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ANNUAL REPORT

THE SCOTTISH HORTICULTURAL RESEARCH INSTITUTE

1958-59

PHOTOGRAPH BY J. SUNDERLAND

A view of the main buildings from the south

THE SCOTTISH HORTICULTURAL RESEARCH INSTITUTE

The Scottish Horticultural Research Institute was incorporated on 31st March, 1953, as a company limited by guarantee without share capital. The business of the Institute is managed by the Governing Body, on which serve the Governing Members who are appointed by the Secretary of State for Scotland. The registered office is at Mylnefield, Invergowrie, Dundee. A West of Scotland Unit is located at Auchincruive, Ayr.

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THE DIRECTOR'S REPORT

In July, Mr R. L. Scarlett retired from the Governing Body, having reached the age limit imposed by Section 185 of the Companies Act, 1948. The Governing Body thus lost one of its most active members and the Institute one of its staunchest supporters. The establishment of a centre for horticultural research in Scotland was a cause for which he, along with others, worked hard, and both the Director and the staff of the Institute owe much to him for his practical help and good counsel, so willingly given. Scottish horticulturalists know well the tireless efforts Mr Scarlett has made over a long lifetime on behalf of their industry. It is fitting therefore that the Royal Horticultural Society should, this year, have awarded him their Victoria Medal of Honour, and that Mr Scarlett was one of the first recipients of the Scottish Horticultural Medal awarded by the Royal Caledonian Horticultural Society. As successor to Mr Scarlett, the Secretary of State appointed Mr A. T. Bryden of New Mains, Scone, Perthshire. We welcome Mr Bryden and look forward to benefiting from his practical experience and good counsel.

THE YEAR 1958/59

The experience of yet another wet summer has emphasised the need for means of preventing the losses caused by the grey mould fungus (*Botrytis cinerea*) in both raspberry and strawberry. The work begun last year by the mycologists has yielded useful results and it is encouraging that some varieties of raspberry seem much less prone to attack than others. The production of resistant varieties may well provide the most effective solution to this problem and, at Auchincruive, strawberry seedlings are being assessed for resistance to grey mould and mildew as well as for resistance to red core disease. A solution to the problem of June Yellows seems more elusive than ever, for it now appears that crosses between the same parent plants repeated in successive years give different proportions of affected seedlings. More evidence on the nature of the factors which control flowering and runnering in strawberry has been obtained and the work promises most interesting developments, some of which may have valuable practical applications. The value of post-harvest defoliation in increasing the yield of some varieties of strawberry under Scottish conditions has been clearly established, as has also the cold-storage of runner plants for planting in early summer. Soil-borne viruses have been found infecting strawberry in many parts of Britain but, as with the raspberry, varieties differ in susceptibility to infection and some may be immune. A good start has been made in the application of some of the results of work on aphid- and soil-borne viruses to the practical problems of raspberry breeding, and we look forward to seeing results from the virus-free raspberry stocks which are on trial at the Institute and which were distributed to commercial growers for the first time this year. Although a general problem for soft-fruit growers, weed control is a major difficulty with raspberry cane nurseries. Chemical means of control are promising and may remove at least one deterrent to the propagation of healthy raspberry stocks. De-

spite the wet summer, the apple crop at Mylnefield was magnificent and was a source of satisfaction to all those who have tried to stimulate a greater interest in apple growing in Scotland. Vegetable growers will find interest in the two reports of trials which appear below and in the evidence of the range of crops which can successfully be grown in Scotland for processing. Work on the breeding of new varieties of vegetables is progressing and stocks of French beans raised at Mylnefield will soon be ready for field trials.

BUILDINGS

Although the main laboratory and office building is barely six years old it has already become overcrowded, and the increase in staff expected during the next five years made the provision of new accommodation urgent. Plans for an extension to the present building were drawn up with the Institute's architects and these were approved in principle by the Department of Agriculture for Scotland and the Agricultural Research Council last autumn. As this Report goes to press, work on the site has started. The new extension is of modern design and unit construction, and will house the Crop Physiology, Genetics, Mycology, Pomology, Vegetable Culture and Virology Departments. The new Chemistry Department will occupy two or three of the laboratories in the old building now being used by existing departments. Other rooms will be used by the administrators and to provide a much-needed extension to the library.

During the winter the Long Barn was transformed from a somewhat inhospitable farm building into a hall where meetings and lectures can be held in comfort. This was done almost entirely by members of staff in their spare time under the leadership of Dr A. R. Wilson and Mr A. B. Wills. The lack of any such facility has been sorely felt and the Institute is much indebted to all concerned for doing such a splendid job.

A Dutch light structure for use by the Vegetable Culture Department was constructed during the year. The screen house, intended to protect the virus-free stock plants of raspberry and strawberry, was enlarged.

FARM AND PLANTATIONS

The year was a difficult one for the field staff because the long periods of wet weather in spring and summer hindered cleaning and interfered with the soft fruit and grain harvests. However, conditions favoured some crops and, in general, yields were good. The wheat crop was somewhat reduced by an outbreak of loose smut, but oats and barley yielded well. The barley was combine-harvested. Root crops grew very well although the sugar content of the beet crop, 15.15%, was the lowest yet recorded at Mylnefield. The crop, 340 tons (an average of 12 tons/acre), was cleared by mechanical harvester. Turnips survived an infestation of diamond-back moth and yielded excellently. The hay crop was good, summer keep was plentiful and 60 bullocks were fattened during the year.

Despite the wet weather the soft fruit crop, 35 tons, was a record. Over 12 tons of strawberries were picked, mostly from an outstandingly good plot of maiden Redgauntlet. Although the acreage of mature raspberry plantations was less than last year, the yield, 20 tons, was almost as much. Black

currants cropped well but a high proportion of the berries split because of the wet weather. About 4½ tons of apples were picked and, for the first time, consignments were sent to wholesalers in Dundee. Produce sold from the vegetable experiments included 4 tons of Brussels sprouts.

A new mixed deciduous and coniferous windbreak was planted along the boundary between Steading and School fields, and another, consisting of *Cupressocyparis Leylandii*, Corsican pine and poplar, was planted this spring along the former boundary between West Loan and Mid Loan fields. Plantings were also made along the south boundary of Quarry field.

In July, the Institute acquired the tenancy of a neighbouring nursery comprising a range of three glasshouses, each 100 ft. × 16 ft., which will be used for experiments concerned with commercial production of tomatoes. Essential repairs to the property have been made by the factor, and the houses, now planted with tomatoes, are being tended by the Institute's glasshouse staff. During the year a new tractor was acquired and facilities in the farm workshop were improved. The outdoor staff now numbers 23.

STAFF

Changes in the staff have been unusually numerous this year. A. G. Fisken left the Virology Department in May to take up an appointment with the Shell Chemical Co. D. W. Burd resigned from the Pomology Department in November and Mrs J. R. Gemmell from Laboratory Service in April. In November, S. R. Chant joined the Virology Department to work on aphid-borne viruses in raspberry and other crops, and in February, W. P. Mowat was appointed to the Mycology Department for work, in co-operation with the Virology Department, on the mechanism of transmission of soil-borne viruses. G. M. L. Haskell was appointed in January as head of the Genetics Department. His particular interest in and experience of the genetics of *Rubus* species and vegetable crops should be valuable aids to progress in the work now being done at the Institute. In June, Barbara Riddoch was appointed as Assistant (Scientific) to the Crop Physiology Department, and in July, Margaret Martin and Beatrice Oswald came as Assistants (Scientific) to the Vegetable Culture and Mycology Departments respectively. Miss Martin also assists with work in the Pomology Department. In July, J. Cathro was transferred from Laboratory Service to take charge of electron microscope work in the Virology Department. J. Couttie became head of Laboratory Service, and was joined in July by J. A. A. Renwick, as Assistant (Scientific), and in January by J. Stewart as joiner-handyman.

R. D. Reid was awarded one of the first four of the newly-created Scottish Horticultural Medals by the Royal Caledonian Horticultural Society in recognition of his services to Scottish horticulture.

L. S. Gray gained the National Diploma in Agriculture. The Director's secretary, Miss Sheila Rodger, qualified as a member of the Faculty of Teachers in Commerce.

VISITS OVERSEAS

A grant-in-aid by the A.R.C. and the Department of Agriculture for Scotland enabled the Director and C. North to attend the 15th International Horticultural Congress at Nice. Opportunity was taken of combining

attendance at the conference with visits to horticultural research centres in France and Switzerland and to a number of commercial centres in France. The visits paid while making the journey to and from the conference were extremely profitable and rewarding and have led to exchanges of information and breeding material.

A travel grant from the Wellcome Fund enabled C. H. Cadman to attend the 7th International Microbiological Congress in Stockholm where he read a paper on the mechanism of transmission of soil-borne viruses. He also visited the Netherlands in May at the invitation of Professor E. van Slogteren, for informal discussions on soil-borne virus problems, and lectured to students at the Agricultural University, Wageningen.

A grant from the A.R.C. enabled A. B. Wills to spend a week at the Max Planck Institut für Züchtungsforschung, Cologne, for discussions with Dr Bauer and others on mutual problems in the breeding of strawberry and other soft fruits. He also visited centres in the Netherlands, the Max Planck Institut für Züchtungsforschung at Hamburg/Volksdorf, the Bundesortenamt and the Pflanzenschutzamt both at Hanover.

A. R. Wilson also received a grant-in-aid to attend the Annual Council Meeting of the European Association for Potato Research at Brunswick in January.

The value of these overseas visits both to the individuals concerned and to the Institute cannot be over-emphasised. During such visits one is able to learn at first hand of work in progress, the results of which may not be available in the literature for several years to come. More important still, the personal contact enables the exchange of ideas which is so important in research.

OTHER ACTIVITIES

In September, C. G. Guttridge read a paper on his strawberry work to Section M of the British Association's meeting at Glasgow, and in October R. D. Reid and C. A. Wood read papers at the meeting of the Agricultural Association of Ireland held at Bray, County Wicklow. C. North lectured to N. A. A. S. horticultural officers at their conference at Keswick in February, and the Director and other members of staff lectured to a number of Scottish horticultural societies.

As already mentioned, the apple crop at Mylnefield was exceptional this year, and the Institute was awarded a David King Gold Medal for its non-competitive exhibit of apple varieties and uncommon vegetables at the autumn show of the Royal Caledonian Horticultural Society at Edinburgh in September. Exhibits of apples were also displayed at Aberdeen and Ayr.

Among overseas visitors to the Institute this year, we were particularly glad to welcome Dr R. Stace-Smith from the Plant Pathology Laboratory, Vancouver, who spent the months of May and July working in the Virology Department. Other visitors from Canada were Dr H. Hill, Dr C. D. McKeen, Dr H. N. Racicot and Dr C. C. Strachan; those from the U.S.A. included Prof. L. G. Holm, Dr R. Gilmer, Dr F. L. S. O'Rourke and Dr C. E. Yarwood. Dr S. D. Chaudhuri came from Pakistan, Dr A. Koslowska and Mrs J. Pieniazek from Poland, and M. and Mme. A. Dufour from Switzerland. Visitors from the United Kingdom included Mr E. W. Hobbis and the N.A.A.S.

Fruit Specialists who visited Mylnefield and Auchincruive in July. Two Growers' Days were held, one for fruit growers in July and the second for vegetable growers in September, and both were well attended.

ACKNOWLEDGMENTS

We are, as usual, much indebted to the British Food Manufacturing Industries Research Association, Leatherhead, Chivers & Sons Ltd., Montrose, and Smedley's Ltd., Dundee, for help in the assessment of processing quality of fruit and vegetable varieties. The Experimental Factory of the Ministry of Agriculture, Fisheries & Food also took part in this work, and we are indebted to Mr J. C. Forrest, of this establishment, and to his staff for help in designing and building a machine for measuring the firmness of Brussels sprouts.

Through the kindness of Prof. G. D. Preston, Queen's College, Dundee, and by agreement with the Department of Scientific and Industrial Research, the Metropolitan-Vickers EM2 electron microscope was loaned to the Institute for use by the Virology Department. Mr J. McKie of the Regional Physics Department, Eastern Regional Hospital Board, again helped with work on the irradiation of raspberry material.

Co-operation continued with the three Scottish Agricultural Colleges in fruit and vegetable trials, and the Institute is indebted to the Chemistry Department of the Edinburgh and East of Scotland College for the increasing quantity of analytical work it is undertaking in connection with the experiments on raspberry cultivation at Mylnefield.

Plant Protection Ltd., Fison's Pest Control Ltd., May and Baker Ltd., the Mirvale Chemical Co. Ltd. and the Murphy Chemical Co. Ltd. kindly advised on and supplied materials for use in weedkiller trials, and Mr E. H. M. Cox, Glendoick, allowed a part of his raspberry plantations to be used for trials of this kind.

The Agricultural Research Council's Unit of Statistics, University of Aberdeen, and the Statistics Section of the East Malling Research Station assisted with the design and statistical analysis of experiments. The Chief Surveyor of the Department of Agriculture for Scotland and his staff again assisted in the reproduction of the Institute's Annual Farm and Plantations Cropping Record and Map.

POMOLOGY

C. A. WOOD

After a rather late start in spring the 1958 fruit season developed quickly, and the picking periods at Mylnefield for raspberries (14th July-1st September) and strawberries (8th July-15th August), except for being more prolonged, were similar to those of 1956, a fairly average year. Most early and mid-season varieties of black currant, however, ripened from a week to ten days later than in 1956. The soft fruit season was again wet and difficult, but in the absence of spring frost damage the crops were heavy. The year was noteworthy for the high fruit quality, particularly in colour and finish, of a large proportion of the apple varieties on trial. Fruit of excellent colour was produced not only by certain overseas varieties well known for this feature, but also by a wide range of British varieties familiar in the apple-growing areas of England.

PLANT BREEDING

Raspberries

Further assessments were made of four families, raised from seed in 1955, which had the East Malling seedling 64/53 as a common parent; but although 26 seedlings were selected for further observation, none of them appeared to combine sufficient firmness of fruit texture with the other desirable characters sought. This result was the same as that obtained with earlier families, and indicates that little all-round advance is now likely to be achieved in F_1 generations of inter-varietal crosses. Much greater emphasis is therefore being placed on the longer-term programme, mentioned in previous Reports, in which suitable parents are being inbred for several generations and subjected to repeated and intensive selection for particular characters. As inbreeding of the raspberry usually results in loss of vigour, intercrossing of the inbreds will later be neccessary before vigorous commercial varieties can be produced. The first inbred families were planted in 1957: some of their seedlings produced a small amount of fruit in 1958 and preliminary selections were made.

Forty-eight families, containing altogether 1,667 seedlings, were planted during the year. Eleven of the families had been raised by self-pollinating raspberry varieties or seedlings, nine by self-pollinating species of *Rubus* other than the raspberry and 28 by crossing the red raspberry with other forms of *Rubus*. Most of the seed from the interspecific crosses germinated poorly. New pollinations made in 1958 included crosses between seedlings selected for good fruit quality, crosses designed primarily to elucidate the genetics of resistance to soil-borne viruses (see below) and further self-pollinations of selected seedlings.

In two families where the female parents were raspberry varieties and the male parents *Rubus chamaemorus* and King's Acre Berry, it was noted that the

seedlings—whilst showing some segregation—all appeared to resemble the maternal parents. The possibility that apomixis occurred in these crosses is being investigated.

In co-operation with the Physics Department of the Eastern Regional Hospital Board, preliminary experiments were started to assess the value of X-irradiation as a means of inducing mutations in raspberry root cuttings and seeds. Small root cuttings tolerated a maximum dosage of 6,000 r., beyond which the production of shoots was depressed: poor germination of the control untreated samples prevented any assessment of the dose-tolerance of seeds. The treated material is being observed for the presence of mutated tissues. (D. L. Jennings, B. Tulloch.)

Genetics of Resistance to Raspberry Viruses

Outbreaks of severe disease are liable to occur when raspberries are grown on land containing any of three soil-borne viruses, arabis mosaic, raspberry ringspot and tomato black ring, now known to be widespread in Britain (see p. 36). Work done by the Virology Department has shown that some present-day varieties of raspberry are immune from infection by one or more of these viruses, and knowledge of the genetics of these immunities is desirable in order to facilitate the breeding of new immune kinds. A start has been made by using plants from seven existing families raised by selfing or crossing varieties each immune to at least one of the three viruses. Twenty seedlings of each family were multiplied by root cuttings so that each seedling could be tested for susceptibility to each virus by grafting with infected scions. It is hoped that the results of such tests made in the summer will give information in 1959 on the heterozygosity of the varieties for the genes concerned and on the dominance of the latter, so that larger families can be chosen for more detailed study.

The best way by which the plant breeder can control aphid-borne raspberry viruses may well be by raising varieties resistant to colonisation by the principal aphid vector, *Amphorophora rubi*, work which is in progress elsewhere in Britain. This approach, whilst potentially useful, could fail if the aphid developed new races capable of feeding on the resistant varieties. As an insurance against this possibility, attention is being given to two varieties—Norfolk Giant and Malling Exploit—which, although colonised by the aphid, tend to resist infection by certain viruses which it transmits. Seedlings derived from them have been multiplied by root cuttings prior to being tested for field resistance to vein-banding disease, one of the more serious diseases caused by aphid-borne viruses. (D. L. Jennings.)

Black Currants

The last Report mentioned 28 black currant families raised from seed harvested in 1956. Most of the seedlings remained in the nursery during 1958, but 25 of the largest seedlings from each of 24 of the families were planted out in the spring for a preliminary assessment of their fruit in 1959.

The seed from the crosses made in 1957 germinated rather poorly. Fifteen intervarietal crosses yielded only about 1,000 seedlings, although the numbers obtained from the crosses of Baldwin with Magnus, Consort, Tinker and Laxton's Giant, and of Magnus with Seabrook's Black and Consort, should be

adequate for an assessment of these families. Of 13 interspecific crosses, most of which had produced seed in reasonable quantity, only that of Baldwin black currant x *Ribes ussuriense* germinated well. Crosses between black currant varieties and nine species in the *Ribesia* (red currant) sub-genus of *Ribes* gave a total of 45 seedlings. The seed from self-pollinations of four red currant varieties germinated satisfactorily.

New pollinations in 1958 were confined to interspecific crosses, mainly between black currants (Baldwin, Seabrook's Black) and species chosen from five sub-genera of *Ribes*. Thirty-six crosses, including reciprocals, were attempted and only four failed to produce seed. All but four of the remainder gave substantial quantities of seed. (M. M. Anderson, W. Fordyce.)

THE CULTIVATION OF RASPBERRIES

General observations on the purpose and progress of the field experiments on raspberry cultivation were made in the last Report. Six experiments of the older series (planted in 1952 and 1954) were continued in 1958, two of them being terminated at the end of the season, and three new experiments were planted in the spring.

Experiments planted in 1952

The experiment to compare the value of planting canes singly with planting in twos ("double" planting) has cropped for six seasons, and the double-planted plots of Lloyd George, Malling Jewel and Malling Promise now show accumulated additional yields ranging from 35 to 45 cwt./acre, largely established during the first two or three years. On recent prices for fruit and nursery stock these margins are amply sufficient to cover the initial cost of the extra canes planted. In the fourth variety, Norfolk Giant, however, the advantage from double planting gained in earlier years has been lost during the past four seasons, and the single-planted plots now have slightly the higher total yield. The reason for this result is uncertain, but it is quite likely to have arisen solely by chance and not because Norfolk Giant is unsuited to the double method of planting. The experiment is being continued.

In the experiment on the effects of frequency of picking and number of canes fruited per stool, the cane numbers compared were approximately 4, 5, 6 and 7 per stool in Lloyd George and 5, 6, 7 and 8 in Malling Promise. In both varieties the crop again increased with increasing cane numbers, but whereas in Malling Promise this effect was significant at the 0.1% level, it did not reach significance in Lloyd George at the 5% level. On the combined yields of the two varieties the less frequent (4-day interval) picking treatment gave a significantly higher crop than the more frequent (2-day) picking ($P < 0.01$), but this effect was much greater in Lloyd George than in Malling Promise. The experiment was terminated after the crop had been picked and the production of new canes recorded. An analysis of total yields from 1954 to 1958, the period during which the cane-number treatments were applied, has shown that in each variety the differences due to cane numbers were significant at the 0.1% level. The best crop in Malling Promise was from the highest cane-number treatment, where the average numbers of canes fruited in the five years of the period were respectively 6, 7, 8, 9 and 8 per stool. In Lloyd George the best crop was from the second-highest cane-number

treatment, where the corresponding numbers were 5, 6, 7, 8 and 6 per stool. These results show that no cropping advantage is to be expected from a severe thinning-out of new canes; on the contrary, some increase might be made in the numbers of canes usually retained for fruiting.

The results of the experiment with Malling Promise on methods of treating the tops of canes in winter were similar to those of previous years. Where the tops were arched over at tipping height, re-tied to the top wire and shortened below the wire the yield was 91 cwt./acre, compared with 86 cwt./acre where they were similarly trained but not shortened and 70 cwt./acre where the canes were tipped in the normal way. There was again no difference in yield between canes tipped when dormant and canes tipped after bud-burst. This experiment was concluded in the autumn but the same treatments were first applied in 1958 to a two-year-old experiment planted with Norfolk Giant. The season's results from this supported those of the original experiment.

Experiments planted in 1954

In the experiment to compare the practice of maintaining raspberry plants as separate stools with that of allowing the rows to form continuous "hedges" of non-stooled canes, the non-stooled plots of two of the varieties—Malling Promise and Norfolk Giant—for the first time cropped slightly better than the stooled. Lloyd George gave the reverse result. The non-stooled rows of all three varieties, however, carried more fruiting canes than the stooled. In both types of row the numbers of canes retained for fruiting had been determined in the previous winter by thinning procedures designed to make best use of the new canes present, having regard to their numbers and quality. Now that the yearly production of new canes throughout this experiment is more than adequate, it is clear that cropping can be materially influenced by arbitrary decisions on methods of thinning, and that each individual treatment must be assessed and managed strictly on its merits. Annual records of cane numbers and heights, fruiting-lateral formation and other growth data continue to enable the cropping performance of each treatment to be examined in relation to the procedures applied to the canes.

Similar comments on arbitrary effects of management apply to the two experiments on systems of supporting and training fruiting canes. In these, the posted and wired rows again yielded more than rows in which the canes were either tied together into vertical bunches or arched over from stool to stool. The latter systems avoid the expense of posts and wire but depress productivity per cane. The performance of these self-support systems in terms of fruit yield per acre could doubtless be improved, however, by adopting closer planting distances, thereby increasing the populations of fruiting canes: they might then be efficient as methods of production for units small enough to be worked by two-wheeled power implements.

Experiments planted since 1956

These experiments, described briefly in the last Report, are concerned mainly with effects of nutritional factors, either alone or in combination with some of the other cultural factors previously studied. The experiments planted in 1957 became well established during 1958 and cropped satisfactorily, but it is still too soon to indicate more than very preliminary results.

One experiment of the 1957 series is an attempt to determine how the optimum number of canes that should be fruited per stool is influenced by distances of planting and rates of fertilizer application. Four average numbers of fruiting canes per stool will be compared against a background of two inter-row distances (6 ft. and 8 ft.), four inter-stool spacings (1½ ft., 2 ft., 2½ ft. and 3 ft.) and four rates of spring application of a compound inorganic fertilizer (nil, and two-thirds, four-thirds and twice the recommended rate). In another experiment, Malling Exploit raspberry will be grown under six different systems of management, consisting of a straw mulch, a cover crop and four variants of the conventional clean-cultivation system. These experiments first received their full treatments early in 1959, after two seasons' growth.

Two experiments of this series which received differential fertilizer treatments in 1957 and 1958 have already shown increases in cane growth and fruit yield from the application of extra quantities of inorganic nitrogen. In one, where the basic levels of nitrogen for the two years were 20 and 30 lb. per acre, sub-plots on which these rates were doubled gave an increase of yield for the two seasons of 32%. The basic nitrogen dressing was contained in a compound fertilizer (analysis 5 : 7 : 20) and the extra quantity supplied as sulphate of ammonia. In the second experiment, where three levels of application of nitrogen, phosphate, potash and farmyard manure are being compared separately and in combination, increase of nitrogen level was the only treatment that increased the fruit yield both in 1957 (the year of planting) and 1958. The site of these experiments was not previously regarded as nitrogen-deficient.

Included in the 1957 series is an experiment to compare the performance of virus-free stocks of Lloyd George and Malling Jewel (obtained by heat-treatment) with that of the mildly virus-affected stocks hitherto released by the Institute as the best available. (The latter are the stocks which have produced the heavy crops reported for these varieties in several past trials.) In total productivity to date—*i.e.*, on the combined 1957 and 1958 crops—the virus-free stocks have now out-yielded the older stocks by 39% in the case of Malling Jewel and 13% in Lloyd George, and they continue to show the more vigorous growth. The virus-free stocks are, of course, subject to gradual contamination by viruses spreading within the experiment from the older stocks; about one-fifth of the originally healthy stools now appear to have become so affected. Insecticides are used in spring and early summer to reduce this spread of virus as far as possible, and tests will be repeated to record the amount of spread. For convenience, this experiment also contains on a factorial basis three different planting treatments: single planting at inter-stool spacings of 1½ ft. and 3 ft. and double planting at 3 ft.

One of the three new experiments planted in 1958 is a comparison of eight possible methods of preparing ground for raspberry growing, including the incorporation of farmyard manure, green manure crops, peat and organic and inorganic fertilizers, followed by eight different post-planting systems of manuring. The green manure crops (tick beans followed by rye) were grown on the appropriate plots in 1957. The other two experiments are repetitions of earlier work on the performance of canes lifted from the nursery at successive monthly dates in autumn and winter and planted in spring, and on the

autumn and spring planting of autumn-lifted canes. (C. A. Wood, M. M. Anderson, W. Fordyce, J. P. Sutherland, B. Tulloch, M. J. Martin.)

WEED CONTROL

Work with chemical herbicides for weed control in soft fruit plantations was expanded. The materials used for the first time in preliminary "screening" tests at Mylnefield and at Glendoick, Perthshire, were simazin (2-chloro-4,6-bisethyl-amino-s-triazine), amino triazole (ATA), a 2,3,6-trichlorobenzoic acid/MCPA proprietary mixture and the substituted ureas monuron (CMU), diuron (3,4-DDU) and fenuron (PDU). These were included among treatments applied in early April to raspberry fruiting plantations and cane nurseries and to strawberry runner-beds, shortly after the ground had been cleaned by normal cultivation.

Initial results from these tests enabled a small replicated trial to be started in June in a first-year cane nursery of the raspberry variety Malling Exploit. The treatments were monuron and simazin, each at 1, 2 and 3 lb. of active ingredient per acre, and a mixture of IPC (5 lb.) and 2,4-DES (3.6 lb.), all applied as sprays to the raspberry foliage and freshly-cleaned soil surface. Neither simazin nor the IPC/2,4-DES mixture appeared to damage the raspberries, but monuron at all three rates caused leaf-scorch. Weed counts suggested that optimum application rates for the new materials, to give good weed control for about three months, should be about 2 lb. for simazin and 3 lb. for monuron. The IPC/2,4-DES mixture, successful in earlier experiments, gave excellent weed control for about 10 weeks but failed to control henbit (*Lamium amplexicaule*). This experiment will be continued and special attention paid to the possible accumulation of harmful quantities of simazin and monuron in the soil.

Four herbicide treatments, all of mixed chemicals—dinoseb/TCA, IPC/2,4-DES, IPC/fenuron and 2,4-DES/fenuron—were applied for the first time to a two-year-old raspberry experiment in which their effects on growth and yield can be recorded quantitatively. Any other herbicides found to be potentially useful and safe will similarly be introduced into long-term replicated experiments, designed to test programmes of chemical weed control that might be incorporated into the general management of the crop.

The preliminary work in strawberry runner-beds showed promising results from simazin and an IPC/2,4-DES mixture. Trials were also begun on the control of vegetation, mainly grass, growing too close to the stems of apple trees to be reached by the mower. (J. P. Sutherland.)

STRAWBERRY INVESTIGATIONS

A replicated trial of six strawberry varieties and seedlings planted in spring 1956 was used to obtain further information on the effects of post-harvest defoliation on the following season's flowering and cropping. Shortly after the completion of picking in 1957, the foliage on half of the plots was scythed off and the entire trial given a dressing of sulphate of potash at 1 cwt./acre. Substantial increases in yield, ranging from 50% in an unnamed seedling to 190% and 350% in Redgauntlet and Talisman respectively, were recorded from the mown plots in 1958. These plots also showed much lower proportions of fruit infected by grey mould (*Botrytis cinerea*). Except for one

variety, the plants in the mown plots produced considerably more flowers than those in the unmown, and in all the varieties a higher proportion of flowers on the mown plots set fruit. The higher flower numbers on the mown plots were due to the greater numbers of inflorescences present: these, in all but the one exceptional variety, more than balanced the slightly higher numbers of flowers per inflorescence which occurred on the unmown plots. The marketable berries from the unmown plots were slightly higher in average weight than those from the mown. These results confirmed the value of defoliation as a post-harvest treatment to promote fruitfulness in the following year (see also p. 29). Varieties appear to differ in their response to it, and there is evidence from earlier work that it is effective only if carried out fairly soon after the completion of picking. (M. M. Anderson).

The large observation plots of Talisman (planted 1955) and Redgauntlet (planted 1957) described in the last Report were used for a comparison of wettable sulphur and Karathane as controls for powdery mildew, but under the wet conditions of the season this disease was not prevalent. Both plantations were also completely sprayed with Orthocide (Captan) on three dates between early flowering and fruiting, each time at 6¼ lb. wettable powder in 250 gal. water/acre. This perhaps contributed to the relative freedom of the crop from grey mould in a season in which the disease was widespread and severe; but there is an objection to the use of Captan on strawberries which are to be sold for canning. The plot of Redgauntlet, nearly an acre in area, yielded slightly under 6 tons of saleable fruit, much of it of very large size. The saleable crop from Talisman exceeded 4 tons per acre.

Trials of new strawberry selections were continued in co-operation with the West of Scotland Unit. (C. A. Wood, M. M. Anderson.)

APPLE VARIETY-ROOTSTOCK TRIALS

These continued to make satisfactory progress. The trial to compare the vigorous rootstocks M.XVI and M.XXV was completed by the addition of a third variety, Howgate Wonder, and preparations were made to add the variety Laxton's Fortune to the trial of dessert apples on four Malling and four Malling-Merton rootstocks.

Light crops were harvested from most combinations of dessert varieties and rootstocks, but Worcester Pearmain on M.XVI and M.XXV has yet to fruit. In the trial of dwarfing and semi-dwarfing rootstocks most varieties cropped well on M.IX, Red Melba being outstanding both on this and M.VII. Of the culinary varieties on rootstocks M.I, M.II, M.XVI and Crab C, light crops were picked from Grenadier, Royal Jubilee and King Edward VII but Bramley's Seedling did not fruit. All the fruit harvested was of good size, but poorly coloured in comparison with fruit from older trials (see below).

No serious wind damage occurred during the year. There was considerable spread of stem canker, mainly among the dessert varieties on rootstocks M.IX and M.VII. (W. Fordyce, J. P. Sutherland.)

OTHER VARIETY TRIALS

Red Currants

The red currant trials and observation plots planted in autumn 1955 are now well established and gave useful crops in 1958. In the smaller trial, of

five varieties, the best in yield were Laxton's No. 1 and the American variety Red Lake, followed by Jonkheer van Tets, a Dutch variety. The last two were outstanding for their large berry size. In the trial of 15 varieties, the best so far have been Laxton's No. 1, Laxton's Perfection and Red Dutch.

Black Currants

In the black currant variety and pruning trial, also planted in autumn 1955, the Finnish variety Brödtorp (syns. Soorbackgoord, Danish Black) again led in yield, followed by Wellington XXX and Wallace Seedling. Differential summer and winter pruning treatments were first applied to this trial in 1957, and in all the eight varieties the winter-pruned bushes gave the better crop in 1958.

Blackberries and Loganberries

A small trial of blackberries and loganberries, planted in 1952, was concluded and the results were published.

Plums

In the "elimination" trial of plum varieties and rootstocks, planted in spring 1953, seven more trees died from bacterial canker. The total losses from this cause have been so high as to call into question the continued value of the plantation, but the good condition of the trees in one outside row, grassed down and closely protected by shelter, has suggested that the trouble may have been accentuated by environmental factors—perhaps by the combination of severe wind exposure and clean cultivation. The whole plantation is therefore to be grassed down in 1959. The majority of the original trees are still alive and most of the gaps have been filled.

Twenty-one varieties cropped in 1958, two—Black Prince and McLaughlan's Gage—for the first time. Only Laxton's Cropper and Czar, however, carried reasonably heavy crops of fruit which did not split. Belle de Louvain, Black Prince and Pond's Seedling gave light crops of good quality fruit. The late variety Wyedale again failed to ripen, and all the gage plums except Denniston's Superb suffered severely from splitting.

Apples, Pears, Cherries

The season was easily the best for apples at Mylnefield since the establishment of the Institute, and was remarkable for the good quality, particularly in colour, of much of the fruit harvested. This was true not only of apples like the Canadian varieties Hume, Lawfam, Lobo and McIntosh Red, in which high colour is expected, but also of such well-known British varieties as Worcester Pearmain, Laxton's Fortune, Laxton's Superb, Norfolk Royal, Lord Lambourne, Sunset and Monarch, and the newer varieties Merton Worcester, Tydeman's Early Worcester and Exeter Cross. Sunset and Laxton's Superb, often difficult to ripen in Scotland, matured well, and even the late-flowering Crawley Beauty coloured well in the field and ripened in storage.

In the apple Variety Collection, 373 varieties cropped, 79 of them for the first time, and in the "elimination" trial of modern and commercial apples, 94 varieties cropped, four for the first time. Some 4½ tons of fruit were harvested from the two plantations.

Twelve varieties in the Pear Collection cropped, three of them for the first time.

In the 1955 cherry trial, all the trees have now made good heads apart from some of Early Rivers which were badly injured by gales in 1957. Very little wind damage occurred in 1958. The varieties Early Rivers and Merton Heart set small quantities of fruit but most of this split and dropped before ripening.

Scottish Regional Fruit Trials

Variety trials of raspberries, strawberries, black currants and plums were continued under the aegis of the Scottish Fruit Trials Committee. In the raspberry trial, which was in its sixth cropping season, all the varieties except Lloyd George gave lighter crops than in 1957. Lloyd George, however, the yield of which fell to 24 cwt./acre in the frosty season of 1957, again cropped at more than 4 tons/acre and resumed its position as the heaviest-yielding of the six varieties on trial. Malling Promise and Malling Jewel cropped at more than 3½ tons/acre and Malling Exploit, Malling Enterprise and Norfolk Giant at between 2½ and 3 tons.

The present strawberry trial, planted in spring 1958, contains the British varieties Merton Princess, Royal Sovereign, Cambridge Rearguard, Cambridge Vigour, Talisman and Redgauntlet and the German varieties Senga Sengana and Senga 54. Most of the varieties grew well during the year, but Royal Sovereign was disappointing in vigour and several plants of Senga 54 were affected by the soil-borne tomato black ring virus, apparently as a result of being propagated on infective soil in 1957.

Nine of the 16 varieties in the black currant trial gave heavier crops than in 1957: all these were varieties in the early and mid-season ripening groups, which probably suffered least from the late and difficult picking season. Thirteen more bushes were removed on showing symptoms of reversion disease, and all the varieties became badly attacked by leaf spot (*Pseudopeziza Ribis*) in late summer. This trial was concluded at the end of the season. During its six cropping years it provided valuable experience of the difficulties of black currant growing in eastern Scotland, as well as much of the stimulus for the breeding work now in progress with this crop.

The 1954 plum variety trial of this series made satisfactory progress but has not yet started to crop. (M. M. Anderson, W. Fordyce, J. P. Sutherland, B. Tulloch, M. J. Martin.)

MISCELLANEOUS

The co-operative experiment on the control of bacterial canker disease of plums, described in the last Report, was continued. Maiden trees of the variety Victoria on Myrobolan B rootstock received protective paint treatments in the nursery and are due to be planted out as 2-year-old trees in the winter 1959/60.

Work was continued in co-operation with the Chemistry Department of the Edinburgh and East of Scotland College of Agriculture on the recording and analysis of waste cane material removed from raspberry plantations during routine seasonal operations. The same department also chemically

analysed leaf samples from the main experiment in progress on raspberry manuring.

Raspberries, strawberries, black and red currants, blackberries, apples and plums were supplied to the Ministry of Agriculture, Fisheries and Food's Experimental Factory at Aberdeen, mainly for dehydration tests and determinations of ascorbic acid content. Raspberries and strawberries were also sent to the laboratory of the British Food Manufacturing Industries Research Association, Leatherhead, Surrey, for jam-making and spray residue tests.

PUBLICATIONS

WOOD, C. A. (1958). Experiments on Raspberry Growing. *Farming Post* (Dublin), **8**, 169.

(This article, based on a paper read at a Conference of The Agricultural Association of Ireland, at Bray, Co. Wicklow, discusses raspberry varieties and breeding, the production of healthy nursery stock and experimental work on the management of raspberry fruiting plantations.)

WOOD, C. A., FORDYCE, W. & SUTHERLAND, J. P. (1959). The Performance of Apple Varieties at Mylnefield in 1958. *J. R. Caledonian hort. Soc.*, 1958, 13.

(Information is given on the apple varieties which coloured and matured best in 1958. The history and present cultural treatment of the older trials at Mylnefield are briefly described.)

WOOD, C. A. (MCINTYRE, W. & HALL, J. W.) (1959). Raspberry Cultivation (Advisory Leaflet No. 14 of the Department of Agriculture for Scotland). H.M. Stationery Office. Price 1/6.

(This is a further revised, illustrated edition of the leaflet first published in 1949. Prepared in collaboration with Mr W. McIntyre, Essendy House, Blairgowrie, Perthshire, and Mr J. W. Hall, O.B.E., Senior Horticultural Inspector of the Department of Agriculture for Scotland, it covers the main practical aspects of commercial raspberry production, including the control of insect pests, and briefly describes the Department's official Stock Inspection and Certification Scheme for raspberries.)

WOOD, C. A. & SUTHERLAND, J. P. (1959). Preliminary trials of weedkillers in raspberry cane nurseries. *Proc. 4th Brit. Weed Control Conf.*, 1958. (In press.)

(Trials conducted in 1955-58 gave promising results from the use of propham, 2,4-DES, simazin, monuron and diuron, all of which, used strictly as pre-emergence herbicides, caused no observed injury to the raspberry cane crop. Propham and 2,4-DES, controlling (among other species) *Stellaria media* and *Senecio vulgaris* respectively, formed a useful mixture. CIPC seriously damaged raspberry canes and TCA caused distortion and chlorosis of the foliage.)

WOOD, C. A. & TULLOCH, BARBARA (1959). The Cultivation of Blackberries and Loganberries in Scotland. *Scot. Agric.*, **39**, 28.

(A small trial planted in 1952 gave information on the cropping of blackberries and loganberries and on their seasons of ripening in relation to the raspberry season. Among blackberry varieties, Ashton Cross cropped heavily and Himalayan Giant moderately. Two loganberry stocks (one thornless) grew and cropped poorly. Although the ripening seasons of raspberry (Lloyd George) and loganberry overlapped, the raspberry was always the first to reach the peak of its yield. The blackberries were much later than the loganberries, and in some years continued to crop until late October. The commercial importance of these fruits is briefly discussed.)

VEGETABLE CULTURE

C. NORTH

The unusually cold spell of weather at Mylnefield during June and July 1958 had an adverse effect on some of the vegetable crops. It delayed the development of those kinds which require a long growing season, such as Brussels sprouts, and thus led to poor yields, and it caused more premature bolting than usual in root crops.

VARIETY TRIALS

Dwarf French Beans

As in previous cold seasons, Masterpiece and Record were more productive than any of the other varieties tested in the yield trial, and Saxa yielded nearly as well. The variety Mangetout nain extra-hâtif, which was included in the trial for the first time, yielded so poorly that it will not be retested.

Eighty-three varieties, including for the first time some from Japan, Latvia, Lithuania and Hungary, were grown in observation plots. Most of them, including Early Blue Lake, the variety usually grown in England for quick-freezing, matured too late to be of any value for general cultivation in Scotland. However, the following varieties which formed stringless pods and matured early were selected for further trial: Prelude (Sluis Bros., Holland); Top Crop and Top Most (Asgrow, U.S.A.); Párathan Viasz, Korischnevaja, Slavia (Czechoslovak Academy of Agricultural Sciences). The last of these formed extremely long pods which were of rather coarse appearance but nevertheless completely stringless.

Broad Beans

Forty-three varieties were tested in yield trials at Mylnefield and at Aberdeen on the Craibstone estate of the North of Scotland College of Agriculture. The plants made very lush growth during the wet summer weather and many lodged. Therefore, the crop could not be harvested without damaging the plants and both trials were picked only once instead of twice as in previous years.

Masterpiece (Cullen), with dark green seeds, and Bunyard's Exhibition (Finney), Extra Lange Afhangers (Rijk Zwaan) all with pale green seeds again gave the highest yields of shelled beans, both at Mylnefield and Craibstone.

In addition to three strains of Three-fold White, the varieties, Lux (A. R. Zwaan), Sugar and Three-fold Long-podded (Sharpe), gave negative results with the leuco-anthocyanin test and are therefore suitable for canning.

In October 1958, seeds of 25 varieties, selected for productivity and suitability for canning, were sown along with five varieties of winter field beans obtained from the National Institute of Agricultural Botany. None of the broad bean, but some of the field bean seedlings survived the winter.

Peas

Sugar peas were again grown in observation plots. The most outstanding of the 10 varieties was again Dvärg Sabel (Olson), which produced early-maturing, dwarf and compact plants with no tendrils. The climbing variety Furst Bismark (Daehnfeldt) also matured early and produced good-flavoured pods.

The field pea variety, Karlik Zelonnij from the Latvian University at Riga produced three or more pods on a stem and has been seeded for further examination.

Brussels Sprouts

The low yields from this crop resulting from the unusually cool summer weather were further decreased by severe frost damage in January 1959 which caused most of the crop harvested in the new year to be unmarketable.

Brussels sprout plants were also damaged by an exceptionally heavy attack of diamond-back moth, *Plutella maculipennis*. However, by spraying with methyldemeton and DDT most of the larvae were killed and the plants were not severely damaged.

The Engineering Department of the M.A.F.F. Research Establishment, Aberdeen, kindly constructed an improved pressure-tester for Brussels sprouts, based on the prototype designed, built and used at Mylnefield in 1957. Through the use of this new machine it has been possible to demonstrate significant differences in sprout firmness between varieties grown in the yield trials.

The best yields of medium to large sprouts were given by Irish Elegance and The Cluseed. The first of these is a new variety bred by Professor G. O. Sherrard of Dublin University and is not yet in commerce. Cambridge Special, Sanda and the Swiss variety Marché de Berne (Vatter), not tested before, gave the highest yields of sprouts small enough for quick-freezing. In tests made by Smedley's, Ltd., Sanda and Irish Glacier gave the best results. The colour of quick-frozen sprouts of Marché de Berne was also very good but this variety produced a fairly high proportion of rotted sprouts.

Fifteen varieties were grown in observation plots. Plants of the new Japanese F_1 hybrid strain, Jade Cross (Takii), were very uniform and early-maturing and had tall strong stems. However, most of the lower sprouts were open and there was a high proportion of unmarketable waste. The two varieties Prominent (Rijk Zwaan) and Danish Giant (Ohlsens Enke) were selected for further trial.

Cabbage

Observation plots of 120 strains of cabbage were grown. As in 1956 and 1957, the Ditmarsh types matured first, in particular the strains Ditmarsh Extra Early (Sharpe), Syston Earlihead (Hurst), Primo (Sharpe), Forehead (Hurst) and First Crop (Ohlsens Enke). The Japanese variety, Toyoda Gokuwase from Shizuoka Experimental Station also matured very early; the plants formed small flattened heads and had dark green, coarsely savoyed leaves.

Of the varieties which matured in late September to October, two Japanese

F_1 hybrid strains were outstanding for uniformity and quality of the heads. These were, N-S Cross (Takii) with slightly flattened heads and slightly savoyed leaves, and DD x KN (Shizuoka Experimental Station) with very firm heads of the Amager type.

In view of the promising results with storing cabbage in 1958-1959 a trial of five varieties of the Amager type was conducted. The heads were harvested 12th November, 1958, half were stored in a barn and half were clamped in the field. At the end of February 1959, most of the heads were in good marketable condition, especially those from the clamp. The weights of stored heads after trimming, expressed as percentages of the weights of heads put into store during November, were 56-67 and 18-43 respectively for clamp and barn storage. Individual trimmed heads weighed 8-12 lb. Although the heads of most varieties became white after storing, those of Amager Vintergroen (Ohlsens Enke) retained some green colour.

Broccoli

Most of the plants raised from seed sown in the spring of 1957 were killed in the following winter and only 50% of the plants of the hardiest strains survived to form curds in May 1958.

In the yield trial, six selections of Royal Oak were tested and two yielded significantly more marketable and first-grade curds than the control variety St. George. Plants of four strains of Late Roscoff grown in observation plots were all killed by frost, and very few plants of other strains, including Cambridge Hardy Late, survived.

Calabresse

In view of the interest in calabresse as a crop for quick-freezing, eight varieties were compared in a yield trial. This vegetable had a very long harvest season; plants which were first picked on 8th July were still productive in mid-November. However, most of the shoots picked late in the season were very thin and unlikely to have been of any value for processing. A strain from Ohlsens Enke gave the highest total yield but it formed marketable shoots three weeks later than the earliest-maturing varieties.

Spinach

Seventeen strains were compared, in observation plots, with Verina which gave the best results at Mylnefield during the previous three years. Of new varieties, Noordland (A. R. Zwaan) bolted about the same time as Verina; Elsoms 23 (Elsom) and Noorman Improved (Jacob Jong) a few days later. All were more suitable for processing than Verina because their leaves were darker green and held more upright. Plants of Loreley (A. R. Zwaan) bolted a few days earlier than Verina and had thick, very dark green leaves similar to those of the variety Troubadour already tested at Mylnefield. Six Japanese varieties were unsuited to Scottish climatic conditions because they ran to seed when the plants were still small.

Celeriac and Leaf Celery

Most plants of nearly all the 18 varieties of celeriac tested bolted without forming roots of marketable size. This was probably because of the abnor-

mally cool summer weather and the early planting of the trial. Seed was sown 7th March and the seedlings transplanted in the open on 8th May as compared with 15th March and 27th May in 1957. However, these conditions provided a useful opportunity for selecting those strains less prone to premature bolting.

Comparatively few of the plants of Invictus (Dippe), Imperator (Weibull) and Globus (Vatter) bolted, and as in 1957, the first of these gave the highest yield of marketable roots.

The third and final cut of the leaf celery trial sown in 1957 was made in June 1958. Although the variety Gewone Grove Snij had given the highest yields in 1957, it was killed during the winter. The differences between the total yields of the four varieties tested was not significant.

A second trial of leaf celery was sown in 1958 and included two varieties previously untested. One of the strains, Soup Celery (Hurst) bolted whilst still in the seedling stage and will not be retested.

Parsnip-rooted Parsley

The roots of most varieties were less fangy than in 1957 but Lange Glatte again produced very coarse fangy roots and many of the plants of this variety bolted. The varieties Tyk Sukker (Ostergaard), Berliner (Daehnfeldt) and Halblange (Dippe) gave high yields of roots of good quality.

Carrot

For the first time, a yield trial of carrots was grown at Mylnefield. Twenty-three varieties were compared. The seed was sown with a precision band-seeder lent by the Scottish Plant Breeding Station. In order to sow equal numbers of viable seeds of each variety, sowing rates were adjusted according to unit seed weights and the laboratory germination percentages provided by the Scottish Seed Testing Station. The crop was sprayed with a mixture of a refined mineral oil preparation and dieldrin, to control weeds and carrot root fly respectively.

The yield of roots lifted in October was good, but a high proportion of the roots of some varieties were split. Flakee types yielded best although the roots were of poor colour. Chantenay types gave good yields of well-coloured roots although most strains showed a distinct tendency to bolting. Intermediate types produced good yields of roots of rather variable colour. Nantes types gave rather low yields of pale-coloured, small-cored roots which were mostly well-flavoured. Amsterdam types yielded poorly but the roots were well-coloured and had small cores. Taking quality and yield into consideration the best strains were the intermediate types Regulus II (Weibull) and Supreme Half Long (Ferry Morse).

Of 27 varieties tested in observation plots, several strains tended to bolt excessively. The strains Chantenay from Osaka University, Japan and Himerouge (Godineau) were selected for further trial, because few plants bolted and all produced well-coloured roots.

Beetroot

Two new Danish varieties of beetroot which produce more or less cylindrical roots were compared with Detroit Globe, the standard canning variety.

The yield from Bloodred Cylinder (Daehnfeldt), now to be called Forma Nova, was more than double that of Detroit Globe and the roots were equally as dark-coloured: the plants were also less prone to bolting. A canning test made by W. A. Baxter & Sons, Ltd. with Bloodred Cylinder showed that there was less wastage from trimming and slicing in the factory and the canned product was of as good quality as that from Detroit Globe.

Leek

Twenty-one strains of leeks were sown outdoors on 26th March 1958 for a yield trial and harvested towards the end of February 1959. The variety Giant (Cullen) yielded significantly more than any other variety but Genne-villiers Improved (Ohlsens Enke), Elefant (Daehnfeldt), Dubouchet (Vatter) and strains of Musselburgh from Finney, Alexander and Brown, and Sutton also yielded well. Standard (Sharpe), Siegfried (Daehnfeldt) and Leicester Hero (Harrison) were the only varieties with very dark green leaves which yielded more than the average.

Géant de Bulgarie (Vatter) grew to twice the length of any of the other varieties tested but it gave a low yield, mainly because, having been bred for summer use, it was severely damaged by winter frosts.

Winter Lettuce

Thirteen strains of winter lettuce were sown in the autumn of 1957. Stanstead Park types proved to be the hardiest but most plants of Imperial and Arctic King types survived the winter. Plants of Winter Density and Tro-cadero strains were all killed by frost.

Heads of the Imperial type were larger and of better quality than any of the other types and remained longer in a marketable condition. The most productive strains were Imperial (Tozer) and Winter Pearl (Dickson, Belfast).

Miscellaneous Vegetables

Fourteen varieties of so-called Chinese cabbage were tested. Most of the plants ran to seed at an early stage of growth. The following gave satis-factory crops: Wong Bok (Roberts), a flat cabbage lettuce-like type; Pak Choy (Roberts) and Oosaka Shirona (Osaka University) both seakale beet-like types, the former dwarf and very dark leaved; Nozaki Tetraploid (Osaka), Hamuraki (Osaka) which resembled a Webb's Wonderful lettuce; Okute Mizuna (Osaka) a type with very finely divided leaves and no distinct head.

Of 36 ridge cucumber varieties which were tested, plants of only four survived to give a reasonable crop. These were Prolific (Sutton), Perfection Ridge (Nutting), Vert Long Marâicher (Vilmorin) and Morecrop (Canada Department of Agriculture).

A number of uncommon vegetables were tested and the following grew well: burdock root (variety Akakuki Takinogawa from Osaka University, Japan), Chinese artichoke, Florence fennel (variety Früher Sommer from Vatter, Switzerland), orach (variety Blonde from Vilmorin, France), patience dock, salsify, scorzonera (especially the variety Russian Giant) and sorrel (variety Épinard, Vilmorin). (C. North, L. H. Frith, H. Taylor).

CULTURAL EXPERIMENTS WITH BRUSSELS SPROUT

It is common practice in Scotland to sow Brussels sprouts outdoors in September, overwinter the plants in the seedbed and transplant them the following spring. An experiment was therefore made to compare the yield and sprout-quality of plants of five varieties sown both in autumn and spring. The varieties used were Cluseed, Evesham Special, Masterman, Sanda and Unicum and plants of all survived the winter with very little frost damage. A number of transplants of Unicum, Cluseed and Evesham Special bolted, but most of them subsequently gave a crop of sprouts. None of the plants of Sanda bolted.

In October 1958 autumn-sown plants of all varieties yielded significantly more and produced larger, firmer and paler-coloured sprouts than those sown in spring. (C. North).

PLANT BREEDING

Brussels Sprout

An experiment to find if progeny testing for yield is in fact advantageous was begun. Plants selected from high and low yielding F_2 families in 1957 were self pollinated in spring 1958. The resulting F_3 progenies will be compared in a yield trial in 1959.

Ramets taken from male-sterile plants in spring 1957 flowered in the glasshouse in 1958 and were pollinated in various combinations so that the inheritance of male sterility could be studied. After flowering, the plants were induced to form vegetative shoots for cuttings by keeping them at a high temperature. The clones differed greatly in productivity of vegetative shoots.

Forty lines of breeding material, including F_2, F_3 and sib-crossed progenies, were compared in yield trials. They were also examined for uniformity and the firmness, colour, general appearance and internal browning of the sprouts. One of the lines, which originated from hybridisation between the three varieties, Ashwells, Amager and Cambridge Special, was outstanding for its high yield of large dark-green sprouts.

Cabbage

Plants selected from lines originating from Danish Keeping × January King and January King × Ormskirk Savoy were self-pollinated and sib-crossed in the glasshouse in spring 1958. White-flowered plants from a cabbage × broccoli cross were back-crossed to cabbage. The seed from these pollinations will be grown in the field in 1959.

Thirty-one lines, originating from Blåtopp × Christmas Drumhead, were grown in a randomised block layout to compare the progeny from selfed and sib-crossed plants. Clones of the parent plants were maintained so that pollinations which had given the best progenies could be repeated.

Lines originating from (1) Amager × January King subsequently back-crossed to January King and (2) January King × Slow Bolting I.M.2 were grown in the field. The first contained some promising late-maturing material and the second was outstanding for its uniform, good-quality heads which matured about the same time as Christmas Drumhead. (G. Priestley, C. North.)

French Beans

Lines derived from 108 single-plant selections of the F_4 generation of Double Princess × Record were grown in the field. They were examined for uniformity and yield and quality of the pods and 118 plants were selected from 18 of the best lines for testing in 1959.

Material from the cross Refugee × Record, which was very promising in the previous season, grew poorly during the rather cold summer of 1958. Only four of the 30 lines were considered worth further selection.

Lines derived from 87 single-plant selections of the F_3 generation of Fullcrop × Record were more vigorous and uniform than the Double Princess × Record hybrids but the quality of the pods was mostly inferior; however 111 plants were selected from 16 of the best lines.

Stocks of the F_1 generation from Record × Contender and Record × Ženevská Trzní were increased by plants grown in the glasshouse, and new crosses made between the dwarf varieties Double Princess and Refugee and the climbing variety Early Blue Lake.

Interspecific hybrid beans

One hundred and twenty-one single plant progeny lines originating from *Phaseolus vulgaris* × *P. coccineus* were grown in the field. Growth was generally rather poor, but a few individual plants were exceptionally vigorous and were selected for further testing. Some of the more promising lines, which are now breeding true, were bulked for further trials. The hybrid strains combine the true dwarf habit of the French bean with a pod flavour approaching that of the Scarlet Runner bean.

Other interspecific hybrids, in which the variety Tschermak multigaris, (obtained from the research station of the Czechoslovak Academy of Agricultural Sciences at Olomouc) was used as a parent, were grown in the glasshouse. Sufficient seed of this material was produced for field testing in 1959. (G. Priestley.)

VEGETABLES FOR DEHYDRATION EXPERIMENTS

One acre of peas of four varieties, and crops of broad beans and French beans were grown at Mylnefield for dehydration experiments at the Ministry of Agriculture Fisheries & Food's Experimental Factory at Aberdeen. Small quantities of leaf celery, cabbage and Brussels sprouts from the variety trials were also sent there for experimental work. (L. H. Frith in collaboration with L. S. Gray.)

PUBLICATIONS

NORTH, C. (1958). Vegetable varieties for Scotland. *The Grower* **49**, 1197.
(An account of the variety trials at Mylnefield.)

NORTH, C. (1959). Relationship between leaf shape and head formation in cabbage (*Brassica oleracea L. var. capitata*). *Proc. 15th Int. Hort. Congress, Nice, 1958.* (In press.)

(The leaves of non-heading rogue plants of January King cabbage were found to be narrower than those of headed plants sampled from the same crop. This led to an examination of the shape of the leaves of five varieties, and a negative correlation was discovered between the length-width ratio of the 7th-12th oldest leaves of a variety

and the time needed to form and head. A trial of 33 varieties showed that it may be possible to forecast varietal rates of maturation from measurements of the 7th leaf made at transplanting time.)

NORTH, C. & FRITH, L. H. (1958). Variety trials of vegetables in Scotland IV. Summer spinach at Invergowrie 1956-1957. *Rept. Scottish hort. Res. Inst.* 1957-58, 48.

(In a second series of trials with spinach, the comparatively new variety, Verina OJO/53 from Otto J. Olson, Sweden, gave outstandingly good yields. Other highly productive varieties were: King of Denmark strains from Gehlin and Zwaan and de Wiljes, Noorman (Rijk Zwaan), Troubadour (Zwaan and de Wiljes).
Yield of leaf is closely linked with the rate at which plants of a variety bolt. The magnitude of this relationship was such that a delay of one day in bolting, due to varietal characteristics, led to an increase varying from 2.4 cwt./acre in 1955 to 9.3 cwt./acre in 1956.)

NORTH, C. & FRITH, L. H. (1959). An instrument for measuring the firmness of Brussels sprouts. *J. hort. Sci.* **34**, 183.

(A pressure-tester for assessing the firmness of Brussels sprouts is described. It measures the diameter of a sprout before and after compression by a plunger of 1 cm. diameter to which a 2 kg. weight is applied. The diameter of the sprout after compression, expressed as a percentage of that before compression, is a measurement of sprout firmness. The instrument shows significant differences in firmness between varieties and is sufficiently accurate for use in studies of inheritance of, and the effects of climatic and cultural treatments on sprout firmness.)

NORTH, C., FRITH, L. H. & TAYLOR, H. (1958). The assessment of yield in canning-pea varieties in Scotland. *J. hort. Sci.* 33, 237.

(Yield trials of seven varieties of canning peas are described and evidence is given to show that canning peas may ripen more slowly in Scotland than in many parts of England. The stage of maturity was measured by the Alcohol Insoluble Solids Content of the peas and with a texturemeter. It is suggested that this instrument is not sufficiently accurate to determine the harvest dates of canning-pea crops grown under Scottish conditions.)

CROP PHYSIOLOGY

T. SWARBRICK

THE SEASONAL GROWTH OF PLANTS IN RELATION TO LIGHT INTENSITY AND TEMPERATURE

In 1956 and 1957 a series of pot experiments had shown clearly the seasonal pattern of vegetative growth in the sunflower and field bean in relation to light intensity and temperature. The results suggested that light and temperature were the two main environmental factors affecting the vegetative growth of these two species at Mylnefield because a high proportion of the total variation in the relative growth rates, (increase in dry weight per unit of plant dry weight, per unit of time) net assimilation rates (increase in dry weight per unit of leaf area, per unit of time) and leaf area ratios (leaf area/plant dry weight) was accounted for by fluctuations in light intensity and temperature. However this type of experiment in which neither of the factors can be controlled, does not allow a critical assessment of the quantitative effect of either factor alone.

As it is both difficult and expensive to control air temperature under full daylight, experiments were begun in 1958 with *Lemna minor*, an aquatic plant, grown in thermostatically controlled baths constructed for use outdoors.

The essential feature of each bath is a tray 3½ in. deep through which water flows at the required temperature. The speed of flow of the water is adjusted so that there is no appreciable variation in temperature from one end of the tray to the other. The cultures of *Lemna minor*, in containers filled with nutrient solution, stand in this tray. Water leaving the tray enters a large thermostatically controlled reservoir (30 gal.) where it is heated or cooled as required before being re-circulated over the tray.

Cultures of *Lemna minor* placed in the baths in early July were considered to be adapted to the selected temperatures (12.5, 17.5, 22.5 and 27.5°C) by late July. From this time, until early December, 17 consecutive experiments were made at weekly intervals. At the beginning of each experiment five matched samples of *Lemna*, consisting of 134 fronds, were selected from the cultures in each bath. One of these samples was immediately harvested, the fronds were photographed and then dried *in vacuo* at 50°C. The area of the fronds was determined later, from an enlarged photograph, by means of a planimeter. At the end of the period the four remaining samples were treated similarly and the assimilation and growth rates and the leaf area ratios were calculated. The data are as yet insufficient to warrant a detailed statistical analysis and the series will be continued during 1959. (G. L. Hodgson.)

THE PHYSIOLOGY OF GROWTH OF THE STRAWBERRY PLANT

Effect of Photoperiod

More evidence on the transmission of the growth-regulatory hormone detected in strawberry plants was obtained from experiments made in the new

growth cabinets with runner plants joined in pairs as donor-receptor units. The vegetative growth habit of receptor plants was promoted and flower formation inhibited when donor plants were exposed to long days. Receptor plants responded well when grown at a higher temperature than their donors. In these experiments, evidence of promotion of the early stages of runner formation was obtained for the first time. Exposure of donor plants to short days failed to inhibit vegetative growth and promote flowering in receptors exposed to long days, although the conditions appeared to favour translocation from donors to receptors. When receptor plants had no mature leaves, they acquired the habit of growth induced by the treatment given to their donor plants, irrespective of whether this was a long- or short-day treatment.

These results suggest that the photoperiodic regulation of the growth habit of the strawberry is controlled by a hormone which promotes vegetative growth and inhibits flowering, and which is transported from the leaves to meristematic and growing areas, probably in the solute stream. This idea is contrary to the widely accepted one that flowering in higher plants is controlled by a positive, flower-inducing hormone. Defoliation experiments, reported below, also support this idea since the results show that removal of mature leaves promotes the formation of flower trusses, as would be expected if the source of inhibitor was removed by defoliation. The explanation is also plausible because the action of the hypothetical growth regulator is closely paralleled by that of gibberellic acid, (see below) a substance which has been isolated from plant tissues.

Transmission of Growth Regulators and Radioactive Isotopes

The translocation of radioactive isotopes applied to the leaves has again been studied, as their movement within the plant appears to parallel the movement of natural growth regulators. Carbon^{14}, applied in urea, moved freely from mature leaves into growing regions of root and shoot including emerging and unfolding leaves. No export of C^{14} from immature leaves was detected, however.

Effect of Leaf Maturity on Flowering

Intact plants were compared with plants defoliated in one of two ways. Either all mature leaves were removed leaving only the two youngest leaves on each plant, or all young leaves were removed as they unfolded, leaving only three fully mature leaves per plant. The plants were transferred from long-day conditions in the glasshouse into a 12 hr. photoperiod in growth cabinets at 60°F. They were then either left intact or treated in one of the ways described above. Plants were removed from the cabinets after varying numbers of short-day cycles and returned to long-day conditions in the glasshouse. A fortnight or three weeks later they were dissected to determine the effects of the treatments on flower initiation during exposure to the 12 hr. photoperiod.

In two experiments, intact plants exposed for 16 days initiated flowers, but plants which had only mature leaves formed none even after 22 days, the longest exposure given. Plants with only immature leaves initiated flowers after exposures of 16 and 12 days. These results are in agreement with

experiments reported in 1958. Then it was found that plants, on which three mature leaves were left, initiated flowers much later than intact plants, but the delay in flower initiation was considerably reduced by the presence of one emergent leaf. Plants on which only the youngest leaf was retained initiated flowers at about the same time as intact plants.

This suggests that the decisive factor in flower initiation is the presence of young, immature leaves; such leaves acting either as a source of some flower-promoting substance or as a "sink" for an inhibitor formed in the mature leaves. Experiments with radioactive C^{14} in urea, reported above, have demonstrated that there is little or no translocation of radioactive materials from immature leaves but that translocation into these leaves occurs when C^{14} is applied to mature leaves. A hormone, which promotes vegetative growth and inhibits flowering, has been demonstrated in the strawberry under long days, as described above, and it is suggested that under borderline conditions competition for this hormone by the young leaves may result in the concentration falling at the growing point to a level at which flower initiation is no longer inhibited.

In commercial practice, defoliation may result in substantial increases in yield of fruit. Repeated experiments have shown that defoliation consistently results in an increase in the number of inflorescences produced the following spring. In 1958, three-year-old Talisman and Redgauntlet plants defoliated on both 3rd and 13th August, 1957 produced 13 and 23 oz. of sound fruit per plant respectively, compared with yields of 8 and 15 oz. from plants of these varieties cleaned in the usual way. These increases in marketable fruit were obtained in spite of losses amounting to 43% for Talisman and 18% for Redgauntlet, mainly because of *Botrytis* infection. Defoliation on 23rd August had much less effect and post-harvest defoliation in early August is recommended for Talisman and Redgauntlet in Scotland. (C. G. Guttridge, P. A. Thompson.)

Effects of Growth Substances

GIBBERELLIC ACID

When applied to Talisman strawberry plants in the glasshouse in autumn, gibberellic acid inhibited the formation of flower trusses and promoted the formation of runners, thus simulating the effect of exposure to long day-lengths. Aqueous sprays, containing 12.5, 25, 50 or 100 ppm. gibberellic acid applied fortnightly, increased petiole length, although only the two highest concentrations promoted flowering and inhibited runner formation. The runners did not grow out until the plants were transferred to a lighter and warmer glasshouse. As daylength was subsequently without effect on the emergence of runners, their failure to develop may have been due to unfavourable growing conditions and not to gibberellic acid acting as only a partial substitute for long days. As well as these recognised photoperiodic effects, gibberellic acid also caused elongation of the main stem, and plants receiving high concentrations completely lost the rosette habit of growth. In other experiments, plants given a single application of 3 mg. gibberellic acid produced internodes up to 35 cm. in length. When the effect of treatment diminished and internodes again shortened, roots emerged from the stem near the leaf bases

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CORRECTION

On page 30, in paragraph headed "GIBBERELLIC ACID", line 6 should read "highest concentrations promoted runnering and inhibited flower formation".

as they do from the base of a runner plant after elongation of the stolon has ceased. Gibberellic acid also greatly increased the length of the stems of flower trusses which grew out during treatment. Plants which were dormant as a result of growing in the natural short days in autumn grew away vigorously when treated with gibberellic acid in short days. In this instance gibberellic acid appears to be acting as a substitute for chilling.

The physiology of these responses and especially the relationship between gibberellic acid and the hypothetical natural hormone discussed above promises to be a fascinating and profitable field of research. (P. A. Thompson, C. G. Guttridge.)

CELL LENGTHS IN LEAF PETIOLES

Measurements were made of the lengths of epidermal cells of leaf petioles taken from plants growing in long and short days, at two different light intensities and treated or untreated with gibberellic acid. Sixty cells were measured at each of nine equally spaced positions on each petiole and the means used to estimate the total number of cells per petiole. Long days, low light intensity and gibberellic acid all increased petiole length and both the length and number of cells. Gibberellic acid increased cell length and number about equally, whereas daylength increased cell length more than cell number.

MALEIC HYDRAZIDE

On 8th July, maiden plants of Talisman and Redgauntlet were treated with 500, 1,000, 2,000 or 3,000 ppm. of maleic hydrazide using the triethanolamine salt. A proportion of plants was treated a second time on either 12th August or 1st September with maleic hydrazide at a concentration of 1,000 ppm. Two control treatments consisted of plants from which all runners were removed at fortnightly intervals and others from which no runners were removed at any time. At the time of the first application, one or two runners on each plant were on the point of rooting. These runners were not prevented from rooting and sending out further secondary runners except at 3,000 ppm., which also damaged the parent plant. At 2,000 ppm. the majority of primary runners emerging from the plant after treatment were prevented from developing. Most of the runners present at the end of the season originated from the plants rooted before 8th July. A concentration of 1,000 ppm. considerably reduced the production of primary runners and it seems likely that adequate control of runners throughout the season could be achieved by spraying twice, at the appropriate times, with this concentration. At 2,000 ppm. and 3,000 ppm. the parent plants showed signs of toxicity; this was particularly severe in Talisman. Leaves remained chlorotic for about six weeks and the plants became stunted. By the end of the season all treated plants, except for those treated at the 3,000 ppm. level, were more vigorous than the controls from which no runners had been removed, but less vigorous than the controls which had been derunnered at fortnightly intervals. It is not yet known what effect these treatments will have on the cropping of the plants.

Experiments with plants in pots in the glasshouse confirm that the inhibitory effects of maleic hydrazide are dependent on the stage of development of the runner. An application of 1 mg. to the parent plant inhibited 90% of

runners which had only elongated one internode but less than 50% of those with two elongated internodes. It failed to inhibit any runners which had started to unfold leaves, even though they had not rooted. Un-emerged runners were particularly sensitive to inhibition and a number of branch crowns arose from sites which, if untreated, would have formed runners. This emphasises the importance of spraying in the field whilst the runners are still very young. Other experiments in the glasshouse were done to investigate the range of tolerance to maleic hydrazide, the pattern of recovery following doses of up to 10 mg. per plant, and the effect of maleic hydrazide on the initiation and development of flowers and leaves. (P. A. Thompson.)

Cold Storage of Runner Plants

Runner plants of Redgauntlet cold stored from February 1957 until planting on 1st July, 1957 yielded over 10 oz. per plant of sound fruit in 1958, which, at the 3 ft. × 1 ft. spacing, is equivalent to over 4 tons/acre. Planting three weeks later reduced the yield to 6 oz. per plant. Fresh runners were not available until 23rd July and then only in small numbers. Planted on this date they yielded nearly 12 oz. per plant in 1958. Plantings of fresh material on 12th August and 2nd September yielded only 4½ oz. and 1½ oz. per plant, respectively. The smaller yields of the later plantings were partly due to an increase in the number of barren plants. An average of less than 5% rotted fruit was recorded, a low figure considering the prevalence of *Botrytis* this year.

Cold storage seems to be a satisfactory way of providing runners for early planting in Scotland, where fresh plants are not freely available until August. The advantages of early planting are clearly demonstrated. In an earlier experiment, runners of Talisman and Redgauntlet kept in store until May and June, 1956 were compared with fresh runners planted in April that year. In 1957, the yields from the three lots of Talisman were 5.1, 4.9 and 3.6 tons/acre from the April, May and June plantings respectively; those from Redgauntlet were a little higher. Yields from the same plots were lower in 1958 but the accumulated yields from each planting were nearly equal: respectively these were 8.2, 8.0 and 8.0 tons/acre from Talisman and 10.5, 9.7 and 9.6 tons/acre from Redgauntlet. A new and better cold store is now being used for this work. (C. G. Guttridge.)

PUBLICATIONS

General Papers

GUTTRIDGE, C. G. (1958). Photoperiodism in strawberries. *The Grower*, **49**, 806.

GUTTRIDGE, C. G. (1958). The use of controlled environment chambers to investigate the physiology of the strawberry. British Association Meeting, Sect. M., Glasgow, Sept. 1958. (Abstract in *World Science Review* 71, 32.)

Research Papers

GUTTRIDGE, C. G. (1959). Evidence for a flower inhibitor and vegetative growth promoter in the strawberry. *Ann. Bot.*, **23**, 351.

(Adjacent runner plants of the cultivated strawberry, a short-day plant, joined in pairs by the stolons were used as donor/receptor units. Long photoperiods or a light break treatment of the older "parent" plants increased petiole length and leaf size and delayed flower initiation in the younger "daughter" plants, themselves in short photoperiods. The response of daughter plants was increased by illuminating parent plants

with full daylight three hours earlier each morning than the daughter plants. Parent plants in short days did not respond when daughter plants were given light break treatment, indicating that daughter plants failed to function as donors. Translocation experiments with foliar application of P^{32} showed that the accumulation of P^{32} in receptor plants and their response to long-day treatment of donors were both increased by factors which appear to favour translocation of assimilates from donor to receptor. These results are submitted as evidence for a growth-regulating hormone in strawberry which promotes vegetative growth and inhibits flower initiation.)

GUTTRIDGE, C. G. & THOMPSON, P. A. (1959). Effect of gibberellic acid on length and number of epidermal cells in petioles of strawberry. *Nature, Lond.* **183,** 197.

(Weekly applications of gibberellic acid to strawberry plants at the rate of 8 μg./plant increased petiole length by 35.6% in a light intensity of about 1,200 f.c., and by 13.3% in a lower intensity of about 800 f.c. in growth cabinets. These increases resulted from increases in both number and length of epidermal cells.)

THOMPSON, P. A. & GUTTRIDGE, C. G. (1959). The effect of gibberellic acid on the initiation of flowers and runners in the strawberry. *Nature, Lond.* **184,** B.A. 72.

(Runner formation was induced, flower initiation inhibited and petiole lengths increased when plants growing in natural short days in autumn in the glasshouse were sprayed fortnightly with gibberellic acid in aqueous solution at concentrations of 12.5, 25, 50 and 100 ppm. Flower formation was completely inhibited by the two higher concentrations. In addition to these responses, which are typical of the growth habit of the strawberry in long days, stem elongation occurred mainly at the two higher concentrations. Although they may be similar, it appears that gibberellic acid and the natural vegetative growth promoting hormone are not one and the same.)

GUTTRIDGE, C. G. (1959). Further evidence for a growth promoting and flower inhibiting hormone in strawberry. *Ann. Bot.* **23.** (In press.)

(Further experiments with runner plants of the cultivated strawberry joined in pairs as donor-receptor units are reported. Long-day treatment of donor plants again increased petiole length and inhibited flower induction in receptor plants exposed to short days. For the first time the stimulus was transmitted in amounts sufficient to increase significantly the production of runners by receptor plants. These photoperiodic responses were induced by supplementary light of low intensity. It is argued that the photoperiodic responses of the strawberry plant are controlled mainly by a hormone, produced in the leaves and which promotes vegetative growth and inhibits flowering when transmitted to the meristematic shoot apices.)

GENETICS

T. SWARBRICK

SPRING CHLOROSIS OF STRAWBERRY

Among the affected progenies planted in 1956 and 1957 many more plants showed June Yellows in 1958 than in 1957. For example, in a family of 183 seedlings raised by pollinating Huxley with Auchincruive Climax, only two showed June Yellows in 1957, whereas in 1958 the number had increased to 21. There is also a great difference in behaviour between progenies of the same origin raised in different years. Thus in a family of parentage Auchincruive Climax plant 16×Perle de Prague plant 12, raised in 1956, 8% of seedlings were affected in 1957 and 45% in 1958. But when the cross was repeated in 1957, using the same parental plants, 73% of the seedlings showed June Yellows when planted out in the field in 1958.

Auchincruive Climax has been crossed reciprocally with six standard varieties, and 50% of the seedlings raised now show June Yellows. Clear differences between reciprocal progenies in the percentages of affected seedlings can be seen in only one instance.

When plant characters are determined by nuclear genes their expression in the progeny from crosses is independent of the direction in which the crosses are made. On the other hand, characters determined by cytoplasmic factors tend to be inherited only through the maternal parent because the male gametes usually contribute a negligible amount of cytoplasm to the zygote. June Yellows follows neither of these patterns of inheritance: it is transmitted by both male and female parents and behaves in an unpredictable manner.

To find if plants exposed for long periods to high temperature are freed from June Yellows, a plant of Auchincruive Climax showing June Yellows was planted in a propagating pit in a hot-house in September. As is usual under warm conditions the June Yellows symptoms began to disappear within a few weeks. Flowers and stolons were produced and new runner plants were rooted in sequence as they developed. In March all plants were removed from the pit and planted in the field. June Yellows developed in all plants in the following spring, and so far as could be determined, the treatment had in no way affected the expression of the symptoms.

PRODUCTION OF POLYPLOIDS

Interest in the doubling of the chromosome number of horticultural plants is increasing, as this procedure enables fertility to be restored to sterile hybrids which so often arise in the course of breeding work. The usual method of applying colchicine to germinating hybrid seed or to vegetative shoots is laborious and uncertain. Recently a method enabling amphiploids to be produced directly from the newly fertilised egg was described in Sweden. Plants, the flowers of which have been pollinated, are exposed to nitrous oxide, under pressure, at about the time when the first division takes place in

the fertilised egg; this division is suppressed and embryonic development continues at an increased level of ploidy.

Experiments were made at Mylnefield with apparatus constructed from a dental vulcaniser in which plants can safely be subjected to pressures of up to 10 atmospheres of nitrous oxide. Late-flowering raspberry plants set no seed when treated 18 hr. after pollination, but there is now evidence that in at least one species of *Rubus* the first division of the egg cell may occur several days after fertilisation. In a second experiment where plants were subjected to a constant pressure of gas for a constant time at varying intervals after pollination, those treated three and four days after pollination produced seeds.

RIBES CROSSES

Among seedlings from interspecific crosses which germinated in 1958, plants were noticed which, instead of being intermediate in leaf, gland and hair characters, resembled the maternal black currant parent, the variety Baldwin. These might have arisen by accidental self-pollination, seed admixture or apomixis. Strict precautions to guard against the first two occurrences are always taken. Contamination cannot be entirely discounted but seems an unlikely explanation because similar black currant-like seedlings occurred when Baldwin was pollinated with *Ribes alpinum* and red currant (see above p. 11). These crosses will be carefully repeated because apomixis in *Ribes* would have interesting applications to the breeding and genetics of the genus.

CYTOLOGY OF *BRASSICA OLERACEA*

Investigations of polyploid inheritance in the *Brassicae* were begun with a cytological study of meiosis in cabbage and Brussels sprout. A single quadrivalent was found in 57% of cabbage pollen mother cells and in 39% of those of Brussels sprout. The frequency of chiasmata was 1.51 per bivalent in cells when no quadrivalent was present, but dropped to 1.34 per bivalent in cells with a quadrivalent. This decrease is not statistically significant but was seen in nearly every plant examined. The formation of quadrivalents in this material appears to be limited by the low frequency of crossing-over, and this may have some bearing on the problem of secondary association in *Brassica* species. (A. B. Wills.)

VIROLOGY

C. H. CADMAN

SOIL-BORNE VIRUSES

There is now much evidence that viruses of this kind occur widely in soils in Britain and probably also in western Europe and that they are associated with economic diseases in many kinds of crop plants. The soil-borne viruses so far found in Britain fall into three groups, exemplified by tobacco necrosis, tomato black ring and tobacco rattle viruses, which are distinguishable by differences in the physical properties of the viruses. Those of the first two groups have spherical particles and thermal end-points around 75-90° and 60-70°C respectively whereas those of the third group have rod-shaped particles and thermal end-points of 80-85°C. Most of the year's work was concerned with studies on the properties, relationships and mechanism of transmission of viruses of the second and third groups.

Ringspot Viruses

Raspberry ringspot virus, hitherto known only in Britain, was isolated from each of three samples from sweet cherry trees affected by Pfeffinger disease sent from Switzerland by Dr G. Schmid of the Eidgenössische Versuchsanstalt, Wädenswil. Viruses isolated from cherry in Germany by Dr L. Kunze, Institut für gärtnerische Virusforschung, Berlin and in England by Dr A. F. Posnette, East Malling Research Station were also found to be strains of raspberry ringspot virus.

The virus earlier named raspberry yellow dwarf was found to be serologically related to arabis mosaic, a virus described some years ago from Cambridge. It was also isolated from plants of horseradish from Denmark and of elderberry from Perthshire. A virus isolated from cherry by Dr A. F. Posnette also proved to be a strain of arabis mosaic virus.

As with tomato black ring virus, Scottish isolates of both raspberry ringspot and arabis mosaic viruses are more closely related to English isolates of these viruses than to continental ones. (C. H. Cadman.)

Some 12 varieties of strawberry are now known to be susceptible to infection by one or other of the soil-borne ringspot viruses and outbreaks of the diseases these cause were found in most of the important strawberry-growing areas in Britain ranging from Sutherland to Pembroke, Devon and Kent. Glasshouse tests and field observations suggest that varieties differ in the rates at which they become infected. Some varieties seem to resist infection by raspberry ringspot and tomato black ring viruses but it is uncertain whether they are immune.

Lettuce plants from Pembroke which were stunted and chlorotic and had failed to "heart" contained arabis mosaic virus. In glasshouse tests, plants of 20 varieties of lettuce showed symptoms resembling those of lettuce mosaic when infected by arabis mosaic, raspberry ringspot or tomato black ring viruses by mechanical inoculation with infective sap.

Antisera to raspberry ringspot and arabis mosaic viruses were prepared by injecting rabbits with leaf extracts, made with the aid of nicotine, from naturally infected plants of Huxley and Cambridge Favourite strawberry respectively. The titres compared well with those of antisera made by using infective saps from *Petunia hybrida* or *Nicotiana tabacum* although the preparations used for injection contained too little virus to be detectable in precipitation tests. (R. M. Lister.)

Tobacco Rattle Viruses

Viruses of the tobacco-rattle type occur in soils in many parts of Scotland and have been isolated from potato haulms showing stem-mottle disease and from the necrotic areas of spraing-diseased tubers as well as from many species of crop and weed plants. These viruses possess several unusual properties. Viruses isolated from severely diseased potato haulms and tubers were usually transmitted mechanically only with difficulty whereas those from the roots of potato and other crop and weed plants were easily transmitted by mechanical inoculation. All cultures of the second kind that were tested, including one from the Netherlands, were serologically related: however, different cultures, and different samples of the same culture propagated on different occasions, varied in antigenic constitution.

There is now good evidence that both spraing and stem-mottle diseases are caused by viruses of the tobacco-rattle type. In the variety Kerr's Pink these viruses are inefficiently transmitted through the tubers. (C. H. Cadman.)

Mechanism of Transmission

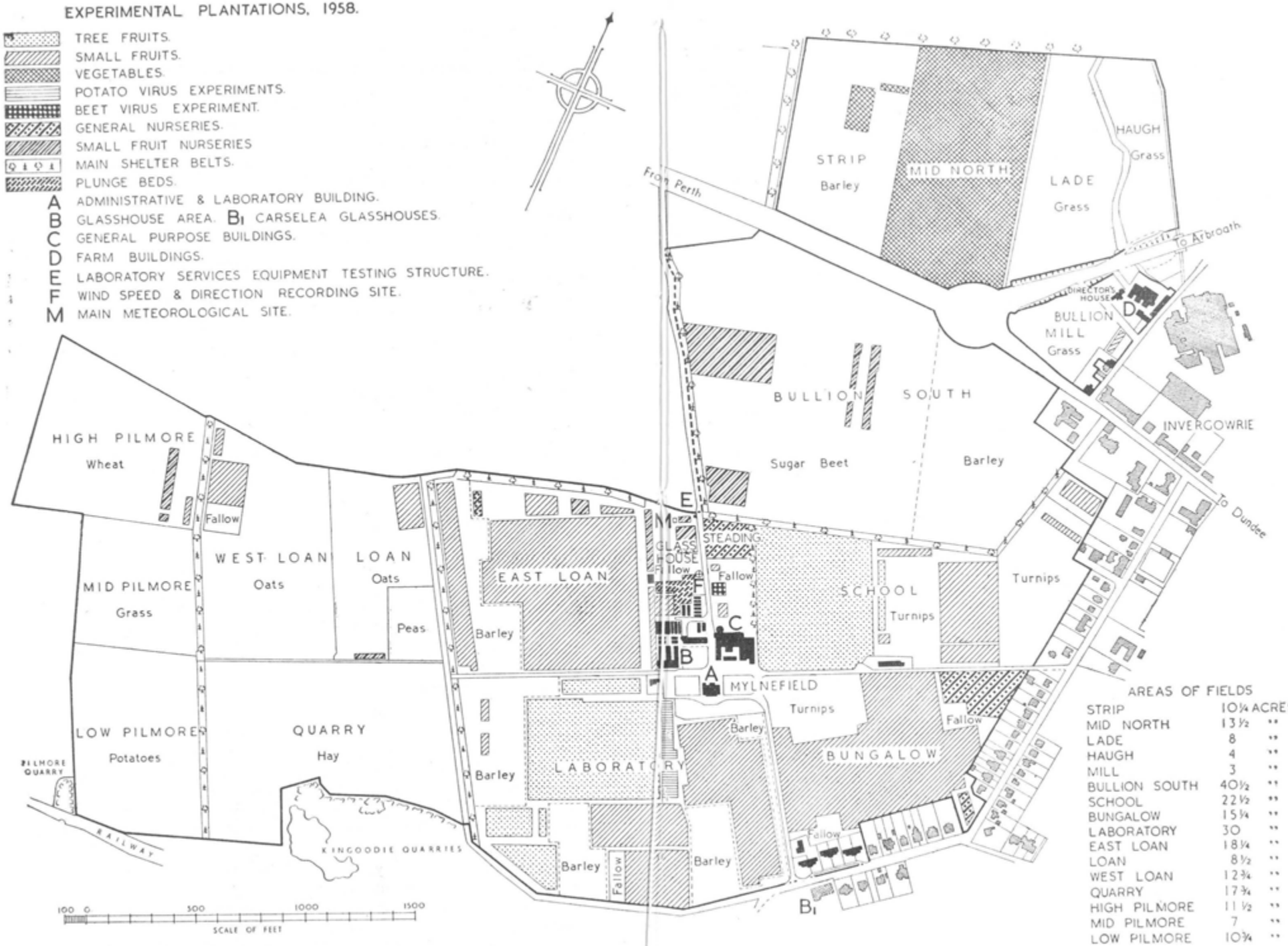
Many experiments were made with soils containing tomato black ring or tobacco rattle viruses to study the pattern of infection in plants, the effects of various treatments on the infectivity of soil and on the introduction of these viruses into soils. Most of the results are most plausibly interpreted as indicating that the transmission process is a biological rather than a mechanical one and that soil-living organisms are associated with it. (C. H. Cadman.)

APHID-BORNE VIRUSES

Spread of Viruses in Strawberry

The results of the field experiment begun in 1957 showed that the strawberry varieties Cambridge Vigour, Redgauntlet, Royal Sovereign, Talisman and an unnamed seedling from Auchincruive (5V322) differed greatly in the rates at which plants became infected by viruses when grown alongside diseased Cambridge Favourite plants. Judged by the frequency of infection, 5V322 was significantly the most susceptible, and Royal Sovereign and Cambridge Vigour were more susceptible than either Talisman or Redgauntlet. Counts made during the year revealed no consistent differences between varieties in extent of colonisation by strawberry aphids.

Exposing successive batches of runnerless *Fragaria vesca* plants to infection by viruses spreading from diseased Cambridge Favourite plants again showed that far more spread of aphid-borne viruses occurred in September and particularly in October than in the months of April to August inclusive. (R. M. Lister.)



SCOTTISH HORTICULTURAL RESEARCH INSTITUTE
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DEPARTMENT OF AGRICULTURE FOR SCOTLAND,
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Virus-free Raspberry Stocks

Because the nurseries planted in 1956 suffered severely from damage by summer gales they produced too few canes for distribution in 1957. They were therefore grown on for another season and received a Special Stock Cane certificate in 1958.

Material propagated in 1957 by the technique described in the last Report gave an outstanding performance in the field. The nurseries of Malling Jewel and Lloyd George in particular produced canes of a height and uniformly high quality never before seen, and information on the cropping capacity of these stocks is eagerly awaited.

The 1957 material received an Elite certificate and, by arrangement with the Department of Agriculture for Scotland, canes from the 1956 and 1957 stocks were distributed to commercial growers during the winter. To distinguish them from earlier stocks the virus-free ones have been given new code numbers. These, together with the total of first size canes distributed in 1958 are as follows: Lloyd George, $SH_1/57$ (3,000), $SH_1/58$ (3,700); Malling Promise, $SH_2/57$ (1,000), $SH_2/58$ (2,000); Malling Exploit, $SH_3/58$ (5,500); Norfolk Giant, $SH_4/58$ (825); Malling Enterprise, $SH_5/58$ (100); Malling Jewel, $SH_6/57$ (6,000), $SH_6/58$ (10,050). Of these, 20% were allocated to the Nuclear Stock Association for distribution to growers in England and Wales. Thirty-nine Scottish growers applied for and received allocations of Malling Jewel.

In order partly to meet increasing demands, the number of root cuttings of Malling Jewel taken this year was increased and more than 3,000 plants have been raised for planting in the field this season. (J. Chambers.)

Spread of Leaf Roll and Y Viruses in Potato

Experiments to find the effects of times of planting and of roguing on the rates of spread of leaf roll and Y viruses in potato were repeated in 1957 and the results confirmed those of previous years. In both experiments, virus Y spread more than leaf roll and most spread of both viruses occurred before mid-July and in crops planted late in the season, early to mid-May.

To find if the susceptibility of potato plants to infection by leaf roll virus varies during the season, leaf roll infectors, heavily colonised by *Myzus persicae* were exposed for fortnightly periods, from June to September, in a crop of healthy Majestic potato. The results showed that virus spread most from infectors exposed in late June and early July and not at all from those exposed after mid-July. (J. Chambers.)

OTHER VIRUSES

Cassava Brown Streak Disease

Brown Streak is an important virus disease of Cassava (*Manihot utilissima* Pohl.) in all the cassava-growing areas on the coasts of Kenya and Tanganyika because necrosis of the starch storage tissues of the roots of infected plants results in serious losses in yield. Transmission of the virus by a white fly (*Bemisia* sp.) is suspected, though unconfirmed, and the behaviour of the disease in the field suggests it might be soil-borne.

A virus causing typical brown streak symptoms in cassava seedlings has

now been transmitted from infected cassava, obtained from Tanganyika by Mr D. L. Jennings, to several solanaceous plants and its properties are being investigated. (R. M. Lister.)

PUBLICATIONS

CADMAN, C. H. (1959). Some properties of an inhibitor of virus infection from leaves of raspberry. *J. gen. Microbiol.* **20**, 113.

(Raspberry leaves contain an unidentified polyphenolic substance which prevents the infection of plants by viruses, precipitates the proteins in normal rabbit serum and is probably a tanning agent. Unlike most other inhibitors of plant virus infection, the tannins from raspberry and other sources seem to act directly on viruses. Combination between tannin and virus seems always associated with loss of infectivity but both effects are reversed with some viruses by dilution or increase in pH value. Extracts made from raspberry leaves with the aid of 2.5% nicotine in water contained less tannin than those made with alumina or phosphate buffer at pH 8. When raspberry leaves containing tomato black ring virus were used, extracts made with the aid of nicotine contained enough virus to be detected by the serological precipitation test.)

CADMAN, C. H. (& HARRISON, B. D.) (1959). Studies on the properties of soil-borne viruses of the tobacco-rattle type occurring in Scotland. *Ann. appl. Biol.* **47**. (In press.)

(Soil-borne viruses of the tobacco-rattle type occur in soils in many parts of Scotland. They infect many species of crop and weed plants and occur in potato plants that have diseases of the stem-mottle type. Many of the viruses cultured from naturally infected plants were difficult to transmit by mechanical inoculation; others which were easily transmitted mechanically were serologically related and shared antigens in common with a Dutch culture of tobacco rattle virus and with belladonna mosaic, a virus described from England. Different cultures, and different samples of the same culture propagated on different occasions, varied in antigenic constitution. In many of its properties tobacco rattle virus resembles tobacco mosaic virus.)

FISKEN, A. G. (1959). Factors affecting the spread of aphid-borne viruses in potato in eastern Scotland. I. Overwintering of potato aphids, particularly *Myzus persicae* (Sulzer). *Ann. appl. Biol.* **47**, 264.

(Three species of potato aphids, *Myzus persicae*, *Macrosiphum euphorbiae* and *Aulacorthum solani* overwinter in eastern Scotland chiefly as apterae on perennial, glasshouse, frame and brassica crops. Crops of spring cabbage, cabbage for seed and broccoli are the most important overwintering hosts for *Myzus persicae*, because they usually persist long enough to allow the development and dispersal of winged aphids to spring-planted crops.)

FISKEN, A. G. (1959). Factors affecting the spread of aphid-borne viruses in potato in eastern Scotland. II. Infestation of the potato crop by potato aphids, particularly *Myzus persicae* (Sulzer). *Ann. appl. Biol.* **47**, 274.

(The results of a three-year survey showed that potato crops in most districts of eastern Scotland became colonised by *Myzus persicae*, *Macrosiphum euphorbiae* and *Aulacorthum solani*. Crops farthest away from sites where *M. persicae* overwinters became colonised latest and to the least extent by this aphid. The freedom of potato crops in good seed-producing areas from infection by potato leaf roll and Y viruses is probably associated with lateness of aphid infestation rather than scarcity of aphid vectors.)

HARRISON, B. D. (1958). Further studies on raspberry ringspot and tomato black ring, soil-borne viruses that affect raspberry. *Ann. appl. Biol.* **46**, 571.

(Raspberry ringspot virus, the cause of raspberry leaf curl disease, occurs widely in soils in eastern Scotland and was found infecting raspberry in Wiltshire. Tomato black ring virus was also isolated from diseased raspberry plants in eastern Scotland. Although both viruses often occur together in soils they are serologically unrelated and differ in physical properties. A few varieties of raspberry seem immune from

infection by either raspberry ringspot or tomato black ring virus; others are susceptible to one or other or to both viruses.

The results of glasshouse experiments suggest that transmission of raspberry ringspot and tomato black ring viruses through the soil requires some factor other than free virus, possibly some soil-inhabiting organism.)

HARRISON, B. D. (1959). The pattern of field infection of potato by the beet ringspot strain of tomato black ring, a soil-borne virus. *Ann. appl. Biol.* **47**. (In press.)

(Although a few plants of a stock of Kerr's Pink potato developed symptoms when grown for one year on land containing tomato black ring virus, few showed symptoms but up to 40% became infected and set tubers which produced diseased plants. The number of infected plants in each progeny was small. Some of these progeny plants were symptomless although systemically infected whilst others showed leaf necrosis or produced stunted shoots with cupped and distorted leaves. Most of the progeny from plants with these symptoms contained the virus and nearly all such infected plants were stunted and distorted or were symptomless. Without continual new infections from infested soil, the virus tends to be self-eliminating in stocks because systemically infected plants produce fewer tubers than healthy ones.)

LISTER, R. M. (1958). Soil-borne virus diseases in strawberry. *Plant Pathology* 7, 92.

(Raspberry ringspot virus was isolated from plants of Talisman, Huxley and Cambridge Vigour strawberry from localities in eastern and western Scotland by rubbing leaf sap on the leaves of *Chenopodium amaranticolor*. Raspberry yellow dwarf virus was similarly isolated from plants of Cambridge Favourite from Devonshire and from patches of stunted Talisman plants on farms in Lanarkshire. Infected plants showed various crinkle and yellow blotch symptoms and were stunted. Evidence is presented to show that the symptoms described were caused by the viruses isolated, and it is suggested that such symptoms have previously been confused with those caused by other pathogens.)

LISTER, R. M. (1958). Some turnip viruses in Scotland and their effects on yield. *Plant Pathology* 7, 144.

(Strains of turnip yellow mosaic, turnip crinkle and turnip rosette viruses were isolated from yellow turnip and swede plants in Angus and Perthshire in 1956. In replicated field trials made in 1957, inoculation of yellow turnips (variety Bruce) at the 6-8 leaf stage with the strains of turnip crinkle and turnip yellow mosaic viruses had little effect on the yield of roots despite drastic effects on the foliage. Glasshouse tests indicated, however, that turnip seedlings may be killed or severely damaged when infected by means of flea beetles.)

LISTER, R. M. (1958). Preparation of virus antisera from strawberry. *Nature, Lond.* **182**, 1814.

(Using a development of recent techniques for removing tanning agents from leaves during maceration, antisera were prepared to two viruses from strawberry leaves, namely raspberry ringspot from Huxley and raspberry yellow dwarf from Cambridge Favourite. The extracts used for injecting rabbits were obtained by macerating leaves in 5% nicotine base and clarified by centrifugation and dialysis against water and saline.)

LISTER, R. M. (1959). Mechanical transmission of cassava brown streak virus. *Nature, Lond.* **185**, 1588.

(A virus causing typical brown streak symptoms in cassava seedlings was transmitted mechanically to several solanaceous plants by rubbing with sap from the leaves of brown streak-infected cassava plants macerated in water with "Celite" powder and alumina. The symptoms cause by infection in *Datura stramonium*, *Nicotiana rustica*, *N. glutinosa*, *Petunia* and tobacco and some of the properties of the virus are described.)

MYCOLOGY

A. R. WILSON

GREY MOULD OF SOFT FRUIT

Autecology of Botrytis cinerea

In contrast to 1957, grey mould was very prevalent in soft fruit at Mylnefield in 1958. Fruit infections, apparently initiated from spore germination and germtube penetration, were infrequent compared with those resulting from contact with infected material, *e.g.*, calices, fruit and plugs. Data from a Theis and Calpouzos dew recorder indicated that minimal conditions of water persistence and temperature for infection from spores occurred infrequently, whereas, because of difficulties in removing ripe fruit promptly, contact infection was favoured. In 1958, almost all plugs and often their peduncles became infected and fruit sometimes became infected from diseased plugs by the growth of the fungus along adjacent peduncles. Leaves also were attacked frequently from plugs.

Results obtained with a Hirst spore trap, again operating in a raspberry plantation, confirmed those of previous years in that the greatest concentration of air-borne spores usually occurred at mid-day, often followed by a secondary peak at dusk. Such increases could again be broadly correlated with a rising or falling relative humidity within the range 65-80%. Unlike 1957, the mean daily concentration of air-borne spores remained remarkably constant throughout the latter part of the season, despite the progressive diminution in the quantity of ripe fruit present and in the proportion of infected ripe fruit. This is regarded as resulting from heavy sporulation on the plugs. Despite the greater incidence of the disease and far greater sporulation of the fungus in 1958, daily concentrations of air-borne spores were of the same order as in 1957. There is no obvious explanation in the available meteorological data for the discrepancy between the two years in the proportions of spores formed and liberated.

The mechanism of spore release is now being investigated in specially constructed apparatus in which cultures of the fungus can be moved rapidly between atmospheres of differing relative humidity. Mature conidiophores are flattened and are twisted through 90° about their long axis at every septum. The cytoplasm is often unevenly distributed in the cells, commonly appearing as a reticulate cylinder, a flat or twisted ribbon, a filament or a spiral or combinations of these in adjoining or even the same cells. The conidiophores are very sensitive to changes in relative humidity; they have not been seen to twist about their long axis, as was noted by de Bary, but appear to move in one plane, with one of the lower cells as a fulcrum. The movement is erratic and can also be produced by a small mechanical shock. Spores have not been observed to be liberated by hygroscopic movements but small clumps of spores have been released by mechanical shock. Spore release on the scale observed when handling heavily infected berries has not yet been reproduced in a controlled environment.

Varietal Susceptibility

Great differences in the susceptibility of a number of raspberry varieties were noted during 1958 when fruit infection varied from 7% in Malling Jewel to 51.4% in Malling Promise. No correlation was found between relative humidity within plantations of six varieties and their habit as measured by cane density and spread across inter-row spaces at the time of fruiting; neither was there correlation between habit and fruit infection.

Attempts to correlate varietal and seasonal differences in fruit infection with physical and chemical differences in the fruit are being made. It has been established that, *in vitro*, *B. cinerea* can tolerate concentrations of citric and malic acids well in excess of those found in green and ripe strawberries and raspberries.

Control

In field trials with the raspberry variety Malling Exploit and the strawberry variety Talisman, various fungicides were compared with standard captan treatments. None was as generally efficient as either captan spray (2½ lb. 50% wettable powder/30 gal./acre) or captan 3% dust (21 lb./acre). Griseofulvin oxime liquid concentrate* (280 gm./30 gal. water/acre) reduced the mean infection in Malling Exploit from 18.2% to 6.4% (P=0.05) as compared with a reduction to 14.3% and 16.1% (not significant) for captan spray and dust respectively. In Talisman, captan spray and dust reduced infection from 26.2% to 20.8% and 16.9% respectively; griseofulvin oxime spray and 3% dust reduced infection to 22.5% and 21.7 % respectively.

To obtain information on the effect of various types of fungicide on *B. cinerea* in the field, but not necessarily for practical purposes, a number of other materials were included in the trials and were applied at the same times and rates as the standard captan treatments. Of these, a copper-8-quinolinolate formulation† reduced infection to 11.6% in Malling Exploit. Other materials, including another copper-8-quinolinolate formulation, TCNB and PCNB did not reduce infection in either crop.

Storage Rots

In 1958, rotting was severe in fruit stored overnight in four-pound wooden chip baskets. *Rhizopus nigricans* was frequently associated with *B. cinerea* and was also occasionally observed on berries in the field. In one experiment the mean number of Talisman strawberries developing perceptible infections overnight was reduced from 6.0% to 3.7% (P=0.05) by storage in chip baskets treated previously with a copper-8-quinolinolate formulation,‡ but there was no difference in the mean numbers of Malling Exploit raspberries affected.

Baskets treated with the same material were used for routine picking throughout the season of nine weeks in comparison with untreated baskets. Because of the waterproofing and fungicidal properties of copper-8-quinolinolate, treated baskets did not become badly water-soaked and stained, fruit debris did not adhere readily and sporulation of *B. cinerea*, *R. nigricans* and other fungi was inhibited on the fragments remaining. No treated basket was rejected as unusable during the period of trial. In contrast, untreated

* Supplied by Glaxo Laboratories, Ltd. † Cunilate 2419, supplied by Cuprinol Ltd.
‡ Cunilate Wood Seal, supplied by Cuprinol Ltd.

baskets soon became soaked, discoloured and coated with fruit debris on which fungi spored profusely, the average life of these baskets being approximately two weeks. (W. R. Jarvis.)

GREY MOULD OF TOMATOES

Thirty-two isolates of *Botrytis* sp. from grey mould lesions on tomato stems petioles, leaves and fruit, found in 21 nurseries in Lanarkshire, have been compared with isolates from other sources. Spore size and other morphological characters suggest that the isolates from tomato are all *Botrytis* of the *cinerea* type although they vary considerably in gross appearance in culture. Preliminary experiments indicate that there may be some variation in their ability to infect tomato stems through fresh leaf scars.

Various methods of inoculating tomato stems with *B. cinerea* have been tried in an attempt to find one which would ensure the high percentage infection desirable for "screening" work on fungicides. The method initially consisted of inoculating fresh leaf scars on potted plants 12-18 in. high with a standard spore suspension in distilled water. The plants were then placed in a chamber in the greenhouse at a relative humidity approaching saturation for 24 hr., after which they were returned to the greenhouse bench. Less than 10% infection was normally obtained in this way. Placing the inoculum in incisions, using spores suspended in 2% sucrose in water for varying periods before application, preconditioning plants at a high humidity before inoculation, applying a dressing of sulphate of ammonia (1 gm./5 in. pot) at various intervals before the plants were used and increasing the period during which plants were kept at a high humidity after inoculation all failed to effect any material improvement in results. It has now been found that virtually 100% infection can be obtained by cauterising a small area of the fresh leaf scar with the tip of a hot wire (2.5 mm. diam.) before inoculation. The small necrotic spot produced provides a substrate for saprophytic growth thus facilitating subsequent invasion of the healthy tissues below.

To find an effective fungicide the composition of which may be more precisely defined than that of the creosote at present used for local application to stem lesions, various creosote oils are being tested for fungitoxicity both *in vitro* and on infected plants in the greenhouse. (A. R. Wilson.)

POWDERY MILDEW OF SOFT FRUIT

There was very little mildew in 1958, and concentrations of air-borne spores of *Sphaerotheca humuli* were again very low. (W. R. Jarvis.)

STRAWBERRY RED CORE

Work is continuing on the role of host-parasite enzyme system interactions in disease resistance mechanisms, with special reference to polyphenol systems. (W. R. Jarvis).

MISCELLANEOUS

A species of *Phytophthora*, apparently *P. cactorum* (Leb. & Cohn) Schroet. has been isolated from roots of raspberry plants in parts of eastern Scotland. The affected plants were growing in waterlogged soils and showed yellowing of the leaves and an unhealthy root system. The fungus has been transmitted from diseased to healthy roots and its taxonomic position and pathogenicity are now being studied in more detail. (W. R. Jarvis, I. G. Montgomerie.)

WEST OF SCOTLAND UNIT (AUCHINCRUIVE)

R. D. REID

STRAWBERRY BREEDING

The work consisted mainly of testing and re-selecting seedlings for resistance to red core disease. The very wet summer resulted in heavy losses of fruit because of grey mould (*Botrytis cinerea*), the policy now being to leave this disease and mildew uncontrolled in order to gain more information on the relative susceptibilities of the numerous seedlings raised. Because of spring frost damage in 1957 there was a considerable back-log of seedlings fruiting as single plants which could not be evaluated then, and the proportion of land devoted to them was greater than usual. Approximately 5,000 seedlings from 1954 and 1955 were in this category. Of the selections fruiting in the field in small plots, final judgements were made of large numbers which had been under observation for several years. A review of the situation therefore seems apposite.

Of the seedlings raised between 1947 and 1951 inclusive, none was considered worthy of introduction. Several were retained for breeding purposes because of their field resistance to red core disease. Although susceptible to infection and growing in heavily infected land, these seedlings have shown no perceptible reduction in vigour.

From the 1952 crossings, over 200 seedlings had been retained. Most of these were rejected and about 50 are being grown in plots of a size which will allow a better assessment of their fruiting capacities in 1959. Three are being tried on a large scale.

The 1953 crossings yielded a smaller crop of seedlings, of which the most interesting was a family obtained by crossing Auchincruive 11 (a highly resistant selection never developed commercially) with a strain of *F. virginiana*. A large proportion of the seedlings showed an outstandingly high degree of field resistance to red core and several have been used a great deal in recent breeding work. None of the 1953 seedlings is likely to be of commercial value but five are still on trial.

In 1954, *Fragaria* species were extensively used. Over 7,000 seedlings were raised and 1,400 were grown in infected land until autumn 1958 when some 20 were selected for further work. The outstanding feature was the effect of *F. virginiana* in crosses with other resistant selections. Most of the seedlings grew vigorously even under the most adverse conditions, and although few proved immune from red core very many suffered no check in growth and appeared free from degeneration in the field.

In 1955, crosses included those between highly resistant selections as well as between species and varieties and selections. Of the 9,000 seedlings raised, 4,000 were retained and in 1958, 31 of these were selected for further trial.

The 1956 programme was more ambitious and included (a) crosses between F_1 species hybrids and seedlings selected for fruiting quality, (b) outcrosses

and backcrosses of derivatives of species hybrids (some made as many as 18 years previously) with the object of improving fruiting quality and (c) utilisation of older or obsolete named varieties, or selfed seedlings from them, as sources of genes for specific pomological characters such as ease of plugging and earliness. These yielded over 10,000 seedlings of which about 3,000 were rejected because susceptible to red core. Of the remainder, 3,000 fruited in 1958 and 70 were selected for further work. The balance, 3,800, were again examined for reaction to red core in the spring of 1958 and about 1,100 were planted in the field for re-examination in the spring and fruiting in the summer of 1959.

Work in 1957 followed the same lines. Some of the newer hybrids were used as well as seedlings from a number of overseas, especially oriental named varieties. The results of bench-testing these seedlings for susceptibility to red core (Table 1) were the most consistent we have yet had, probably because of better control of temperature and humidity in the benches. More infections occurred among seedlings tested during the winter months than among those tested in summer and this confirms past experience. The 1,600 seedlings retained from the first batch were planted in the field in spring, 1958, and will be re-examined and fruited in 1959. The remainder will be re-tested in spring 1959 and then planted out.

TABLE 1. Bench testing of seedlings from 1957 crosses

Batch	Bench	Date planted	Date examined	No. of seedlings	Infected red core	Dead other causes*	Clean	Percentage not infected
1	A	28/1/58	2/4/58	1613	841	112	660	40
	B	30/1/58	23/4/58	2215	1000	183	1032	46
2	A	14/4/58	12/8/58	2516	573	256	1687	67
	B	28/4/58	1/9/58	2472	571	235	1666	67
3	A	18/9/58	5/1/59	2170	754	460	956	44
	B	23/9/58	14/1/59	287	92	84	111	38
Totals				11273	3831	1330	6112	

*Includes losses from miscellaneous causes such as damping-off and severe mildew and therefore probably a proportion of seedlings susceptible to red core.

The same general plan was followed in 1958 with the emphasis on backcrossing and outcrossing of species hybrids. As usual, the seeds are being sown in three batches: the first, sown in September yielded over 4,000 seedlings, the second, sown in January is germinating freely and the third will be sown in April.

Summarising, the breeding policy in recent years has aimed at: (a) combining factors for resistance to red core present in seedlings, mainly of our own raising, from the varieties Frith, Aberdeen, Perle de Prague, Cambridge

Vigour, the Canadian variety Magoon and selected American seedlings as well as from other less resistant types; (b) increasing field resistance by using strains or hybrids of *F. virginiana*, (c) incorporating desirable characters such as earliness, flavour and easy plugging by using, in most instances, selfed lines from older and practically obsolete named varieties.

New sources of resistance to red core are being sought for (see below) and these will be used when they become available. However, the chances of obtaining complete immunity from all races of the pathogen seem slight and it seems more realistic therefore to attempt to combine immunity from as many races as possible with a high degree of field resistance. The proportion of seedlings selected for fruiting trials is inevitably low, because all seedlings are tested at least twice for susceptibility to red core before they are allowed to fruit. Moreover, the use of species hybrids is apt to introduce undesirable qualities. For example, the desirable field resistance of *F. virginiana* is usually associated with fruit of small size and soft texture, and an effort to break the linkage between them has needed extensive outcrossing and back-crossing. Recently F_3 and F_4 hybrids from Little Scarlet have been used and some of the most recent selections represent the F_5 generation. Work with species other than *F. virginiana* has so far been unrewarding although families derived from *F. chiloensis* are still under trial.

Fruiting Trials

Trials of Talisman and Redgauntlet provided no new interesting features. Both varieties again cropped heavily: Talisman suffered the heavier losses from *Botrytis* and Redgauntlet proved the less resistant to red core. The main interest now lies in reports on the performance of these varieties in other areas.

Talisman and Redgauntlet together with five selections from the 1952 crosses were tried under cloches. Several of the seedlings cropped well but none met the demand for an early variety of the kind asked for by growers specialising in cloched crops. Picking started on 5th June. As the cloches had been put on rather early and the ground was somewhat dry, the incidence of mildew was higher than is usual in the open. This provided useful information on the relative susceptibility of these selections to mildew.

Virus Testing

Stock plants of the more valuable selections are kept and propagated under insect-free conditions and as a routine these are tested for virus by grafting to *F. vesca*. The method now used is to "bottle" graft a detached stolon of the stock plant to a stolon of the *F. vesca* indicator. This method works well and avoids the risk of infecting the tested plant with any latent viruses which may possibly be present in the indicator. Seventy plants were tested in this manner. (R. D. Reid, A. M. Sutherland, K. C. McConnell.)

RASPBERRY BREEDING

A large number of seedlings was fruited and a few of the most promising were selected for further work both at Auchincruive and at Mylnefield. None was good enough to introduce as a variety but some useful breeding material is now available. (R. D. Reid, A. M. Sutherland.)

MYCOLOGICAL INVESTIGATIONS

Physiologic Races of Phytophthora fragariae.

Physiologic races of this fungus can usually be identified by the differential response of selected varieties of strawberry to inoculation with the various isolates. Now, however, it appears that comparable plants of one and the same variety may react differently when inoculated with a given isolate. For example, when eight runners of the Perle de Prague variety were inoculated with the same isolate, seven showed no reaction whereas the roots of one became slightly infected. Similar results have been obtained with material of *Fragaria* species. No such inconsistencies have occurred in tests with clonal material highly susceptible or immune to the pathogen. Disease escape seems an unlikely explanation but until more is known of the cause of these variations in plant behaviour it is difficult or impossible to define the pathogenicity of some physiologic races of the fungus.

New Sources of Red Core Resistance

Work this year included the testing of seedlings of wild *Fragaria chiloensis* from three localities in Chile, an un-named species from Jugoslavia, an American variety, several Japanese varieties and plants of three clones of *F. chiloensis* received from North America. Of 741 seedlings inoculated with one of the least pathogenic isolates, 4% were immune; these were all derived from the cultivated varieties. Forty-eight runners from the *F. chiloensis* clones were inoculated with the same isolate but all were susceptible.

Inheritance of Resistance

Studies on the inheritance of immunity from *P. fragariae* were continued by selfing immune seedlings and testing their progenies for reaction to infection by one of the least pathogenic isolates of the fungus. Altogether, 739 seedlings were tested: more than half of these derived from named varieties of strawberry and the rest from various clones of *Fragaria virginiana*, *F. ovalis* and *F. chiloensis*. Progenies derived from cultivated varieties contained 130 immune seedlings but those from *Fragaria* species contained only six. Analysis of the results was complicated because some of the seedlings immune to the race of *P. fragariae* used produced runners which were susceptible. With most progenies, this resulted in only small corrections to the scores but in one family, derived from a selfed plant of *F. virginiana*, where 29% of seedlings were recorded as immune, the runners from all of these proved susceptible.

In other experiments, 16 plants of named varieties and *Fragaria* spp. were selfed and a total of 69 of the immune F_1 seedlings selfed again and their progenies tested with the least pathogenic isolate of the fungus. Thirty-two of these seedlings (19 derived from named varieties and 13 from *Fragaria* spp.) gave progenies which contained more immune seedlings than the F_1 families from which they derived.

Tests made with material derived from cultivated varieties of strawberry and from *Fragaria* species show that immunity from the most pathogenic race of *P. fragariae* available is rarer than immunity from less pathogenic races. Thus out of 1,739 runners from immune seedlings, 580 of which were derived from cultivated varieties and 1,159 from *F. virginiana*, *F. ovalis* and *F.*

chiloensis, 170 were immune from or slightly susceptible to the least pathogenic isolate of *P. fragariae*. Of these, 73 derived from cultivated varieties and 97 from *Fragaria* species. Fewer plants (33 from cultivated material and 50 from *Fragaria* species) were immune from or slightly susceptible to a more pathogenic race and only three, all of which were derived from cultivated strawberry, were immune from the most pathogenic race available. (I. G. Montgomerie.)

PUBLICATIONS

REID, R. D. (1958). Talisman and Redgauntlet in 1958. *The Grower*, **50**, 712.
(This is a general report on the performance of these two strawberry varieties throughout Great Britain in 1958.)

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METEOROLOGICAL RECORDS 1958

J. SUNDERLAND

Daily meteorological observations were made at 09.00 G.M.T. throughout 1958. Week-end and holiday observations were made by Mr A. Fenwick of the outdoor staff.

The meteorological records for 1958 from Mylnefield and Auchincruive are summarised in the following tables. The values relating to Auchincruive have been taken from copies of the Monthly Weather Report, issued by the Meteorological Office.

MYLNEFIELD 1958

Month	Temperature		Rainfall		Sunshine		Ground Frost
	Mean* °F.	Deviation From† Average	Inches	Deviation From‡ Average	Hours	Deviation From† Average	Days
Jan.	34·9	−2·6	1·40	−0·53	64	+14	24
Feb.	36·2	−2·3	2·87	+1·02	60	−16	18
Mar.	36·3	−4·9	4·29	+2·44	103	− 2	16
April	44·4	−0·4	1·41	−0·20	153	+13	13
May	48·8	−0·6	2·71	+0·71	187	+21	7
June	53·4	−1·9	3·03	+1·34	106	−76	0
July	58·4	−0·6	4·09	+1·54	154	0	0
Aug.	57·3	−0·6	2·92	−0·35	108	−33	0
Sept.	56·7	+2·7	2·22	+0·22	124	+ 2	0
Oct.	49·9	−2·0	1·44	−1·16	131	+36	5
Nov.	41·5	−0·2	0·83	−1·49	44	−19	17
Dec.	37·4	−1·6	4·13	+1·61	53	+12	24
Year	46·3	−1·25	31·34	+5·15	1287	−48	124

*Computed from daily mean of maximum and minimum temperatures at 09·00 G.M.T.
†Recorded at official Dundee meteorological station 1921-1950.
‡Recorded at official Dundee meteorological station 1881-1915.

AUCHINCRUIVE 1958

Month	Temperature (°F.)	Rainfall (in.)	Sunshine (hr.)	Ground Frost (Days)
January	38·1	3·93	61	21
February	38·2	3·22	53	18
March	38·1	0·71	122	23
April	44·8	1·18	156	11
May	48·5	2·64	204	12
June	54·9	2·72	131	1
July	58·4	4·44	202	1
August	57·9	4·24	122	0
September ...	58·0	3·91	150	0
October	50·7	3·36	67	3
November ...	44·3	1·43	47	18
December ...	39·1	3·59	38	23
Year	47·6	35·37	1353	131

Averages for previous years at Auchincruive are not available.

WEATHER SUMMARY

JANUARY

Cold, fairly dry and sunny with occasional snow showers. The snow (0.75 in.) which fell on the 24th thawed quickly.

(Highest max. 51°F on 27th
Lowest min. 13°F on 24th)

FEBRUARY

Generally cold but with some mild days. Snow fell on the 7th-9th and 23rd-25th. Although the fall of snow was not very heavy (0.5-2 in.) a strong east wind on the 8th caused drifting to about 18 in.

(Highest max. 53°F on 4th
Lowest min. 16°F on 9th)

MARCH

Cold with moderate snow and sleet showers well scattered throughout the first three weeks. The fourth week was very wet, contributing half of the month's rainfall. Winds were strong and there was a north west gale on the 5th.

(Highest max. 53°F on 4th
Lowest min. 18°F on 11th and 12th)

APRIL

After further showers of snow and sleet during the first three days, the weather improved, becoming warm, sunny and dry throughout the month.

(Highest max. 66°F on 30th
Lowest min. 27°F on 11th)

MAY

A month of changeable weather. Long, warm, sunny periods were followed by heavy, continuous rain and westerly gales on the 19th and 20th.

(Highest max. 72°F on 1st
Lowest min. 33°F on 7th)

JUNE

Generally cool, dull and wet. There were thunderstorms and heavy but short showers on the 3rd, 24th and 25th. A gale accompanied heavy, continuous rain on the 26th.

(Highest max. 69°F on 14th
Lowest min. 40°F on 21st)

JULY

Warm, wet and changeable throughout.

(Highest max. 78°F on 4th and 7th
Lowest min. 40°F on 25th)

AUGUST

Dull. The third week was one of overcast skies, drizzle and mist. Thunderstorms occurred on the 1st and 10th. Winds very light and variable.

(Highest max. 70°F on 11th and 12th
Lowest min. 43°F on 6th, 8th and 17th)

SEPTEMBER

Changeable with rain well scattered throughout. A thunderstorm occurred on the 6th, but with little rain. Winds very light and variable.

(Highest max. 69°F on 14th
Lowest min. 40°F on 23rd)

OCTOBER

Colder; a bright, dry month with light south westerly winds.

(Highest max. 62°F on 8th and 20th
Lowest min. 32°F on 18th)

NOVEMBER

Generally dull but changeable with many days of almost complete calm.

(Highest max. 56°F on 15th
Lowest min. 23°F on 11th and 12th)

DECEMBER

Wet and cold. A shower of hail fell on the 11th. Strong east to north winds blew during the third week.

(Highest max. 48°F on 20th and 28th
Lowest min. 23°F on 14th)

VARIETY TRIALS OF VEGETABLES IN SCOTLAND

V. Spring-sown Broad Beans

C. NORTH, L. H. FRITH AND H. TAYLOR

The broad bean is one of the oldest-known vegetables, yet it has never become a crop of major importance in Britain, and has scarcely been cultivated on a field scale in Scotland. However, within the last few years the demand for canned and quick-frozen broad beans has increased, and crops of this vegetable are now being grown in Scotland for canning. Since these recent developments in the food industry indicated a rising demand for broad beans, field trials were started at Mylnefield to find which varieties are the most productive under Scottish conditions.

Method

Trials were conducted for three years at Invergowrie, and in 1958 at Craibstone near Aberdeen where the average air temperature during the growing season is 1-3°F lower than at Dundee. (Meteorological Office, Air Ministry, 1953).

Land used for the trials at both centres was medium loam of moderately high fertility. The only manure used was a balanced fertilizer worked into the land at the rate of 6 cwt./acre shortly after the seedlings had emerged. Each trial was a randomised block layout with 2, 4 and 5 replications in 1956, 1957 and 1958 respectively. Each plot was a single row 20 ft. long sown by hand with seeds spaced 1 ft. apart. On the whole the plant population was fairly uniform, but at Invergowrie in 1958 it was patchy, due partly to the use of three-year-old seed which germinated badly, and partly to bird damage.

In all the trials the plants grew well and showed few signs of disease. Damage caused by the chocolate spot fungus (*Botrytis fabae*) and bean weevil (*Sitona* sp.) was negligible, and only in 1957 was it necessary to spray the crop to control bean aphis (*Aphis fabae*). In 1957 about 1% of the plants showed virus-like symptoms which resembled bean leaf roll; most of the affected plants were of the Seville and Aquadulce varieties.

The intention was to harvest the trials in 2 or 3 pickings. However, in 1958 the plants made very lush growth at both centres and became so badly lodged that all the pods had to be harvested in one pick, lifting the plants from the ground as harvesting progressed. In other years, although there were varietal differences in resistance to wind damage, the plants did not become tangled and it was possible to harvest the crop in more than one picking. Dates of harvest and sowing are shown below.

Trial	Sown	Harvested
Invergowrie 1956	30th March	26th July, 8th August, 16th August
Invergowrie 1957	10th April	30th July, 9th August
Invergowrie 1958	15th April	23rd August
Craibstone 1958	15th April	19th September

At harvest, the weight of intact pods was recorded. A weighed sample (2-4 lb.) of pods from each plot was shelled by hand and the weight of shelled beans recorded used to calculate the ratio of beans to pods and thence the yield of beans per plot. Measurements were made of pod length and the length and breadth of shelled beans on samples of 10 pods and 10 beans from each plot. The colour of fresh and cooked beans was noted, and to ascertain which varieties were suitable for canning, the dry seed coats were tested for the presence of leuco-anthocyanin by the method described by Dickinson *et al.* (1957).

Varieties Tested

In addition to the 39 strains listed in Table 1, eleven strains were grown for one year only or in such small quantities that it was not possible to judge their productivity. These were: Green Masterpiece (Hurst), Hangdown (Weibull), Jegevas (Lithuania), Krievu melnas (Lithuania), Long-podded Express (Sharpe), Masterpiece Green (Sharpe), Seville New Mammoth (Sharpe), Sugar (Clucas), Threefold White (Sharpe), Threefold White Long-podded (Sharpe) and Windsor Four-seeded (Sharpe).

Results

The varieties listed in Table 1 have been classified into seven groups, based on seed characters. The yield of fresh seeds is expressed as a percentage of that of the variety Threefold White (Hurst) in the same year. This variety was chosen as a standard because it is at present the only one grown in Britain for canning. Yields for the first pick in 1956 and 1957 are expressed also as percentages of the total yield of each variety in each year; these figures indicate varietal differences in rate of maturation.

Table 1 also shows average pod and bean sizes and susceptibility to lodging rated thus: (1) weak steam easily lodged, (2) stems of intermediate strength and (3) strong stems.

TABLE 1. Broad Bean Yield Trials 1956-1958

	Yield of shelled beans (% of Threefold White)				Earliness (% 1st pick of total pick)		Pod length (in.)	Seed size (length/ breadth 1/100 in.)	Stem character
	1956	1957	1958	C* 1958	1956	1957			
A. *Varieties with dark-green seeds*									
Masterpiece (Cullen)	114	142	109	150	30	38	7·9	94/71	2
Robin Hood (Hurst)	103	124	109	134	26	34	8·3	94/70	2
Harlington Green (Hurst)	91	138	86	131	24	30	5·8	102/78	2
Harlington (Cullen)	86	120	96	106	22	43	6·0	98/78	2
Green Monster (Dickson)	95	98	41	125	38	50	6·6	94/74	2
Windsor Green (Ohlsens Enke)	45	111	58	91	14	31	6·0	98/82	2
Giant Green (Cullen)	45	106	56	90	26	47	7·3	102/86	2
B. *Variety with small dark-green seeds*									
Beck's Green Gem (Dickson)	—	64	39	98	40	48	4·0	70/51	2
C. *Varieties with pale to medium green seeds having dark hilum*									
Aquadulce (Cullen)...	70	69	53	50	40	42	7·5	102/79	1
Aquadulce (Hurst)	89	99	62	41	36	66	7·2	98/71	1
Aquadulce (Ohlsens Enke)	79	56	54	46	—	—	7·1	94/71	1
Mammoth Seville (Finney)	65	72	65	61	40	49	6·9	106/75	1
Seville (Ohlsens Enke)	79	43	32	39	46	51	6·9	98/75	1
Seville (Cullen)	81	53	59	65	35	61	7·4	98/75	1
Claudia (Cullen)	37	73	48	44	45	53	8·2	102/75	1

*Craibstone

TABLE I. Broad Bean Yield Trials 1956-1958—*continued*

	Yield of shelled beans (% of Threefold White)				Earliness (% 1st pick of total pick)		Pod length (in.)	Seed size (length/ breadth 1/100 in.)	Stem character
	1956	1957	1958	C* 1958	1956	1957			
D. *Varieties with pale green seeds which cook to brownish grey colour*									
Hangdown (Ohlsens Enke)	130	151	94	203	18	51	5·8	110/75	3
Express (Rijk Zwaan)	145	161	110	131	—	42	7·6	90/71	3
Extra Lange Afhangers (Rijk Zwaan)	141	142	107	163	—	46	8·5	90/71	2
Bunyard's Exhibition (Finney)	159	152	113	163	20	28	5·6	98/74	2
Bunyard's Exhibition (Cullen)	128	154	77	122	24	26	8·1	94/71	2
King of Beans (Clucas)	—	138	104	134	—	54	6·4	106/83	2
Cluseed Long Pod (Clucas)	151	113	94	137	27	50	8·0	98/74	2
Harlington White (Hurst)	98	128	92	143	23	43	5·8	94/74	2
Giant Windsor (Finney)	137	131	74	155	20	37	5·5	94/74	2
Taylor's Broad (Hurst)	106	137	88	135	23	51	6·3	94/74	2
Taylor's Windsor (Finney)	130	133	99	103	22	42	5·4	98/83	2
Giant (Hurst)	80	136	98	139	25	33	8·6	98/74	2
Dreadnaught (Finney)	96	122	73	153	32	42	8·5	98/79	2
Northern Pride (Finney)	105	136	87	130	23	35	7·0	98/74	2
Conqueror (Hurst)	97	153	81	—	29	51	8·3	90/71	2
Giant White (Cullen)	91	126	89	134	26	49	6·6	98/79	2
Record Long Pod (Croll)	—	107	90	117	—	51	7·2	94/75	2
Peerless Long Pod (Nutting)	—	119	77	103	—	59	6·2	94/75	2
Windsor White (Ohlsens Enke)	71	123	67	123	32	46	6·1	94/79	2

*Craibstone

TABLE 1. Broad Bean Yield Trials 1956-1958—*continued*

	Yield of shelled beans (% of Threefold White)				Earliness (% 1st pick of total pick)		Pod length (in.)	Seed size (length/ breadth 1/100 in.)	Stem character
	1956	1957	1958	C* 1958	1956	1957			
E. *Varieties with white seeds which cook to brownish colour*									
Tuin Boon 123 (Rijk Zwaan)	151	127	105	195	—	44	7·0	102/83	2
Witkeim (Rijk Zwaan)	130	132	109	123	—	65	7·3	98/83	2
F. *Varieties with white seeds which cook pale green and give negative reaction in leucoanthocyanin test*									
Driemaal Wit (Rijk Zwaan)	131	93	90	80	—	42	6·9	90/71	3
Threefold White (Hurst)	100	100	100	100	21	45	7·4	87/67	3
G. *Variety with white seeds which cook white and give negative reaction in leucoanthocyanin test*									
Lux (A. R. Zwaan)	—	99	87	39	—	—	5·8	79/59	3
LSD P=0·05	—	34	30	20					
Yield of Threefold White in cwt./acre	35·5	30·0	63·4	21·5					

*Craibstone

Discussion

The standard errors for differences in yield are high, probably because the figures for varietal yield include errors incurred by sampling the pods for shelling. Nevertheless the general ranking of varietal yields is similar for the four trials, so that conclusions about the relative productivity of the varieties tested are probably valid.

Most broad beans are unsuitable for preservation by canning because they change to a brown or grey colour when processed. Dickinson *et al.* (1957) have shown that this discoloration is associated with the presence of methanol-soluble leuco-anthocyanin and have described a test for this substance. Six of the stocks grown in the trials gave negative results with this test and are therefore suitable for canning; these were Threefold White from three sources (including the Dutch strain Driemaal Wit), Threefold Long-podded, Sugar and Lux. All these varieties have white or pale green seeds and were distinguishable in the field from those unsuitable for canning by the absence of purple or black coloration on the wing petals of the flowers. The variety Sugar could be distinguished from the other canning varieties by its round, as distinct from oblong-shaped seeds and Lux was distinguishable by the pure white colour of its fresh seeds. The yields of only three of the six varieties shown to be suitable for canning are given in Table 1: the varieties Threefold White (Sharpe), Threefold White Long-podded (Sharpe) and Sugar (Clucas) are not included there as they were grown for one year only. The results in Table 1 show that two strains of Threefold White were moderately productive but did not give as high yields as some varieties classified in groups A and D. The variety Lux always yielded less than Threefold White, but the difference was significant only in 1958 at Craibstone.

The requirements of a variety for preservation by quick-freezing are not as exacting as those for canning, and it seems from work by Crang & Sturdy (1956) that a wide range of different types of broad beans may be suitable for this purpose. However, most processors prefer varieties which have dark green seeds, such as those classified in groups A and B in Table 1. Although the variety in group B, Beck's Green Gem, may have some value when a specially small-seeded variety is required, it is not very productive and large-seeded varieties in group A are probably the most suitable for quick-freezing, especially Masterpiece (Cullen) and Robin Hood (Hurst).

For the fresh market, productivity is the main criterion and some varieties from groups A and D appear to be most suitable, in particular Masterpiece (Cullen), Robin Hood (Hurst), Hangdown (Ohlsens Enke), Express (Rijk Zwaan), Extra Lange Afhangers (Rijk Zwaan) and Bunyard's Exhibition (Finney and Cullen).

For garden purposes high-yielding varieties with sturdy stems, that rarely need staking are desirable. Long-podded varieties are also preferable, as long pods contain a large number of beans so that shelling is a less laborious task for the housewife. The trials suggest that the following varieties are most suitable: of the green seed type, Robin Hood (Hurst), Masterpiece (Cullen): of the pale green seed type, Cluseed Long Pod (Clucas), Giant (Hurst), Dreadnaught (Finney), Express (Rijk Zwaan). The varieties Threefold White and Lux may also be useful for garden work as they produce beans which are

less strongly flavoured than those of varieties in other groups; moreover they have an especially good growth habit and could be grown to provide shelter for crops which are susceptible to wind damage.

Although the Seville and Aquadulce varieties, such as those included here in group C, are said to be especially suitable for autumn sowing, they are also frequently recommended for spring sowing. However, the trial results show that these varieties consistently yielded poorly. Moreover, the plants had weak stems that frequently lodged and the fresh beans were less attractive than those of most other varieties because of the very dark brown or blackish colour of the hilum.

Acknowledgments

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VARIETY TRIALS OF VEGETABLES IN SCOTLAND

VI. Hamburg Parsley, 1957-1958

C. NORTH AND H. TAYLOR

Hamburg or parsnip-rooted parsley is derived from *Carum petroselinum* Benth. & Hook., the same species as the well-known curly-leaved parsley. It is grown chiefly for the root, which resembles a small parsnip, has a rather floury texture and a mild but distinct flavour reminiscent of parsley, parsnips and celery. The leaves of Hamburg parsley are of little value for garnishing as they are not usually curled but they are quite as suitable for flavouring as those of ordinary parsley.

According to a contemporary record of 1783 by Bryant, quoted by Hedrick (1919), Hamburg parsley was, at that time, frequently seen in London markets. Nowadays it is rarely grown in Britain and has become somewhat of a curiosity. However, Hamburg parsley is at present a popular vegetable in Germany and to some extent also in Denmark and Sweden where strains of this vegetable are carefully maintained. The trials described here were planned to find if Hamburg parsley could be satisfactorily cultivated in Scotland, and if so, which strains would give the best results.

Method

Trials were conducted at Mylnefield in 1957 and 1958. Each trial was a randomised block layout with five replications, the individual plots being single rows 15 ft. long. The rows were spaced 15 in. apart and there were guard rows around the outside of the trials. Dates of sowing and harvesting and distances between plants after hand thinning were as follows:—

Year	Sown	Intra-row distance	Harvested
1957	16th April	3 in.	16th October
1958	7th April	6 in.	13th November

A dressing of complete fertilizer, at a rate equivalent to 6 cwt./acre, was applied to the crop after thinning.

At harvest the roots were weighed with and without their tops. Fifty roots were sampled from each variety, washed and examined for core size, smoothness of the skin and rotting. They were then classified into three grades: (1) regular shape without side roots, (2) regular or slightly irregular shape with a few side roots, (3) fangy and unmarketable. Some of the roots from the crop sown in 1957 were left in the ground until 18th March, 1958 when they were lifted and examined for rotting.

TABLE 1. Yield Trials of Hamburg Parsley 1957-1958

Variety	Yield of roots cwt./acre		Yield of tops cwt./acre		Graded roots %				Rotted roots March 1958 %
					1957		1958		
	1957	1958	1957	1958	1	Market-able	1	Market-able	
Tidig vit Socker (Weibull)	206	342	129	306	69	87	85	85	16
Berliner (Daenhfeldt)	197	327	103	206	81	91	95	95	17
Halblange (Dippe)	180	324	181	287	39	76	96	96	55
Tyk Sukker (Ostergaard)	224	313	134	227	75	91	92	100	28
Kurze Dicke (Dippe)	217	301	166	298	67	92	81	86	24
Hamburg Parsley (Hurst)	—	298	—	320	—	—	61	90	—
H. Parsley (Thompson & Morgan)	—	253	—	247	—	—	77	88	—
Lange Glatte (Dippe)	160	143	167	480	18	51	0	0	21
LSD (P=0·05)	35	58	33	95	—	—	—	—	—

Varieties Tested

In 1957 six varieties from German and Scandinavian sources were tested, and in 1958 the same varieties were retested together with two strains supplied by British seed firms.

Results

In shape and size the roots resembled intermediate-type maincrop carrots, except for those of the varieties Lange Glatte and Hamburg Parsley (Thompson & Morgan) which were very long and thin. The skin of the roots was usually somewhat wrinkled but the variety Berliner gave roots which were distinctly smooth-skinned, especially in 1957. The core of the roots was large in comparison with that of most varieties of carrot and it was comparatively flavourless. Most of the characteristic flavour of the vegetable derives from the cortex.

No split roots were observed in any variety and few plants bolted. In 1958, however, about 15% of the plants of Lange Glatte bolted and a small number of those of varieties Tidig vit Socker (Weibull) and Hamburg Parsley (Thompson & Morgan).

Table 1 shows the yields of roots and tops, and the proportions of first grade, marketable roots and rotted roots.

Discussion and Conclusion

The crop was easy to grow and fairly productive, and is probably quite suitable for cultivation in Scotland. With the exception of the variety Halblange, a fairly high proportion of the roots which had been left in the ground survived the winter of 1957-58, indicating that the crop is hardier than carrots and probably nearly as hardy as parsnips.

The main fault of most varieties is that they produce a fairly high proportion of roots which have thick side-roots or are excessively fanged. This fault was most apparent with the long-rooted varieties Hamburg Parsley (Thompson & Morgan) and Lange Glatte, and as the second of these also yielded poorly it is probably unsuitable for cultivation in Scotland. The other six varieties, however, gave fairly good yields of marketable roots and it is difficult to single out any one variety as clearly better than the others. The three varieties which yielded best were: Tidig vit Socker from W. Weibull, A.B., Landskrona, Sweden; Tyk Sukker from Østergards Frøavl A/S, Stensballe, Denmark; and Berliner from A/S L. Daehnfeldt, Odense, Denmark. The quality of the roots of the first of these varieties was only moderate but that of the last was good.

The strains of Tyk Sukker and Berliner grown in the trials described here also gave good results when compared with 14 other strains in Denmark between 1954 and 1956 (Blankholm & Klougart 1957).

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A REVIEW OF RECENT RESEARCHES ON BRASSICA OLERACEA*

C. NORTH

From a horticultural standpoint *Brassica oleracea* is probably the most important crop species in the world. It thrives in climates as different as those of equatorial Africa and Alaska, and is cultivated in nearly all countries. In Britian and other parts of western Europe, it is rivalled in importance only by peas. Somewhat neglected by professional horticulturalists in the past, *B. oleracea* has become more popular as a subject for research during the last ten years and it is now becoming a respectable, and one might even say, a fashionable subject for study. It is to be hoped that this vogue will extend to all branches of horticulture and that soon, students may be expected to have as good a knowledge of, for example, the factors influencing premature bolting in cabbage as they have had in the past of orchard design and the principles of budding and grafting.

The successful cultivation of any crop mainly depends on three factors: these are choice of a suitable variety, resistance of the plants to pests and diseases, and a suitable environment. It is proposed to divide this review into three sections corresponding roughly to these three aspects of crop requirements. However, the third section will be expanded to include briefly not only the effects of environment on growth and development but also some investigations on the broader aspect of physiological studies.

VARIETY

During the last few years there have been some changes of emphasis in the demand for brassicas principally because of:—

(a) changes in consumer preference: with the rising standard of living the demand for the cheaper kinds of vegetables has fallen in favour of the choicer and more expensive kinds.

(b) increasing confidence in the results of officially sponsored variety trials: commercial growers are now inclined to place more reliance on these impartial assessments and less on the claims of those who sell seeds.

(c) the increasing demand for brassicas for canning, quick-freezing, prepackaging, and to a lesser extent, dehydration. This has involved a search for varieties specially suited to these processes. Some little-known kinds of brassicas, such as calabresse, are being grown for quick-freezing, and special varieties of popular kinds, such as Brussels sprouts, are required for quick-freezing and canning.

Brussels Sprout

This is probably the most important kind of brassica grown in Britain. There is a bewildering number of ill-defined strains and for many years the

*Based on a paper given at N.A.A.S. Inter-regional Horticultural Staff Conference, Keswick, February, 1959.

grower has not had a reliable impartial guide as to which of these best suits his needs. The trials run by the National Institute of Agricultural Botany (N.I.A.B.), in conjunction with the advisory services, have gone a long way to sort out the tangled situation and work at Mylnefield has extended the investigations to Scotland.

The first series of N.I.A.B. trials (Finch, 1952) indicated the superiority of the varieties Cambridge No. 1 and Masterman. Later trials, however, (Finch, 1954) showed that Masterman, and also Evesham Special, Masterpiece and Best of All, usually outyielded Cambridge No. 1. Trials at Mylnefield (North & Frith, 1957) confirmed that Evesham Special and Masterman were more productive there than Cambridge No. 1 and further tests have shown that, in Scotland, Cluseed may often give higher yields than any of these three varieties.

All the varieties referred to above give good yields of sprouts which are of medium to large size (1.2-2.0 in. diameter), acceptable in most markets. However the quality of the sprouts—in terms of firmness, greenness and smoothness—is often poor. It seems difficult to find strains which produce sprouts that are both reasonably large and very firm and dark-coloured. The compromise is choice of a variety which gives sprouts of high quality but sub-optimum size. At Dundee we find Cambridge Special a useful "compromise" variety for the green market although it has two defects; it is difficult to pick, and the sprouts tend to rot more readily than those of many other varieties.

Before long, high quality strains of sprout suitable for the green market may become available. Professor G. O. Sherrard's (Sherrard, 1952) thirty years of breeding work with Brussels sprout at Dublin University is now coming to fruition and some of his strains look very promising. His variety Irish Elegance, which will probably be released in 1960, seems to produce good yields of fairly large sprouts of high quality. Already, one of the family, Glasnevin Supreme, is available from some seed firms. It is giving good results in some areas but the quality is certainly not as good as that of Irish Elegance and it produces sprouts which are too small for most markets.

For quick-freezing, varieties which give a high proportion of small, dark green sprouts that will pass through a $1\frac{1}{8}$ in. sieve are usually required. Cambridge Special is often used, but the sprouts are rather large and are prone to rotting. The varieties Harrison's Freezer, Clucas Canner and de Rosny are also being used for processing and several of the small-sprouted Dutch varieties, described by Jensma & Kraai (1954) seem to be suitable. The Dutch variety Sanda has done well in Scotland (North & Frith, 1957); it gives good yields of small, very dark green sprouts which do not tend to rot like those of Cambridge Special.

Amongst more unusual sorts there is the unique red-sprouted Dutch variety Rubin which has been available for some years. It is a novelty which might be useful for pickling and as a curiosity for private gardens but the strain is variable and not very productive. A Japanese line from Takii, called Jade Cross, aroused considerable interest when it was first grown in Britain in 1957, because it is the first F_1 hybrid variety of Brussels sprout ever to be put on the market. The strain is very uniform and early maturing

but our experience with it in Scotland during 1958 has been disappointing. The lower sprouts tended to blow badly and the variety consequently gave a high proportion of unmarketable waste.

Cabbage

The demand for summer cabbage seems to be decreasing, but large quantities of spring- and winter-maturing varieties are still needed because they are usually available at a time when choicer fresh vegetables are not.

Johnson (1956) compared 100 strains of spring cabbage which he was able to classify into 17 groups based on differences in period of maturity, shape of head and other morphological characters. Some varieties, such as Rous Lench, were especially suitable for use as spring greens and others, such as Harbinger, as early hearting cabbage. Although varieties like First Early Market 218 and Early Spalding gave good crops suitable for either purpose, they formed loose, coarse heads of a type which is not popular in southern markets. A first rate dual-purpose spring cabbage has yet to be found.

Of the varieties which mature in late autumn, Christmas Drumhead is probably the most popular. However, strains are very variable and although attempts have been made by Mr D. Boyes and others to improve this variety, there are no stocks which can be relied upon to give good crops in all areas. Climatic conditions in northern Britain seem to bring out the worst points of Christmas Drumhead and it is hardly worth growing in many parts of Scotland. Trials at Mylnefield indicate that Rearguard and some of the American strains such as Oakview Ballhead or the Norwegian Blåtopp are preferable.

January King remains the hardiest winter cabbage but, in spite of breeders' efforts, all strains produce a high proportion of plants with loose heads. In Scotland, experiments with the continental types of cabbage, grown for winter storage, indicate that these varieties might be cultivated successfully in areas where January King is often a failure. None of them is fully hardy: the heads must be cut in late October or November and stored for use during the winter in barns, clamps or specially designed stores. At Dundee the trials are designed on similar lines to those made recently in Sweden (Nyhlén, 1958) and strains of the Danish variety Amager are being tested.

Trials with savoys are in progress at the N.I.A.B. (Finch, 1957). The variety Best of All is uniform and seems to give the best early winter crop of good quality. For late crops the variety Alexanders No. 1 is probably the most suitable.

Before leaving cabbages one should mention the work on dehydration of vegetables by Mr E. G. B. Gooding at the Experimental Factory of the Ministry of Agriculture, Fisheries and Food at Aberdeen. When reconstituted, cabbage which has been dehydrated correctly is as good as the fresh vegetable in appearance, taste, texture and vitamin-content and has the advantages of being easily stored and quickly prepared for use. At Mylnefield we are collaborating with Mr Gooding to find which are the most suitable varieties for dehydration. Preliminary results suggest that Copenhagen Market and Winningstadt may be satisfactory whereas Flower of Spring and Rearguard are less suitable.

Cauliflower

Trials with early summer cauliflower by Finch (1954) showed that the behaviour of different varieties varied greatly according to soil, climatic and cultural conditions. It is impossible, therefore, to single out varieties which are clearly suitable for all areas. Of the six varieties tested, Meteor matured earliest although somewhat later than Cambridge No. 5 which was grown in earlier trials; possibly Pioneer and the similar variety 110 were the highest-yielding midseason kinds of good quality. Remme proved to be specially prone to " blindness."

The two varieties of autumn cauliflower most widely grown are Majestic and the later-maturing Novo. N.I.A.B. trials (Finch, 1953) have suggested that the variety October may be superior to Majestic and that Lucifer could replace Novo. A comparatively new variety, Tremendous, matures latest of all, being ready for cutting after the old variety Veitch's Self Protecting. However, it is a risky crop to grow because it is prone to " riciness," and, as it matures very late, it may be damaged by autumn frosts.

Trials at Rosewarne have confirmed that only the Roscoff types of winter cauliflower are suitable for growing in the south west of England (Shepherd & Wood, 1957). All other tested varieties were susceptible to ringspot (*Mycosphaerella brassicola*) except the old Cornish type, which produced poor quality curds. Amongst the Roscoff varieties some new strains from Seale-Hayne have given good results in Cornwall, Devon and Hampshire (Finch, 1957).

Roscoff varieties do not often survive the winter in Scotland except in some sheltered coastal areas. Indeed, plants of even the hardiest strains of winter cauliflower are frequently killed by frost in many parts of Scotland. Trials at Mylnefield have shown that St. George is one of the most reliable varieties.

Breeding of Improved Varieties

There is clearly a need for improved varieties of some kinds of brassicas. In the past, most new strains have been raised by mass selection but a more scientific approach to vegetable breeding was commenced in Denmark, America and Holland some thirty years ago. Apart from work done at the John Innes Horticultural Institution, by Dr Davey at Edinburgh, Mr D. Boyes at Cambridge and Mr F. R. Horne at Seale-Hayne, little official work on the breeding of horticultural brassicas was carried out in Britain until about 1950. Breeding programmes are now in progress at Mylnefield and on a large scale at Wellesbourne.

The results of such studies as have been made on the genetics of *B. oleracea*, afford little guide to breeding practice, probably because most of the agronomic characters of this species are polygenic in nature. Knowledge of this basic work is, however, essential to all those working with this crop and the recent thorough survey of the subject by Yarnell (1956) is extremely useful. Most current work is concerned more with breeding techniques and aids to thorough selection than with formal genetics.

One of the great problems with brassicas is strain uniformity. This might be achieved quickly by inbreeding, but with nearly all forms of *B. oleracea*, except the early summer cauliflower, inbreeding is usually accompanied by

loss of vigour However, inbreeding might not always be disadvantageous, and attempts are being made to produce a self-fertile line of Brussels sprout which, like some cauliflower strains, will retain its vigour when inbred.

Strain uniformity can also be gained through controlled outbreeding by producing F_1 hybrid strains. This technique might, in addition, give improved yields and other heterosis effects such as cold resistance (Zeewart, 1955). Hybrid strains of cabbage and Brussels sprout have already been produced in Japan by allowing insects to pollinate compatible pairs of inbred lines that are self-sterile under field conditions. The two parent lines are maintained through the self-pollination by hand of unopened flowers which are self-fertile at this stage of development. Hybrid strains might also be produced by allowing insects to pollinate male-sterile (m.s.) plants with pollen from a normal male-fertile line. Male-sterile plants have recently been discovered in cauliflower (Jensma, 1957) and Brussels sprout (Haigh, 1958; North, 1958). There are indications that some types of male sterility in *Brassica oleracea* are gene-controlled and that the cytoplasm plays no part in the inheritance of this character. Jensma (1957) and Johnson (1958) consider that a single recessive gene is involved but it seems probable that the type of male sterility found at Mylnefield may be governed by more than one gene.

Simple gene control would complicate the practical application of male sterility because, as m.s. plants cannot be self fertilized, crossing to male-fertile lines would yield progenies 50% only of which would be male-sterile. It would therefore be necessary (a) to find a m.s.-linked marker-character, such as the leaf colour of Hansen double stocks, so that m.s. plants could be picked out at an early stage of growth, (b) to maintain m.s. clones by vegetative propagation or (c) to induce plants normally m.s. to produce pollen by artificial treatments. Other types of male sterility, such as that cytoplasmically inherited in onion, may exist in brassicas and if this is so pure lines of m.s. plants could be obtained.

Aids to critical selection are constantly being studied. For example, Krickl (1942) has found a relationship between the length of "core" in cabbage and the proneness to bursting of the head, and at Mylnefield (North, 1959) a relationship between leaf-shape of seedling and time of maturation in cabbage has been discovered. At Mylnefield we have also devised a machine for measuring the firmness of Brussels sprouts (North & Frith, 1959) and this has made possible very careful selection for this important quality.

Another aid to critical selection is vegetative propagation. By this means a clone of a chosen genotype can be multiplied and the plants subjected to a wide range of environments. Thus the tolerance of the genotype to adverse conditions may be examined before it is used in a breeding programme. Although most brassicas can be propagated vegetatively without difficulty, it is not easy to obtain clonal material of some varieties of cauliflower. Nieuwhof (1958) obtained good results by cutting off the curd. This induced adventitious shoots to form on the roots and these were struck as stem cuttings.

Having produced a desirable strain it is an advantage if it has a clear marker-character as an aid to the detection of contamination through outbreeding. An example is the white-petal character, which Pearson (1929) found was controlled by a single dominant gene, and which occurs in a hetero-

zygous condition in some broccoli strains (confirmed recently by Anstey, 1955). At Mylnefield we are attempting to transfer this character from broccoli to cabbage by backcrossing and hope thus to produce a strain which, in one respect at least, is clearly recognisable from all others. We have also attempted, by irradiating seed with gamma rays and neutrons, to induce small mutations in morphological characters which may serve as markers. So far the work has given no useful results.

PESTS AND DISEASES

Undoubtedly the most important pest of brassicas is the wood pigeon. It does untold damage to winter cauliflower and spring cabbage and is also troublesome on Brussels sprouts. Some growers claim to have had good results by spraying plants with repellant chemicals, placing red bottles on bamboo canes in the crop and by using mechanical bird scarers but none of these methods of control has met with consistent success in all areas. The best type of acetylene-operated bangers are useful but they do not work well in very cold weather, when they are most required, because the water used to generate the gas freezes. The only satisfactory control known at present seems to be the persistent use of the shotgun.

Great advances have been made in the control of insect pests with the new insecticides. At one time cabbage white fly was a scourge of Brussels sprout, and it is estimated that cabbage aphides cause a million pounds worth of damage in Britain (Strickland, 1957). Both these pests can now be controlled by some of the new, less persistent systemic insecticides, such as methyldemeton, which may safely be applied to Brussels sprout crops in August and September.

A fair degree of control of cabbage root fly is obtainable with insecticides, used either as drenches or as dips applied to seedlings at transplanting time. Wright (1952) found that gamma-BHC, chlordane and parathion gave good control on cauliflowers. More recently Moreton *et al.* (1957) have found dieldrin particularly useful for controlling this pest and experiments at Mylnefield have confirmed this view. Dieldrin is especially useful because it has much less phytotoxic effect than gamma-BHC or mercurial compounds.

Two pests which are usually of little importance, but which have caused widespread damage in recent years, are swede midge and diamond back moth. Swede midge caused much blindness of cauliflower and cabbage in the north of Britain during 1957. A preliminary trial at Perth by Osbourne & Turner (1957) showed that 0.1% DDT emulsion applied twice to cauliflower plants in the seed bed and twice after transplanting gave a better control than either BHC, dieldrin or methyldemeton. Diamond back moth caused severe damage in many parts of Britain during 1958; it seems fairly readily controllable provided the onset of an attack is noted in good time.

Although diseases of brassicas have been much studied during the last few years, few results of practical interest have emerged. Broadbent's (1957) work on brassica viruses is a notable exception for it has clearly indicated the value of barrier crops of cereals as a means of decreasing the spread of virus in market crops, and the importance of isolating seed crops from those intended for market.

The vexed problem of a really satisfactory control of club root has not yet been solved and the results of recent tests with new fungicides are conflicting. In America, Gallegly & Bishop (1955) considered that PCNB mixed with the soil gave an effective and economic control of club root in cauliflower and broccoli, and Campbell (1954) found Mathieson 275 applied before planting, or thiram directly after planting, effective controls. Rosser (1957) tested griseofulvin, mercuric chloride, PCNB and cadmium chloride and obtained best results with the well-known mercuric chloride treatment. Rich (1957) found that griseofulvin and zinc glass frit applied to the soil gave a measure of control. Last year, Keyworth (1958) reported that trials at Wellesbourne had indicated that aldrin might control club root to some extent in soils where the pH level is fairly high; this is good news, for aldrin also controls cabbage root fly.

Ringspot (*Mycosphaerella brassicola*) continues to be troublesome in some areas, especially on Brussels sprout crops grown near to the coast. Tests of 40 varieties of Brussels sprout in Holland by Quack (1957) did not reveal any varietal differences in susceptibility, but Wood (1956) reports that the variety Carclew's Universal shows some resistance to the disease. It seems probable that the breeding of a ringspot-resistant strain of sprout comparable to the resistant Roscoff types of Broccoli may eventually solve this problem.

In 1953 Dr R. E. Taylor of the N.A.A.S. isolated the fungus *Verticillium dahliae* from Brussels sprouts growing at Evesham, and it is possible that this fungus may be a widespread cause of disease. The symptoms in Brussels sprout include stunting of the plant, death of the leaves, or, characteristically, the halves of leaves, and brown discolouration of the vascular system of the stem and roots (Isaac, 1957). The fungus does not seem to be seed-borne and at present the only control measure is special attention to hygiene. If infected leaves and "runts" are ploughed into the land the organism will be returned to the soil and further infections may occur.

Occasionally wirestem, caused by *Rhizoctonia solani*, is a serious trouble in brassica seedbeds. The traditional treatment for this disease is mercuric chloride, a substance which is fairly effective but which may cause severe stunting of the plants. Work at Wellesbourne (Keyworth, 1959) has shown that PCNB dust gives at least as good a control of wirestem as does mercuric chloride and is less phytotoxic.

Another disease causing some concern is the internal rotting of Brussels sprouts. It seems probable that this is not a pathogenic, but rather a physiological disorder, possibly resulting from a mineral deficiency or toxicity. The symptoms are somewhat similar to the well known "scorch" of winter cauliflower leaves, recently described by Jenkinson & Campbell (1957), and to "internal tipburn" of cabbage described in America by Walker & Edgington (1957). So far the causes of these diseases have not been identified. However, trials at Mylnefield have shown that varietal differences in susceptibility exist and suggest that these are heritable. Selection of resistant strains should therefore be possible.

PHYSIOLOGICAL STUDIES

Research work on the effects of environment on the behaviour of *B. oleracea* started with the investigations of Miller (1929) on cabbage, and Stokes

& Verkerk (1951) on Brussels sprout. These workers showed that both plants are day-neutral and that flowering is induced by a period of cool treatment, provided that the plants have reached a certain size—that is, if they have passed a physiological state which has been termed "puberty." Chroboczeck (1955) has recently repeated and elaborated Miller's work and obtained similar results.

Within the last few years attempts have been made to induce or prevent flowering by treating brassica plants with growth substances. Generally speaking, none of the substances tested were substitutes for cold treatment, but some hastened or delayed flowering, especially if applied during a period of cold treatment. De Zeeuw & Leopold (1955) induced Brussels sprouts, which had not reached puberty, to initiate flowers by applying auxin simultaneously with cold treatment. Moor (1955) found that CLPP (alpha-ortho-chlorophenoxy-propionic acid), when applied to juvenile plants during a cold period, tended to delay or prevent bolting, but if it was applied to plants which had passed puberty immediately before cold induction treatment it hastened flowering. He also found some evidence that maleic hydrazide, applied during cold treatment, hastened flowering. These experiments indicate that it may soon be possible, by chemical treatment, to prevent undesirable bolting in crops, such as spring cabbage grown for market, and to hasten flower formation in some brassica seed crops.

The cauliflower is somewhat different to cabbage or Brussels sprout in its requirements for flower initiation. It can be grown as an annual, and exposure to low temperature is not essential to the formation of a "curd" and flower initials. Parkinson (1952) has shown that a cold treatment after the plant has reached puberty does, however, hasten development of the curd. Of special practical interest is his conclusion that checks in growth do not as a rule encourage the premature formation of small heads—a condition known as "buttoning"; indeed, checks other than a succession of cold nights seem frequently associated with delayed heading. Jensma (1957) has also studied buttoning. He found that if the plants are still in the vegetative phase at transplanting time, buttoning does not usually occur. However, if the plants have passed into the reproductive phase before transplanting, then buttoning may be prevalent. These conclusions are supported by experiments which showed that plants, which had been crowded in the seedbed and were therefore assumed to be retarded in physiological development, buttoned less than plants which had enough space in the seedbed to permit rapid development. Jensma also found that applying molybdenum to young plants sometimes decreased buttoning, a fact which suggests a similarity between certain types of buttoning and whiptail.

An understanding of the effect of a cold period on the development of cauliflower has been complicated by recent work on "blindness." In the past this condition has often been attributed solely to damage by swede midge larvae. Wiebosh (1950), however, considers it to be caused by the subjection of plants to low temperature at an early stage of growth or to dry conditions and high nitrogen content of the soil. Mounsey-Wood (1957) found that it is most frequently associated with exposure to low temperature and that varieties differ in susceptibility; Salter (1957), working at Wellesbourne, in-

dependently reached similar conclusions. Temperatures of 32-33°F. have been used to induce blindness artificially; these are appreciably lower than the threshold temperature of 40-45°F. thought to be critical for flower initiation. It seems, therefore, that blindness may be a form of damage to the delicate tissues of the growing point rather than a physiological condition induced by low temperature.

So far, this review has dealt only with factors affecting the initiation and development of the reproductive phase of *B. oleracea*, whether it is bolting in cabbage or curd-formation in cauliflower. Several of the forms of this species have, however, been selected for parts which develop during the vegetative phase of growth, for example, the "head" of the cabbage and the "bulb" of the Kohl rabi. The development of these parts has been studied at Mylnefield. This work, part of which has already been published (North, 1957), has yielded information which is mainly of academic interest. Very briefly, it seems that difference in rates of maturation of different varieties of cabbage are associated with differences in the times at which leaves cease to unfold rather than with differences in rates of growth in weight or rates of leaf-unfolding. The time at which leaves cease to unfold is related to the length-width ratio of the leaves, and it seems probable that mere mechanical constriction of leaves may play an important part in preventing leaves from unfolding. As has already been mentioned, a practical application of this finding may be the selection of strains in the seedbed for relative times of maturation.

This is not a comprehensive survey of recent work on brassicas, most of which has been published since 1954, but the extent of the investigations clearly shows the rising interest in this species. Some of the investigations are of an exploratory nature and these have revealed opportunities for expansion of the research, especially in studies of breeding techniques and the physiology of the species. No doubt we shall see a further expansion of this work, and more research papers, in the next few years.

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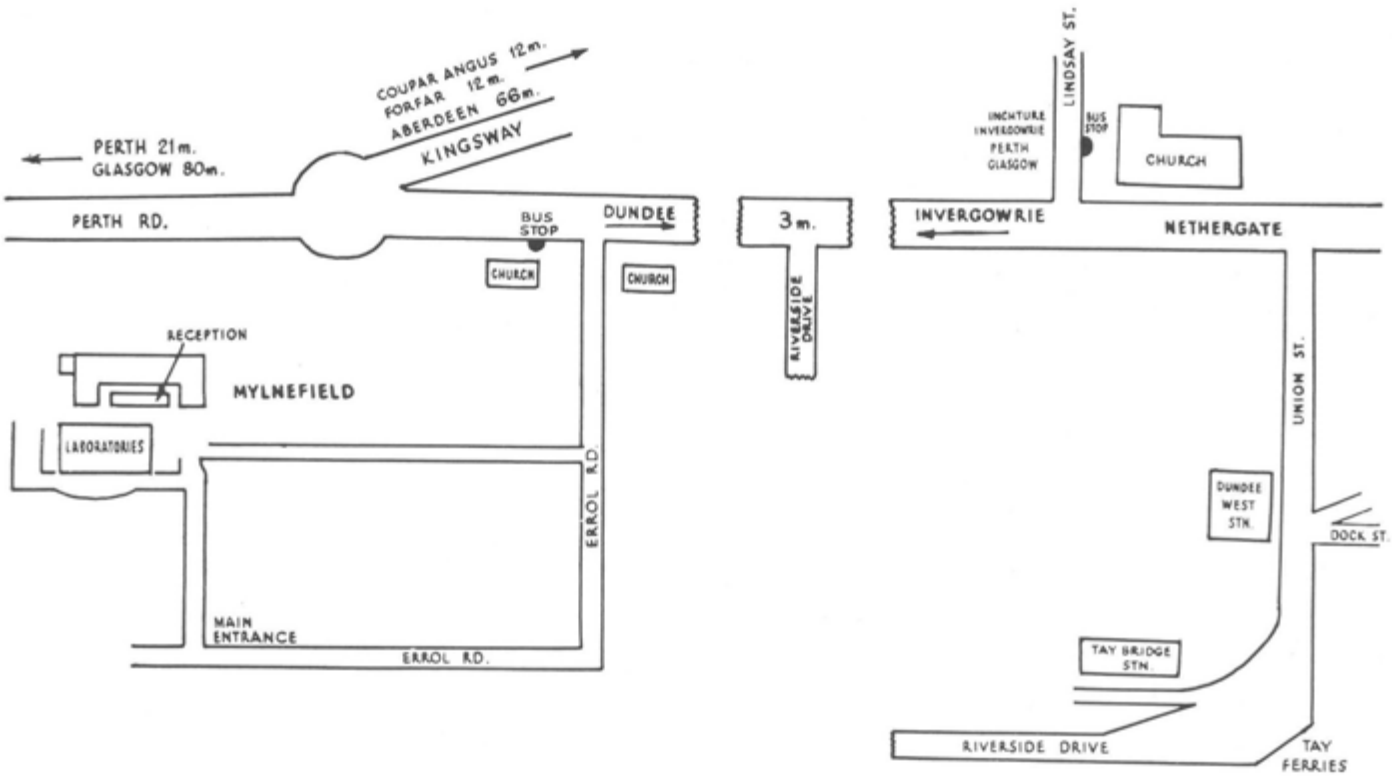

Sketch plan of routes to the Institute