, appears to be open to treatment in a manner similar to virus X. Hypersensitive reactions have been observed in certain Mexican and South American species, and two of these, *S. demissum* (E.P.C. 4) and *S. simplicifolium* (E.P.C. 5IA), have been used in several breeding experiments in recent years. They have also been intercrossed, giving a tetraploid hybrid of some potential value for further breeding. In addition, various seedling samples which are claimed to be resistant to virus Y have been obtained from Australia and Germany, some of which have already been employed in breeding experiments.

In the work of breeding for resistance to leaf-roll the chief varieties used have been Shamrock, Southesk, and Imperia. Progress, however, is handicapped by the lack of a convenient laboratory test for resistance to leaf-roll, and reliable results can only be obtained by exposure to natural infection over a period of years. Accordingly, no routine test for leaf-roll resistance has yet been established. Some additional material has been obtained from Germany which is claimed to be highly resistant to this disease.

Further progress has been made in breeding for blight immunity. Tests involving the three strains of blight, A, B, and C, have shown that amongst the seedling material are four different types of resistance, viz. :—

- (1) Plants immune from A, but susceptible to B and C.
- (2) Plants immune from A and B, but susceptible to C.
- (3) Plants immune from A and C, but susceptible to B.
- (4) Plants immune from A, B, and C.

Breeding operations are now being concentrated on selections from group (4) with the object of obtaining varieties immune from all strains. Much of the material obtained from Germany is susceptible to one or other of the strains, but several specimens have proved to be immune from all strains, and they are being used for breeding purposes. They possess rather too many of the "wild" characters to be of immediate value for commercial breeding purposes.

In 1946 an additional strain of blight was isolated. From the results of tests so far carried out this new strain appears to be of little practical significance since, although it affects plants which are immune from Strain A, it has no effect on the B immunes and C immunes so far tested with it. Further tests will be carried out in the coming season.

The mode of origin of these new strains of blight is not clearly understood. There appears to be two alternative explanations—viz., (a) that different strains of the fungus are co-existent in nature, and (b) that new strains arise by modification of the fungus in contact with a new environment. In order to throw some light on the subject a survey of blight in commercial crops in Scotland was carried out during August and September 1946. Samples of diseased material were supplied, through the courtesy of the Department of Agriculture for Scotland, by district supervisors during the course of their annual inspection of growing crops of potatoes. By inoculating plants belonging to all four resistant types enumerated above it was determined that all specimens of the fungus supplied belonged to the A strain, which alone appears to occur under ordinary field conditions. An account of this survey has been submitted for publication in 'Scottish Agriculture.'

Investigations have been continued on the economic possibilities of Mexican and South American species. Attempts have been made to synthesise 48-chromosome breeding material from various potentially valuable species. Female sterility and incompatibility occur, and experiments dealing with their inheritance have been continued.

Investigations into the nature and causes of bolting in potatoes are being carried out in co-operation with Mr Crane and Mr Revell of the John Innes Horticultural Institution. Duplicate progenies, grown at Merton and at Boghall, gave comparable results and showed that although bolter types may be obtained from normal plants, a significantly higher

proportion of bolters results from the crossing of bolters and normals and from the self-fertilisation of bolters.

During 1946 approximately 10,000 seedlings were raised from crosses made for the purpose of combining as many as possible of the desired qualities of disease resistance with essential commercial features. Of these, over 2000 were tested for reaction to the A strain of blight, and about 7500 for reaction to the B strain. The survivors of these tests, 4875 in number, were grown for comparison and selection. The increased proportion of seedlings tested with the B strain over the corresponding figures for 1945 is an indication of the trend of breeding towards a more comprehensive resistance to the different strains of blight. Owing to lack of sufficiently extensive accommodation the C strain could not be employed in routine tests.

Over 800 selected seedlings raised in 1945 and previous years were grown in trial and observation plots, which ranged in size from 4 to 48 plants according to the probable worthiness of the selection and the amount of seed tubers available. The majority of these seedlings were immune from at least two strains of blight.

Sixteen seedlings which were included in the official trials conducted by the Ministry of Agriculture and Fisheries and the Department of Agriculture for Scotland were grown in multiplication plots at Boghall, the largest of which was half an acre in extent. One of them, 831(113), was also multiplied on a larger scale in Aberdeenshire, through the kind offices of Major James Keith, Pitmedden, Udney. Some notes on these seedlings are included in Table II.



TABLE II.

Ref. No.	Maturity	Immune from blight strains	Field Immune from Viruses	TRIALS.		
				L.D.G.M. Year	M.O.A.F. Year	D.O.A.S. Year
655(43) Craigs Bounty	M.	A. C.	A, C.	+	+	2nd.
831(113)	2nd E.	—	X, A.	1st.	+	2nd.
833b(98)	E. M.	A, C.	X, A, B, C.	1st.	+	2nd.
835a(4)	M.	A, C.	X, A, B, C.	2nd.	+	2nd.
593a(9)	1st-2nd E.	—	B.	—	+	2nd.
914b(52)	M.	A, C.	X, A, B, C.	—	+	2nd.
593b(3)	E. M.	—	A, C.	—	2nd.	—
829a(96)	1st E.	—	A.	—	2nd.	2nd.
834c(29)	2nd E.	A, C.	X, B, C.	—	2nd.	1st.
931b(5)	1st E.	A, C.	A.	—	2nd.	1st.
653d(22)	M.	A, C.	C.	—	1st.	—
829a(134)	E. M.	—	X.	—	1st.	—
1092a(4)	E. M.	A, C.	B.	—	1st.	—
1258a(19)	M.	A, B.	A.	—	1st.	—
827a(185)	1st E.	—	A, B.	—	—	1st.
829a(109)	2nd E.	—	—	—	—	1st.

\* Virus tests incomplete.

*Key to contractions:—*

M = Mainerop.

E.M. = Early mainerop.

1st E. = 1st Early.

2nd E. = 2nd Early.

+ = Trials completed.

L.D.G.M. = Lord Derby Gold Medal Trials.

M.O.A.F. = Ministry of Agriculture and Fisheries Trials.

D.O.A.S. = Department of Agriculture for Scotland Trials.

Seedling selections were grown in trial and demonstration plots at Craigs House in comparison with standard commercial varieties. A few were also included in trials at Craibstone, Auchincruive, Inchmarnock, and Melton Mowbray.

Three selections were included in the Lord Derby Gold Medal Trials in 1946—viz., Ref. No. 831(113), 833b(98), and 835a(4). No award was made, but the Committee recommended that all three should be included in the trials in 1947. It was agreed to conform with this recommendation, and the necessary quantities of tubers of all these varieties have been supplied for the trials.

Seedling Ref. No. 655(43), which was awarded the Lord Derby Gold Medal Certificate for the 1945 trials, has been named "Craigs Bounty"; multiplication plots were grown in 1946 at Boghall, and in Aberdeenshire through the generous

co-operation of Major James Keith, Pitmedden, Udney. The suspected presence of virus X in these plots was confirmed by grafting experiments, and it was decided to make selections of virus-free plants from which to build up a virus-free stock before introducing the variety into commerce. The necessary tests were accordingly made and virus-free plants segregated for multiplication in 1947.

At the request of a few plant breeders and agricultural officers abroad, samples of varieties and seedlings have been sent for trial to the following regions: South Africa, Kenya, Tanganyika, Sudan, Australia, New Zealand, India, Canada, United States of America, Bolivia, Argentina, Poland, Denmark, Germany, Holland, Belgium, France, Jersey, and Isles of Scilly. Two seedlings which showed outstanding promise in South Africa and one in Kenya were multiplied on a small scale and the produce forwarded for more extensive trials in these areas.

#### *Virus Diseases—Craigs House.*

G. COCKERHAM, B.Sc., Ph.D.

T. M. R. M'GHEE, B.Sc.

During the past ten years 198 named varieties of potato have been tested in the leaf-roll infection trials at Craigs House. Some of these varieties have proved to be less susceptible to the virus than others, but only four of them have shown any marked qualities of resistance. Of these four, the variety Shamrock escaped infection in the standard form of trial, but ultimately contracted leaf-roll, though to a small extent only, when exposed to a greater risk of infection in large-scale supplementary trials. The remaining three varieties, Imperia, International Kidney and Southesk, have survived uninfected both the standard and supplementary trials, and there is indication that their resistance is of a very high order.

Shamrock, Imperia, and Southesk have been used as parents in an investigation of the inheritance of leaf-roll resistance. Altogether, 4709 seedlings in 59 progenies have been tested in the standard form of trial. A summary of the results of these tests is given in Table III.

TABLE III.

Parentage	Plants	Susceptible	Fairly resistant	Resistant and very resistant
	Number	per cent	per cent	per cent
Susceptible × susceptible . . .	2232	96.90	3.05	0.05
Susceptible × resistant . . .	1566	94.49	4.95	0.56
Susceptible × very resistant . . .	166	49.32	41.78	8.90
Resistant × resistant . . .	253	35.14	57.76	8.10
Resistant × very resistant . . .	461	37.38	45.54	17.08
Very resistant × very resistant . . .	31	24.00	16.00	60.00

The salient features of these data are (1) the occurrence of a small proportion of resistant types in the families of wholly susceptible parents; (2) the progressive increase in the proportion of resistant types with increasing powers of resistance in the parents; and (3) the marked contribution of resistance made by the highly resistant varieties. It is clear that resistance to the leaf-roll virus is heritable and the nature of its inheritance suggests that it is under genic control and is quantitatively expressed.

From the survey that has been made there is every reason to believe that resistance to leaf-roll is a tangible objective in potato breeding. With this end in view selections of the more promising seedlings raised in the experimental work have been made to provide a wider range of parental material for future use in commercial breeding.

Earlier work with virus Y has brought to light the possibilities of obtaining resistance to this virus through the utilisation of the hypersensitive reactions of certain wild forms of the potato. The resistance value of these reactions were examined during 1946 by exposing to infection under uniform conditions in the field a segregating progeny of 168 hybrid seedlings. At the end of the season 62.5 per cent of the non-hypersensitive types had revealed their susceptibility

by showing systemic severe mosaic symptoms. No trace of infection was observed on any of the hypersensitive plants. It would seem, therefore, that hypersensitiveness to virus Y has a resistance value of the field-immunity type. Studies on the inheritance of this character are in progress, but no clear picture of the factors concerned has yet been obtained. The initial stages in the transfer of this character from the wild forms in which it occurs to commercial varieties have been accomplished successfully by using as female parents in crosses with commercial varieties, a small number of seedlings derived from hybridisations between species of different chromosome groups.

Additional breeding has included interspecific hybridisations for the purpose of (1) introducing resistant characters of wild forms into commercial-type seedlings; (2) examining the fertility relationships of various wild forms; and (3) supplying material for genetical studies on virus-resistant characters. Breeding for the combination of resistance to different viruses with resistance to blight has also been carried out, using as parents those seedlings which have survived various resistance tests.

Progress has been made with investigations into the relationships between the genetic factors which determine field immunity from different mosaic viruses and virus strains.

Studies on the spread of viruses in the field have indicated that virus Y is disseminated chiefly, but not entirely, by winged aphides migrating into the potato crop during the early part of the season. Leaf-roll, on the other hand, appears to be spread chiefly, but again not entirely, by wingless aphides moving within the crop after contact between plants has been established.

As resistance to aphides affords a possible source of resistance to all aphis-borne viruses, studies on the aphis-resistant species *Solanum polyadenium* have been resumed. It was found that aphis-resistant characters took several weeks to develop in young plants raised from seed and that even after they had appeared it was still possible to infect the plants with virus Y through the agency of aphides.

Material was collected from various sources for inquiry into problems associated with strains of viruses X and Y. The installation of artificial lighting in one greenhouse made it possible

to initiate this work much earlier than had been expected, and considerable progress has already been made.

Tests for reactions to viruses were carried out on a number of seedlings submitted by the potato-breeding section and also on a number of South American forms of potato.

### *Herbage Plants.*

J. W. GREGOR, Ph.D., D.Sc., F.L.S.  
PATRICIA J. WATSON, M.A.

*Complementary Grazing.*—During the past year the possibilities of a system of complementary grassland utilisation have been further explored. The problem is one of determining whether specialised cultivated pastures rich in protein can be employed as the nutritional complements of rough grazings with the object of utilising to the full the potentialities of both kinds of vegetation. A complete study of the agronomic and economic problems involved is obviously beyond the scope of the herbage programme. In the meantime the search for suitable plant material and the study of specific and varietal responses to the exacting conditions of the complementary environment continues.

Arrangements were made by the Department of Agriculture for Scotland and the Edinburgh and East of Scotland College of Agriculture whereby facilities were provided at the College for the necessary chemical analyses being made of herbage plant samples from the Society's complementary grazing experiment. The analyses have been made by Mr W. D. Connell, and, although the details of his work cannot be given here, it is significant that values in excess of 30 per cent were obtained for crude protein in the dry-matter of ryegrass samples from the complementary grazing area. By way of comparison the highest figure recorded for the herbage of an adjacent re-seeded pasture of similar age but artificially manured at the time of sowing only was 11 per cent. On the complementary area an average increase of 2.8 per cent crude protein was obtained by increasing nitro-chalk dressings from 1 cwt. per acre per month to 2 cwt., while a further doubling of the dressing gave an additional rise of 3.5 per cent. These figures, however, refer only to the composition of the herbage and do not reflect

the yields of protein per acre. Though no reliable yield data are available, there is no doubt whatever that the most productive pasture was the one receiving the greatest quantity of nitro-chalk.

The field trials have shown ryegrass to be a species well suited for complementary purposes in districts of high rainfall. Several strains of mid-season and late maturity have been used with success, but no early strain of corresponding growth-habit is yet available, and a search is being made for more suitable early material as well as strains capable of withstanding occasional flooding.

*Regional Race Investigations.*—The production of bred strains is commonly regarded as being the plant-breeder's primary objective, but in the cross-fertilising categories of herbage plants, the discovery of local products of natural selection may well be of equal agricultural importance. Notwithstanding the deserved popularity of the bred strains the fact remains that local populations which have long been subjected to the selective action of particular environments not only supply the basic material used in breeding strains, but are often in themselves valuable as direct sources of commercial seed, or of stock seed for commercial multiplication elsewhere. It is a matter of importance from both the seed-growing and breeding standpoints that many of the best grazing types are to be found in districts where environmental conditions are unfavourable to seed production. Preliminary investigations have indicated that such essentially non-breeding populations are liable to exhibit a high degree of variability when sexually multiplied, despite an intensive selection of individuals in the vegetative state by the prevailing environments.

As a practical extension of the ecotype investigations, the study of the composition of regional races of perennial ryegrass has now been included in the herbage programme, and recently well over 7000 plants from 73 local populations have been collected in Devon, Cornwall, and the Scilly Isles. These regions were chosen in preference to others, partly in the hope of finding much-desired early types and partly because the investigations of Messrs Horne and Vear having renewed the interest in Devon and Cornish Eaver, these local products are now in process of being developed for general distribution by the respective Seed Growers' Associations.

In choosing the localities to be sampled (which, incidentally,

include habitats ranging from water-logged meadows to dry sand and from grasslands of known history to natural grazings of great age), consideration was given not only to the ecological conditions of the habitats, but also to the practicability of harvesting seed crops from the established populations. Thanks are due to officials of the National Institute of Agricultural Botany, the Devon and the Cornwall Seed Growers' Associations, and to all the farmers and land agents who co-operated most willingly in facilitating the collection of herbage material for experiment.

#### *Field Centres.*

*Whelpside, Midlothian* (elevation, 600 feet; rainfall, 35 inches).—The programme of interspecific and intervarietal tests will be completed in 1947.

*Dalmahoy, Midlothian* (elevation, 600 feet; rainfall, 35 inches).—The protein production of different maturity races of ryegrass is being tested under three nitrogen treatments. The protein content of rough vegetation is also being examined.

*Dundonnell, Ross-shire* (elevation, 80 feet; rainfall, 74 inches).—A complementary grassland trial of species and varieties on a farming scale is being conducted at this centre, where particular attention is being paid to the agricultural value of different maturity races within species. The centre is used as a source of herbage samples for botanical and chemical examination at Edinburgh.

#### *Multiplication of Strains.*

*Perennial Ryegrass.*—The mid-season strain, *Ca* 448, has had to be withdrawn from circulation on account of the number of Italian ryegrass hybrids which it contains. The late strain, *Ca* 434, now being multiplied in Hampshire has also been contaminated to the extent of 3 per cent, a contamination which can be directly traced to inadequate isolation during the initial multiplication at Corstorphine. The early strain *Ca* 457, which had previously been withdrawn for the same reason, has been reselected and is again being multiplied, but for grazing trial purposes only. The mid-season strain,

*Ca 462*, has been sown in England this spring, but it remains to be seen whether the resulting crop will be fit for further seed production.

The lack of isolation-greenhouses for initial seed multiplication of stocks severely handicapped the perennial ryegrass programme, for without them not only is it practically impossible to increase pure stocks owing to the prevalence of Italian ryegrass hay crops on adjoining farms, but the present practice of multiplying stocks in the open field imposes a limit to the number of perennial ryegrass strains which can with safety be seeded at any one time.

*Scotia Cocksfoot*.—Multiplication of this cocksfoot is now being done exclusively in England, and from the 1946 crops grown for the Society in Essex 34 cwt. of seed were sold to members of the Society. *Scotia* cocksfoot is an early variety, with soft, relatively pale-green leaves. The Society does not have facilities for conducting their own grazing trials at the Plant-Breeding Station, and from time to time various farmers who have tried *Scotia* cocksfoot have been invited to report on its performance, but precise information regarding grazing trials is difficult to obtain. It is hoped, however, that the following notes from reports received will be of interest.

Dr H. H. Corner, reporting on its performance in trials conducted by him at Choicelee, Duns, states, "As far as this test goes your Cocksfoot is equally early to Danish, is more leafy, and seems to be equally palatable. . . . Your Cocksfoot is, I think, extremely promising, particularly for sheep purposes on the Borders." At Choicelee, *Scotia* cocksfoot proved to be rather more palatable than Danish, both in spring and summer, and continued to grow a week or two longer in autumn. Other reports from the Border counties confirm that the strain is early and palatable to the grazing animal, but one from South-Western Scotland, though only observational is decidedly less encouraging. No data are available for north-eastern districts. So far as our information goes it would seem that for certain districts in the Border counties of Scotland at any rate *Scotia* cocksfoot is rather better than Danish.

*Scotia Timothy*.—A late (hexaploid) strain which flowers about fourteen days after Stirlingshire Timothy. In pure culture it has been used in complementary grazing trials on wet land, and under the heavy nitrogen treatment given



formed a close and productive sward. A hay yield estimated at 4 tons per acre was cut in Stirlingshire last season. Stock seed is being grown for the Society in Lincolnshire.

#### ROOT CROPS.

V. M'M. DAVEY, B.Sc., Ph.D.

##### *Swedes, Kales, and Mangolds.*

The objects of the work with swedes have been to investigate methods of breeding and, if possible, to produce improved varieties. The method of breeding swedes by pure lining—*i.e.*, by self-fertilisation of selected plants—has been given close attention for twelve generations, but it has not in itself resulted in marked improvement. For, though the better selections give lines which are not far short of the productivity of commercial varieties, it would appear that the swede, like its more completely cross-fertilising relations, requires the stimulus of intra-varietal crossing to give maximum productivity. Inbred pedigree lines have been preserved to test this possibility, and, meanwhile, strains derived from crosses between the different swede types are being examined to find which combinations are capable of supplying economic types. Self-fertilisation is still the main method of propagation, but groups of plants are also seeded in isolation plots, and this method will be increasingly used as facilities permit. Acknowledgment is made of the help given by various members of the Society in providing plots for seeding swedes in isolation.

*Swede Observation Trials.*—Strains derived from inter-varietal hybrids and pedigree lines from selections out of commercial varieties were observed growing in plots. A collection of commercial varieties was obtained and studied in various groupings, as well as being used as controls for the strains. A number of progenies of F<sub>2</sub> plants selected by dry-matter and bulb-weight tests was tested in the first part of a trial which, through lack of facilities, will have to be conducted over more than one year. Selections were made for the future propagation of the strains.

*Clubroot Resistance.*—The infected field plot was used to demonstrate the resistance of certain turnip and swede varieties. Bruce, Wallace, and the Danish Immuna turnips

gave crops practically unaffected by clubroot, and Coxton Crofter gave a partial crop, but the other turnips and swedes were almost completely destroyed. Seedling tests in boxes of infected soil were continued and differences in strain reaction were noted.

*Winter Resistance Trial, 1946-47*—Despite the abnormally severe winter the swedes left in the field till the end of March averaged 19 per cent of sound bulbs, compared with the 11 per cent average in the spring of 1945. The Edinburgh district escaped the full severity of the winter, especially in the first few weeks; and when temperatures were at their lowest a covering of snow protected the bulbs, the exposed necks of which were nearly all destroyed.

TABLE IV.

Illustrating results of winter-resistance trial, 1946-47:—

Variety or strain	NOVEMBER			MARCH		
	Dry-matter per cent	Yield per acre tons	Yield of dry-matter per acre cwt.	Sound bulbs	Partly sound bulbs	Rotten bulbs
Victory . . .	10.1	26	51	7	31	55
Champion . . .	10.7	23	49	34	38	24
Excelsior . . .	11.1	22	49	26	48	23
Strain ABJ . . .	10.3	25	51	18	41	42
"  AFR . . .	9.4	30	56	10	33	55
"  AFS . . .	10.8	25	53	43	38	21
"  AHN . . .	11.0	25	56	9	36	45
"  AHQ . . .	11.2	19	43	7	56	33
Mean . . .	10.6	24	51	19	40	38

Satisfactory yields, both in gross weight and dry-matter percentage were found in November, and the condition regarding disease was also noted. 11 per cent of the bulbs were found to suffer from brown decay or canker, usually associated with splitting or other injuries. As previously noted the globular and harder types of bulb, such as Champion and

Excelsior, were more frequently affected than the soft types, like Victory, which are less liable to splitting. Clubroot attack varied in different parts of the field, and no significant differences were found in resistance of strains to this disease or to the attacks of swede root-fly maggot. Clubroot was present on 19 per cent of the crop, but severely on only 3 per cent, while maggot damage was noted on 8 per cent. Winter resistance may be judged from the numbers of sound and partly sound bulbs; these numbers being based on areas capable of holding 100 plants at 10-inch spacing. It will be seen that the early types—Victory and AFR, and the previously untested strains, AHN and AHQ—suffered severely. Champion showed fairly good resistance, but strain AFS, which has hitherto been similar to Champion, was the best this year. The sample of Excelsior was less resistant than might be expected from a Scottish hardy type.

*Kales.*—An official British party which visited Plant-Breeding Institutes in Germany in 1945 obtained two samples of seed of marrow-stem kale from Bremen and passed them on to the Plant-Breeding Station for observation. These were compared with two British strains in a small trial of transplanted plants. The German strains were evidently bred to yield a high proportion of leaf to stem, and in this respect the elite stock was highest, but one of the British strains (A) was also a leafy type and having a considerably higher gross yield was best also for weight of leaves. Denoting the gross yields of (A) as 100, the following values were obtained:—

	Gross	Stem	Leaf	Ratio leaf: stem
British (A) . . .	100	38	62	1.65 : 1
German elite . . .	83	29	54	1.89 : 1
German green . . .	71	27	44	1.59 : 1
British (B) . . .	80	47	33	0.70 : 1

The British strain (A) and the German strains showed very marked increases in leaf production over the stemmy type represented by British (B). Leafy forms of marrow-stem kale have also been developed in New Zealand.

A set of kale plots was subjected to rigorous winter conditions, and, in general, it may be said that the lower-growing

plants suffered least, being protected by snow. Thus Hungry Gap, the stems of which had not elongated, escaped very lightly, and some perennial kales and hybrids were sound, except when they had grown erect. Some of the type Tr thousand-headed plants (Plant-Breeding Station selection) were not much damaged, but the derivatives from the Broccoli  $\times$  Thousand-headed kale suffered severely. Such plants as showed resistance have been kept for propagation.

*Mangolds.*—A small collection of mangold types was sown out for observation. It was decided by the Society's Roots Sub-Committee not to attempt breeding work with this crop at present.

### *Broccoli.*

1945-46.—The area of the broccoli trials in 1945-46 was reduced to about an eighth of an acre, and no propagation of seed on a field scale was attempted. Two small trials and some observation plots were laid down; one trial containing some strains obtained from Yorkshire and the other testing progenies of plants seeded at the Station. The Yorkshire strains showed no improvement on winter resistance over Royal Oak and St George, which are varieties found to do well in Edinburgh. One called Masterpiece yielded relatively well and showed average resistance for the trial. Another showed poor resistance, and the third, which was a late type maturing at the end of May, was partially killed out by frost. The station strains differed little in resistance to winter conditions, although two of them had a Roscoff ancestor, which is a non-hardy form. Peculiar weather in the spring of 1946 caused very poor curd production. At the beginning of April it was abnormally warm, and many plants, including some of the late-maturing type, commenced to form curds. The soil dried out, and from mid-April till the end of May there was a drought. Consequently most of the curds never passed the "button" stage, and good-sized heads were obtained only after rain had accelerated growth in the last of the late-maturing plants.

1946-47.—The drought delayed germination and the transplanting of these trials, but their ultimate failure resulted from very different weather conditions. The plants were well established though somewhat small, and their resistance to

the drastic winter was better than might have been expected because the foliage was buried in snow. But as the snow melted and the hearts became exposed, pigeons ate the young leaves and buds, and caused so much damage that the trial had to be abandoned. Notes on winter resistance were taken, and from these it is possible to distinguish which of the progenies of sixteen selections from the station strain of Royal Oak, 9 : 3, show best resistance. These will be grown again next year, and if their curds are free from faults it is hoped to propagate seed from them. A breeding-plot of selection No. 9 : 3 was also grown in 1946-47, and as this was netted against hares, and was covered for a longer period by snow-drifts, there is reason to hope that many of the plants will be fit to seed. Stumps of plants bearing good curds were kept alive for a third year, when seed was obtained by hand-crossing in the greenhouse.

## II. Publications and Lectures by Staff for the Year ended 31st March 1947.

Publications (P) and Lectures (L).

William Robb, N.D.A., F.R.S.E.

"Notes on Plant-Breeding in Sweden." *Scottish Agriculture*, Vol. XXVI., No. 3, January 1947. (P.)

"Commercial Seed Production." *East Lothian Agricultural Discussion Society*, Haddington. (L.)

William Black, B.Sc., Ph.D.

"A Blight-Resistant Potato." *The Countryman*, Vol. XXXIV., No. 2, 1946. (P.)

"Problems, Aims, and Methods in Plant-Breeding, with Special Reference to Potatoes." *First Crop Husbandry Refresher Course*, National Agricultural Advisory Service, Royal Agricultural College, Cirencester. (L.)

"Potato Cultivation in Britain and the Commonwealth." *B.B.C. Transcription Service*. (L.)

G. Cockerham, B.Sc., Ph.D.

"Potato-Breeding and Disease Control." Kinross Young Farmers' Club. (L.)

V. M'M. Davey, B.Sc., Ph.D.

"Classification in the Swede." *Scottish Agriculture*, Vol. XXVI., No. 1, 1946. (P.)

"Roots and Kales—Problems, Aims, and Methods connected with Plant-Breeding." First Crop Husbandry Refresher Course, Royal Agricultural College, Cirencester. (L.)

J. W. Gregor, Ph.D., D.Sc., F.L.S.

"The Use of Complementary Grassland." *Scottish Agriculture*, Vol. XXVI., No. 2, 1946. (P.)

"Ecotypic Differentiation." *New Phytologist*, Vol. 45, No. 2, 1946. (P.)

"Grass as an Arable Crop." Dunfermline Young Farmers' Club. (L.)

"Grassland Problems in Hill Districts." Auchterderran Agricultural Discussion Society. (L.)

"Behaviour of Samples of Devon Ryegrass in Scotland." Devon Seed-Growers' Association. (L.)

"Some Stock-Seed and Certification Problems." Cornish Seed Grower' Association. (L.)

Presidential Address to the Botanical Society of Edinburgh. (L.)

### III. Visits.

Director of Research :—

Swedish Plant-Breeding Station, Svalöf.

Branch Plant-Breeding Station, Uppsala.

Agricultural College, Ultuna, Uppsala.

Uppsala University Experiment Station for Cytogenetics and Ecological Work.

Pasture and Moss Experiment Station, Ultuna, Uppsala.

Messrs W. Weibull's Plant-Breeding Station, Weibullsholm,  
Landskrona.

Seed-Testing Station, Copenhagen, Denmark.

Craibstone Experimental Farm, Aberdeen.

Scottish Co-operative Wholesale Society Ltd., Chancelot  
and Junction Mills, Leith.

William Black, B.Sc., Ph.D.

Imperial Bureau of Plant-Breeding and Genetics, Potato  
Research Station, Plant-Breeding Institute, National  
Institute of Agricultural Botany, and School of Agricul-  
ture, Cambridge.

Various German Plant-Breeding Stations.

G. Cockerham, B.Sc., Ph.D.

Seed Potato Farms, Strathallan Castle, Auchterarder.

Raspberry Virus Disease Investigations, University College,  
Dundee.

V. M'M. Davey, B.Sc., Ph.D.

Sugar-Beet Demonstrations, near Edinburgh.

Research Institutes and Farms in the Reading area.

J. W. Gregor, Ph.D., D.Sc., F.L.S.

Macaulay Institute for Soil Research, Aberdeen.

Rowett Institute, Aberdeen.

National Institute for Medical Research, London.

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Captain Ian S. Robertson.  
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