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ANNUAL REPORT

THE SCOTTISH HORTICULTURAL RESEARCH INSTITUTE

1955-56

THE INSTITUTE'S NEW LABORATORY AND GLASSHOUSES AT AUCHINCRUIVE, AYR.

THE SCOTTISH HORTICULTURAL RESEARCH INSTITUTE

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THE DIRECTOR'S REPORT

We have now had a full year's experience of working in the new laboratory building and, whilst the original allocation of rooms has worked out fairly well, staff build-up during the year has made some re-arrangements necessary. The most important of these involves Laboratory Service, originally allocated one small room in the main building. This proved inadequate and Laboratory Service has been moved to the temporary laboratories in the glasshouse block where two workrooms and a darkroom have been provided. These will serve until a future building programme allows us to bring the service back into the main building where it belongs. All the available laboratory space in the main building is now in use and part of the staffs of the Vegetable Culture and Pomology Departments still occupy the rooms made in the farm buildings.

It was hoped that the new laboratory block would be officially opened during the summer of 1955. However, circumstances made a postponement highly desirable and arrangements have now been made for the opening ceremony to be performed on Saturday, June 16th, 1956, by Mr Niall Macpherson, Joint Parliamentary Under Secretary of State for Scotland.

The outline map of Mylnefield and Bullion farms (p. 20) shows that, after 4 years, already 80 acres are occupied by field experiments and demands on land for this purpose are increasing rapidly. These are coming mainly from the Departments of Pomology, Plant Pathology, Genetics and Vegetable Culture. In Pomology, field work on the culture and breeding of soft fruits is expanding; Plant Pathology is conducting investigations into the spread of virus diseases and the behaviour of insect vectors under field conditions; and the Genetics Department requires increasing areas of land for the growing on of large numbers of strawberry seedlings raised in the course of work on June Yellows. Although these experiments involve a fair acreage, most of the current plantings have an expected duration of ten years or less so that the land will, within a few years, again become available for experiments.

Adequate rotation of cropping is essential for the kind of work carried out by the Vegetable Culture Department and the purchase of Bullion farm made it possible to allocate about 50 acres in Bullion North and South fields exclusively for this work. The Department of Agriculture for Scotland kindly made detailed contour maps of the fields concerned and, on the basis of this information, all the suitable land was permanently marked off into strips, 100 or 120 ft. wide, separated by 15 ft. alleyways. For future reference, records will be kept of the cropping, manurial and other treatments each strip receives. This development has raised special problems. Initially, the land was in semi-permanent grass, heavily infested with weeds and the cost of cleaning has been high. Moreover, as these plots are sited in the centre of two 40 acre fields, there are irregular fringes of relatively poor land difficult both to cultivate and to fit into the farm rotation. Production costs of crops on such areas are thus unduly high.

Substantial progress has been made during the year in the provision of roads, fences and windbreaks. The area behind the main laboratory building has now been kerbed and laid with tarmacadam. The area in front of the building and the approach road from the south have been kerbed and bottomed, and tarmac has been promised for spring 1956. The access road from the village has been much improved. The large banks of earth that had accumulated on either side were cleared away and tarmac was laid on the road surface. A further length of boundary fence was erected and the approved programme of windbreak planting will have been carried into effect by the end of the planting season.

STAFF

There have been a number of staff changes during the year. In the Pomology Department, Dr M. E. Acheson resigned on her marriage to Dr Sudd of Queen's College, Dundee, and our best wishes go with her to West Africa. Miss B. Tulloch and Mr H. Taylor, from East Malling Research Station and the John Innes Horticultural Institution respectively, were appointed as Assistants (Scientific) in April. Finally, in January, the Department welcomed Mr D. W. Burd, appointed to undertake a programme of raspberry breeding. Following a course of training at the Essex Institute of Agriculture, Writtle, Mr Burd was for two years a member of the plantations staff at Long Ashton Research Station. Mr M. M. Anderson was awarded the National Diploma in Horticulture. He now has the unusual distinction of holding the National Diploma in Horticulture, the Scottish Diploma in Horticulture and the Diploma of Horticulture of Edinburgh.

In November opportunity occurred to appoint Mr P. A. Thompson to the staff of the Department of Crop Physiology where he will assist Dr C. G. Guttridge in his strawberry investigations. Mr Thompson has a practical horticultural background and, after graduating in horticulture at Wye College, spent a further year in commercial fruit and vegetable growing.

In the Plant Pathology Department, Miss K. S. Anderson resigned in September and Miss A. Bulloch was transferred from Laboratory Service to assist with the work on virus diseases. Mr A. G. Richardson left in November to take up an appointment with the Shell Petroleum Co. Ltd.

Miss Frances Higgins resigned her post as shorthand-typist at the West of Scotland Unit to go to Canada. She joined the original Strawberry Disease Investigation in 1948. Her place has been taken by Miss S. A. Dodd. Miss A. M. Jobbins joined the West of Scotland Unit as assistant to Dr Montgomerie. Miss J. Weaver was also appointed to the staff of this unit but is stationed at Mylnefield, where she is largely concerned with work arising from the research done at Auchincruive.

Considerable difficulty has been experienced in keeping the labour force up to full strength. One young man was called for National Service and it has proved difficult to replace him because he did not live in one of our own houses. It is becoming increasingly clear that in order to obtain labour it is necessary either to provide housing accommodation or pay a rate sufficient to offset the cost of travelling to and from work.

OTHER ACTIVITIES

It is with pleasure that we record the award of the Veitch Memorial Medal to Mr R. D. Reid for his outstanding work in strawberry breeding. We offer our sincere congratulations for this well merited recognition by the Royal Horticultural Society. It is also a pleasure to report that the University of Glasgow has appointed Mr Reid honorary lecturer in Plant Breeding in the Department of Botany. In addition to honouring Mr Reid, this appointment will provide a valuable link between the University and the Institute.

The Director, Dr Cadman, Mr North and Miss Priestley attended the 14th International Horticultural Congress at The Hague. Dr Cadman read a paper to the Plant Diseases section of the Congress and attended the 2nd Symposium on Virus Diseases of Fruit Trees in Europe at Wageningen. Mr North and Miss Priestley attended a conference on vegetables also at Wageningen, and after the Congress Mr North visited research establishments and vegetable seed firms in Holland, Denmark and Sweden. In December, Mr Reid and Dr Wood lectured to a growers' conference at Stirling. Mr Reid continued to serve on the Strawberry Sub-committee of the National Fruit Trials and both he and the Director attended the scientific session of the Annual General Meeting of the Nuclear Stock Association in London.

During July, the Institute was visited by an A.R.C. group that included Professor Stoughton, Mr Bawden and Dr Brown with Professor Mather as chairman. The group spent one day at Auchincruive and two days at Mylnefield. All the staff had an opportunity of discussing their present and future work and the visit was helpful and useful.

The Institute was visited by scientists from Canada, U.S.A., New Zealand, Uganda, Nepal, Nigeria, the Netherlands, Germany, Poland, Jugoslavia and Portugal. It is a pleasure to welcome these visitors, many of whom have to make the long journey north for the one visit. The Director was particularly glad to welcome Mr Donald Blair of the Central Experimental Farm, Ottawa, Canada, for he was the Director's first post-graduate scholar at Long Ashton. At the request of the British Council, the Institute received Dr S. A. Paunovic of the Institute for Fruit Culture, Cacak, Yugoslavia for a week's study-period. The Scottish Fruit Trials Committee under its chairman Mr Robert Scarlett held its summer meeting at Mylnefield and on 23rd July a Growers' Day was held when some 80 visitors inspected the plantations.

COLLABORATION

It is a pleasure to acknowledge the collaboration and assistance given by the British Food Manufacturing Industries' Research Association, Leatherhead; Messrs Chivers & Sons Ltd., Montrose; Eastern Counties Preserves (1940) Ltd., Forfar; Messrs Smedleys Ltd., Dundee; East Malling Research Station; Long Ashton Research Station; the John Innes Horticultural Institution; the National Fruit Trials; and the Royal Botanic Garden, Edinburgh. Thanks are due also to the Chief Surveyor of the Department of Agriculture for Scotland and his staff for the preparation of the maps reproduced in this report.

FARM AND PLANTATIONS

by L. S. GRAY

In contrast to last year, the rainfall of 17·5 inches was unusually low for the district. Outdoor work proceeded almost without hindrance from March to November but the scarcity of rain caused much anxiety over the fate of newly transplanted crops.

FARM SECTION

Grain crops grew well and yields were fair. Wheat (variety N.59) yielded almost 8 quarters (36 cwt.) per acre; barley again cropped well, giving about 8 quarters (32 cwt.) per acre, but oats were below average, about 8 quarters (24 cwt,) per acre. Symptoms of manganese deficiency, "grey speck," appeared on oats in South Bullion field at the beginning of June but the crop recovered well after spraying with 2 per cent. manganese sulphate solution.

Root crops suffered considerably from the drought. One break of sugar beet suffered from "strangles" and the whole crop wilted severely for many weeks. Nevertheless the yield was about 10 tons clean beet per acre with a sugar content of 18·76 per cent., well above average. Yields of swedes and turnips were sufficient to provide a winter ration for housed cattle. Hay gave a moderate crop of good quality.

Thirty-five head of beef cattle were fattened in the courts and 43 were summer grazed but the general trend of the fatstock trade was not in our favour.

FRUIT AND VEGETABLE SECTION

New plantations of soft fruit included $\frac{1}{4}$ acre of Talisman strawberry in Bungalow field, $1\frac{1}{2}$ acres of Climax in Laboratory field and a $\frac{3}{4}$ acre runner bed of Talisman in Loan field to provide material for 1956 planting. Raspberry experiments were planted in East Loan field, raspberry nuclear-stock nurseries in West Laboratory and Loan fields and black and red currant experiments in Bungalow field.

The soft fruit crop was considerably less than that of 1954. The hot dry weather shortened the season for strawberries and the later varieties of raspberry; blackcurrants suffered severely from the frosts and cold weather of April and May. Fourteen tons of raspberries were sold, chiefly for jam manufacture in Dundee, but the strawberry crop did not exceed 30 cwt. of saleable fruit and the crop of black currants, 10 cwt., was about a quarter of the 1954 crop.

Six acres of summer and two acres of spring cabbage were grown and the produce supplied, as part of a co-operative arrangement, to the experimental factory of the Ministry of Agriculture, Fisheries and Food at Aberdeen.

Three varieties of summer cabbage, Greyhound, Winnigstadt and Copenhagen Market, had a high dry matter content but we have had no report on the spring cabbage.

All straw not required for feeding or bedding was composted for use by the Vegetable Culture Department. Barley straw is much the best for this purpose.

GLASSHOUSE SECTION

Because of difficulty in maintaining sufficiently high temperatures in winter in the main glasshouse range, gilled pipes were added to the heating system. This, together with replacement of surplus ventilators by glass panes and caulking of draughty joints in the houses, has greatly improved growing conditions. Construction of the extension to the glasshouse laboratory has begun.

GENERAL

The surfacing of the farm yard and approaches to the main buildings, glasshouses and steading with tarmac is a most welcome improvement. The appearance of the steading has been improved further by clearing the old stackyard of rubbish and weeds.

In autumn, a mixed deciduous and coniferous windbreak was planted along the north side of East Loan field and the beech hedge, west of the glasshouse was moved to make room for extensions of the glasshouse block. In spring 1956, a line of *Chamaecyparis Lawsoniana* was planted along the north boundary of West Laboratory field and one of black poplars along the roadside boundary of South Bullion.

Distribution of virus-tested raspberry plants was resumed this year and, of the 15,000 canes sold, the majority carried an "Elite" certificate from the Department of Agriculture for Scotland.

POMOLOGY

by C. A. WOOD

The outstanding feature of 1955 was the hot, very dry summer, which shortened the soft fruit season and limited the new growth of bushes and canes. In many parts of eastern Scotland the effect of drought on raspberries and related fruits was combined with that of injury caused, apparently, by the severe late frosts of the previous winter, and resulting in a partial or complete death of fruiting canes, often on an extensive scale. At Mylnefield, this type of injury to raspberries was less serious, and confined mainly to individual buds, chiefly of the variety Malling Promise.

The season was much calmer than 1954. Tree fruit plantations at Mylnefield suffered little wind damage, and under the high summer temperatures made strong, well-ripened growth.

THE CULTIVATION OF RASPBERRIES

Some of the field experiments on cultural factors in raspberry growing were considerably affected by the dry season, and this shows the importance of continuing such work for as many years as possible. In the experiment on planting distances and heights of tipping, the widest rows (8½ feet apart) again led in fruit yield per stool, but in two of the three varieties the intermediate rows (7 feet apart) displaced the narrowest rows (5½ feet apart) from first place in yield per acre, the narrow rows apparently being most affected by the drought. In contrast with previous years, the differences in yield per acre between the various planting distances were not significant; but very significant increases of yield were again obtained by raising the height of winter tipping from 4 to 4½ feet and again to 5 feet.

In the experiment comparing the effect of planting canes singly with planting in pairs ("double" planting), begun in Spring 1952, the double-planted plots for the first time did not significantly out-yield the single-planted. Subsequent winter records in 1955-56 showed that there were still slightly more new stool canes on the double-planted plots of all varieties. The initial period of higher yields from double planting, due to greater cane production, appears therefore to have ended, and the object of future recording will probably be to detect any differences in the number or quality of canes produced under the two treatments as the plantation ages.

In the experiment on frequency of picking and number of canes fruited per stool, both Malling Promise and Lloyd George gave higher total yields when picked at 4-day intervals than when picked every 2 days. This was the reverse of previous results although the differences were not significant. It is assumed that under the very dry conditions the fruit ripened before it reached the normal size. The numbers of fruiting canes per stool compared in 1955

were 4, 5, 6 and 7, but the last two averages were reached only in Malling Promise. The first two increases in cane number gave increases of yield significant at the 5 per cent. level, a result indicating a higher level for optimum cane population than was suggested by the 1954 results.

The experiment on methods of treating the top portions of canes (var. Malling Promise) in posted and wired rows, described last year, again showed a higher yield per plot where the tops had been bent down and re-tied to the upper wire than where they had been normally tipped at the maximum convenient height for picking; but the untreated plots (with the tops free and untipped) did not, as in 1954, also out-yield the tipped.

The newer experiments on distances of planting and methods of training received most of their cane treatments during the winter, but the arching together of canes from alternate stools was impossible with the short growth of 1955. The simpler treatment of arching between adjacent stools was therefore duplicated. Two further experiments were planted in 1955-56, one to compare the performance of autumn- and spring-planted canes and the other to repeat earlier work on the influence of the time at which canes for spring planting are dug from the nursery.

Four smaller experiments planted in the fruit cage became well established, and their first-year growth was used for a trial of future methods of recording.

RASPBERRY BREEDING

A first full assessment was made of the raspberry seedling families germinated in 1953. These are from intervarietal crosses involving Malling Jewel as one parent. A high proportion of the seedlings had thorny canes and soft-textured fruit, but some of the best seedlings were marked for further use as breeding material. The families raised from seed sown in 1954 (mostly having Malling Exploit as one parent) grew well but had insufficient fruit for assessment.

As previously reported, some 7,000 seeds were sown in autumn 1954 from crosses and self-pollinations made that year. Percentages of germination were very low in two selfings of *Rubus* species and two interspecific crosses, and varied in intervarietal raspberry crosses from about 45 to about 70 per cent. Altogether, some 3,900 seedlings from ten families were planted out during the year.

Further additions were made to the collection of *Rubus* species, which, with the *Ribes* collection, is now kept in a special plot at some distance from other plantations.

(C. A. Wood, D. W. Burd and M. M. Anderson.)

STRAWBERRY INVESTIGATIONS

Four trials of strawberry varieties and stocks planted in 1952 were terminated, some of the results being included in publications on the new variety Talisman (see p. 34). Trials of recent Auchincruive selections were continued in co-operation with the West of Scotland Unit. Of the 90 seedlings planted as 4-plant blocks in 1954, 22 were retained for further trial. One hundred and twenty more selections were received for planting at Mylnefield.

Further observations on June Yellows were made on the replicated trial of ten sub-clones of Climax previously described and on samples of eleven commercial stocks of Climax officially certified in Scotland in 1954.

Defoliation of Climax plants in late summer did not increase the crop in 1955. This was contrary to the results obtained in 1954 and it is hoped to investigate this question further. The decline in vigour of stocks may however make it impossible to use Climax for the purpose.

(M. E. ACHESON, M. M. ANDERSON and C. A. WOOD.)

RED AND BLACK CURRANT TRIALS

Two replicated variety trials of red currant and several pairs of bushes for observation were planted during the autumn as a development from the variety collection formed since 1953-54. The trials are to compare new (mainly foreign) and other promising introductions with standard British varieties. The bushes for observation consist of further varieties on which information is needed.

A new black currant trial was planted at the same time, mainly to test certain varieties, including two from Scandinavia, grown on a small scale since 1952. It will also compare summer and winter pruning.

(M. M. ANDERSON, J. P. SUTHERLAND and B. TULLOCH.)

APPLE AND PLUM VARIETY-ROOTSTOCK TRIALS

Growth in the apple variety-rootstock trials planted in 1954 was in general satisfactory, though some more trees were attacked by canker and several were badly damaged in the summer by rooks. The majority of original trees in all five trials remain sound, but a few replacements will be required in addition to those noted in the 1954-55 report.

The 1953 trial of plum varieties and rootstocks clearly benefited from the calmer, warmer season and the presence of shelter trees. Growth throughout was much improved. Several trees blossomed for the first time but no fruit ripened.

(M. M. ANDERSON, J. P. SUTHERLAND, H. TAYLOR and B. TULLOCH.)

SCOTTISH FRUIT VARIETY TRIALS

The Institute continued to take part in these trials in co-operation with the Scottish Fruit Trials Committee. In the soft fruit section, the black currant crop was much reduced by frosts and cold weather in April and May, and raspberries, especially midseason and late varieties, were affected by the summer drought. A feature in the raspberry trials was the renewed good performance of Malling Exploit and Malling Promise after their poorer showing in the wet season of 1954. Exploit led in yield with a crop of slightly over 5 tons per acre. Much fruit from the trials was used for tests of processing quality, including jam-making tests at the laboratory of the British Food Manufacturing Industries Research Association, Leatherhead, Surrey, dehydration trials at the Ministry of Agriculture, Fisheries and Food's Experimental Factory at Aberdeen, and further canning and quick-freezing tests at factories in the Dundee area.

The apple variety collection on M.IX rootstock became of increasing interest during the year; 91 varieties fruited, 57 for the first time. Some 45 more varieties were added to the collection early in 1954, bringing the total to just over 500. In the "elimination" trial of modern apple varieties on four rootstocks, 57 varieties fruited, 52 for the first time. To encourage bearing, the trees of this trial and of the collection were more lightly pruned in 1955-56 than previously.

The trial of sweet cherries planted in March 1955 made satisfactory progress.

(M. M. ANDERSON, J. P. SUTHERLAND, H. TAYLOR and B. TULLOCH.)

MISCELLANEOUS

A preliminary trial of chemical herbicides for possible use in raspberry plantations was arranged in collaboration with Messrs Plant Protection Ltd., and gave results of sufficient promise to justify further work.

Routine spraying for the control of pests and diseases was again carried out with the co-operation of Mr Fisken. The only serious pest problem of the year was a heavy infestation of Glasshouse Red Spider on black currants, strawberries and raspberries during August.

PUBLICATIONS

WOOD, C. A. (1955). Raspberries for Present-Day Planting. *Commercial Grower* (Fruit Survey), 26th August 1955, 433.

WOOD, C. A. (1955). Raspberry Experiments at Mylnefield. *Commercial Grower*, 9th September 1955, 535.

GRUBB, N. H. and WOOD, C. A. (1955). Raspberries: Advice on the varieties to plant. *Grower* (Annual Fruit Review—Part 3), **44**, 825.

VEGETABLE CULTURE

by C. NORTH

Most of North and South Bullion fields have now been reserved for a five-year rotation of vegetable experiments, cereals, sugar beet, potatoes and nuclear stock material, and in 1955 all vegetable experiments were grown there. Part of this land is badly infested with couch grass, but the prolonged dry summer weather greatly helped efficient cleaning both of the experimental plots and of land fallowed in preparation for vegetables in 1956. An innovation in manurial treatment was the use of composted straw instead of farmyard manure for vegetables in order to help reduce the damage caused by club root disease.

The staffs of the Agricultural Colleges co-operated in the assessment of vegetable varieties by growing observation plots in their areas of varieties also on trial at Mylnefield. We also co-operated with the Food Division of the Ministry of Agriculture and Fisheries' Research Establishment at Aberdeen in work on commercial dehydration of cabbage.

VARIETY TRIALS

French Beans

Eight varieties were sown in a randomised-block trial, but seed of one variety, Double Princess, failed to germinate.

The exceptionally fine summer weather permitted the full development of late-maturing kinds which are usually killed by frost before they have ceased to form pods. Consequently the results of the trial gave a false impression of the average performance to be expected from the varieties in Scotland. Picking of Record, Masterpiece, Fullcrop and Saxa was commenced on 2nd August and of Processor and Fiskeby four days later, but Refugee (Idaho strain) did not mature for picking until 25th August. Refugee and Masterpiece gave the highest yields.

The results confirmed that, of the earliest maturing varieties tested so far, Record (Ohlsens Enke) gives the best quality beans. Both Processor (Ferry Morse) and Fullcrop (Hurst) appear to be of the highest quality and to mature considerably earlier than Refugee; the first-mentioned variety has white seed, a desirable character in beans grown for processing.

(L. H. FRITH.)

Spinach

Ten strains were tested in two randomised-block trials sown 30th March and 16th June. The results of the later-sown trial were of little value because the exceptionally dry soil conditions greatly reduced the rate of growth.

King of Denmark Ge/50 (Gehlins) and Troubadour (Zwaan and de Wiljes) gave good yields, as in 1954. The Strain Verina OJO/53 (Olson), not pre-

viously included in the trial, bolted later and gave a significantly higher yield than any other strain.

(C. NORTH and L. H. FRITH.)

Brussels Sprouts

The replicated variety trial included Cambridge No. 1, Cambridge Special, Evesham Special (Tozer), The Clusced (Clucas) and 7 varieties which had not previously been compared in a full-scale trial at Invergowrie. Castricum Glory (R. Zwaan) was the most uniform strain and gave a high yield of first-quality sprouts, these were fairly well spaced, and intermediate in size between those of Cambridge Special and Evesham Special.

None of the 37 strains grown in observation plots was superior to the best in the main trial; but Fancy Most 50-A (Ferry Morse) and one Dutch strain were distinct from all other varieties—they matured very early, and grew no more than 1½ feet tall.

(L. H. FRITH.)

Canning Peas

Five of the 6 varieties grown in 1954, and the previously untested varieties Monarch Canner and Wando, were compared in a randomised-block yield trial. Seed was sown in rows 12 in. apart—instead of 9 in. as in 1954—to facilitate hand hoeing, and lines of Atle wheat were grown between plots to prevent the intermingling of varieties.

The crop grew well but prolonged dry weather caused rapid maturation of all varieties and harvesting was spread over 6 days as compared with 21 days in 1954. The difference in yield between varieties was also greatly reduced. Canner's Perfection, which gave the highest yield in 1954, yielded least because half the ovules failed to develop, presumably on account of dry weather. Monarch Canner (Hurst) and Wando (Nunhem) appeared to be mid-season to late mid-season varieties capable of giving high yields.

(L. H. FRITH and C. NORTH.)

PLANT BREEDING

Cabbage and Brussels Sprout

In 1953 and 1954 strains of January King had been crossed with Amager types and Savoys as part of a programme aimed at producing new strains combining the hardiness of the first mentioned with reliable heading characteristics of other varieties. In 1955, plants from about 50 F_1, F_2 and backcrossed lines were selected on the basis of the external appearance and internal structure of the heads. These plants were pollinated by hand in a heated glasshouse and two mass selections seeded well after pollination by bees in an insect-proof house.

The objectives in brussels sprout breeding are to obtain hardy, early-maturing strains, resistant to blowing over by wind and producing sprouts of a deep green colour. To this end plants of Ashwell's strain had been crossed with Cambridge Special, Amager and Castricum Glory and the resulting F_1 lines were grown in 1955; plants selected from this material were taken into the glasshouse for pollination and seed production.

(G. PRIESTLEY and C. NORTH.)

Dwarf Beans

Interspecific crosses were made between *Phaseolus multiflorus* Willd. var. Princeps and *P. vulgaris* L. var. Record (female parent) with the object of combining the ability of the former to grow under cooler weather conditions with the dwarf habit and high quality of the latter. The F_1 plants were largely self-sterile, but some seed was obtained by backcrossing to *P. vulgaris*. The F_1 cross was made during the summer, and two subsequent generations were grown during the winter using mercury-vapour lamps to supplement daylight.

(G. PRIESTLEY.)

PHYSIOLOGICAL INVESTIGATIONS

Further comparisons between rosette-rogue and normal heading plants of January King cabbage confirmed that the two types do not differ in rate of growth of the stem or number of leaves formed on the main axis.

Flower buds on rogues collected during the winter were in a slightly more advanced state of development than those on headed plants, and it was thought that the failure of rogues to form heads might be related to early flower initiation. However, induction of flower buds by cold treatments, did not lead to the formation of rogue-like plants. It seems, therefore, that early flower initiation in rogues may be an effect rather than a cause of failure to head.

Rogues have narrower leaves than headed plants and an attempt is being made to find whether this difference is associated with the loss of ability of successive leaves of potential heading plants to unfold.

(C. NORTH.)

CROP PHYSIOLOGY

by T. SWARBRICK

LIGHT-INTENSITY INVESTIGATION

Early in 1955 it was considered that (*a*) experiments should be initiated at Mylnefield to study the pattern of seasonal growth in relation to both light intensity and temperature, and (*b*) that seasonal variations in light intensity should be investigated in various parts of Scotland. A primary requirement for these experiments is an instrument for the accurate recording of light intensity. After a careful consideration of the various types of recorder available, four identical instruments were built using the well-known principle of a circuit in which the variable resistance characteristics of an emission photo-electric cell controls the rate of charging of a condenser. The condenser is discharged through a discharge tube and the number of discharges recorded. These recorders were calibrated by reference to a 250 watt substandard tungsten filament lamp calibrated in foot candles for the purpose by Siemens Lamp Research Laboratories, Preston, and operated at a constant voltage. After calibration, the instruments were placed side by side in the open to check the calibration over longer periods and under varying light intensities. Under these conditions the instruments failed to give satisfactory replication and these inconsistences were attributed to the instability of certain of the components. These faults are being rectified and it is expected that the recorders will be ready for use at the beginning of the coming growing season.

(G. L. HODGSON.)

DORMANCY STUDIES IN THE RASPBERRY

During the autumn and winter a study was made of winter dormancy in the raspberry as part of an investigation of the causes of winter die-back. Canes were brought into the laboratory from the field at fortnightly intervals from October 11th. Detailed records have been kept of (*a*) the number of days to the first bud breaking, (*b*) the proportion of the total buds eventually breaking, (*c*) the period of time to maximum bud break. Buds on canes of Malling Promise cut in mid-October broke after 25 days and this period decreased steadily throughout the winter until, at the beginning of March, buds broke within three days of cutting. The proportion of the total buds becoming active also increased. Throughout the experiment the growth produced appeared normal. In contrast, the earliest samples of Lloyd George had not shown any activity when they were discarded after 48 days. In subsequent samples a proportion of buds broke but grew abnormally; flowering shoots developed extremely rapidly but produced few or no leaves. In the latest samples (March) leaf development appeared normal. This experiment has shown that these two varieties differ in behaviour.

(G. L. HODGSON.)

GROWTH HABITS OF THE STRAWBERRY IN RELATION TO THE ENVIRONMENT

The first series of experiments completed this year in the growth rooms was designed to find the effect of exposing plants to low temperature during winter. Plants, rooted in pots in the field in summer, were transferred to the growth rooms in November, before the onset of cold weather; similar plants that had spent the winter outdoors were transferred in March. Each set of plants was kept in the growth rooms for 12 weeks under the same conditions of temperature (60°F), daylength (11 hours) and light intensity (c. 850 f.c. or 500 f.c.). Plants of the November series produced leaves with short petioles, they continued to initiate flowers, produced no runners but formed new adventitious roots; the dry-weight of roots and crowns increased during the 12 weeks. By contrast, flower initiation in plants of the March series was delayed; they produced many runners and leaves with long petioles and the dry-weight of roots and crowns decreased during the 12-week period.

It is known from previous work that increased petiole length, increased runner production and delayed flower initiation are brought about by increasing the photoperiod. The results of the present experiment show that, in the period following exposure to winter conditions, growth under short photoperiods is characteristic of that produced at other times under long photoperiods. This would explain the observation that flower initiation in the field does not take place in the relatively short days of spring, although the autumn-formed flower buds mature and axillary buds develop as runners.

Interesting results were obtained from a pilot experiment in which each member of a pair of runner plants joined by the original stolon received different photoperiods. The older and younger members of each pair of plants (adjacent plants in a runner train) were grown under short and long photoperiods respectively. The growth habit and development of the older plants, in the short photoperiod, was directly affected by the presence of leaves on the younger plant in the long photoperiod. The length of the petioles, the number of stolons produced and the delay in flower initiation were all positively related to the number of leaves retained on the younger plant. These results are important in that they suggest that a substance is produced in leaves in long photoperiods that not only promotes vegetative growth but actively inhibits the initiation of flowers.

Field experiments were made on the mowing of foliage after fruit harvest, time of planting of runner plants and on the rooting of runner plants.

(C. G. GUTTRIDGE.)

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GENETICS

by T. SWARBRICK

STUDIES ON JUNE YELLOWS OF STRAWBERRY

Most British growers were unfamiliar with June Yellows of strawberry prior to its appearance in the variety Auchincruive Climax. This malady is, however, widespread in the U.S.A. and is there considered the cause of the disappearance from commerce of many popular varieties during the past fifty years. During the last war, Madame Moutot, an important European variety, became affected and, since then, June Yellows has been seen in other continental varieties, such as Mainperle and Multiplex.

There is no evidence that June Yellows is caused by a pathogen and much to support the thesis that the cause is genetical. For instance, most strawberry breeders have found that families derived from commercial varieties tend to have a few yellow seedlings; and at Auchincruive similar seedlings appeared in families raised from seed harvested in N. America from wild plants of *Fragaria virginiana*. This species is thought to be an ancestor of the cultivated strawberry. Yellowing in juvenile plants and the disorder in Climax may be unrelated; on the other hand, segregation of yellow seedlings may indicate proneness of particular varieties to produce offspring that are likely eventually to succumb to June Yellows (see also p. 33). To investigate these and other urgent problems connected with the inheritance of June Yellows much material has been collected and appropriate pollinations made.

The varieties selected for this work can be classified as under:

(*a*) Varieties showing a range of expression of June Yellows, *e.g.*, Climax, Madame Moutot.

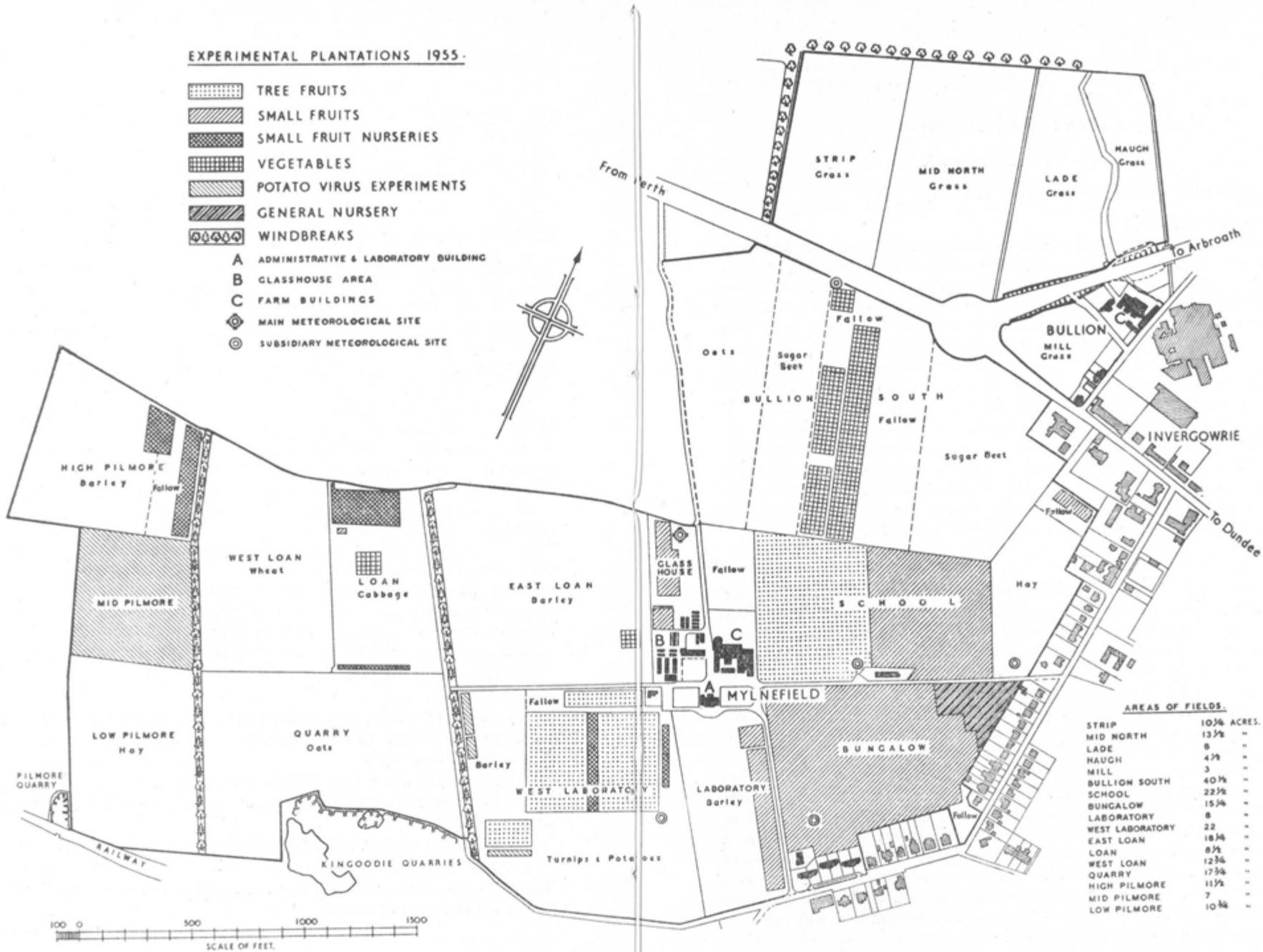
(*b*) Varieties in which June Yellows has not been observed but which are known to give "yellow" or variegated seedlings in their progeny, *e.g.*, Perle de Prague, Royal Sovereign.

(*c*) Varieties in which June Yellows has not been observed and which, so far as is known, do not give "yellow" seedlings in their progeny, *e.g.*, Cambridge Early.

(*d*) Varieties on which information is desired, *e.g.*, Talisman, 6J27.

All these varieties were selfed and reciprocal crosses made between most. The seeds are now germinating and the seedlings will be kept under observation for as long as possible.

(A. B. WILLS.)



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PLANT PATHOLOGY

by C. H. CADMAN

RASPBERRIES AND RASPBERRY VIRUSES

Properties of Raspberry Sap

Difficulties in transmitting viruses by mechanical inoculation to and from raspberry and strawberry are usually attributed to tannins present in the saps of these plants. Extracts of raspberry and strawberry leaves and roots inhibit infection of *Nicotiana glutinosa* by tobacco mosaic virus and of French bean by tobacco necrosis virus. Leaf extracts are more inhibitory than root extracts and strawberry sap is more inhibitory than raspberry sap. However, sap from raspberry seedlings raised during the winter did not inhibit virus infection. The inhibitors present in raspberry and strawberry extracts are dialysable and are precipitated by unclarified but not by heat-clarified sap from healthy leaves of tobacco or French bean. The ability of raspberry sap to inhibit infection seems partly due to the presence of polyphenols that combine reversibly with but do not inactivate tobacco mosaic and tobacco necrosis viruses. There is also evidence that the degree of inhibition depends on the identity of the host plant and it therefore seems unlikely that combination between inhibitor and virus is the sole cause of loss of infectivity.

(C. H. CADMAN.)

Leaf Curl

In 1955, sugar beet, turnip, swede and potato plants were grown on the site of a recent severe outbreak of raspberry leaf curl. Over 75 per cent. of the sugar beet, turnip and swede, and some of the potato plants became infected with viruses of the ringspot type; the viruses were isolated equally often from roots or from shoots of these plants. Sugar beet seedlings were grown in soil brought back to the glasshouse during the winter; many became infected although few showed symptoms. Small amounts of virus were detected in roots of seedlings in the cotyledon stage: later the virus content of the roots increased and subsequently, increasing amounts of virus were found in the shoots.

Although the symptoms produced by the ringspot viruses isolated from raspberry, other crop plants and weeds in a range of test plants vary greatly at different times of the year, symptom differences in *Chenopodium amaranticolor*, French bean, White Burley tobacco and *Petunia nana* were large enough in winter to group all the virus isolates into two types. The first type consists of the viruses from raspberry. The second type includes the isolates from sugar beet, turnip, swede, potato and most of those from weeds. Only viruses of the second type have been shown to be soil borne and it is still not clear whether these can cause raspberry leaf curl.

The thermal inactivation point of viruses of the first type is 68°C and of the second type 60-62°C. The dilution end-point of these viruses in infective tobacco sap is about 1/5000 and their longevity *in vitro* at laboratory temperature is between two and three weeks. Viruses of both types are precipitated

by ammonium sulphate or by 50 per cent. ethanol, but much infectivity is lost when one treatment follows the other.

When searching for possible hosts of the virus that causes raspberry leaf curl, a distinctive strain of tobacco mosaic virus was isolated from plantain plants, *Plantago major* and *P. lanceolata*, growing in Angus and Perthshire. A similar strain of this virus has been described by Holmes in U.S.A. but this is thought to be the first record for Western Europe. In some places, considerable numbers of plantain plants are infected.

(B. D. HARRISON.)

Other Viruses

Final results of the experiment on the rate of spread of veinbanding virus in Lloyd George raspberry showed that the number of infected plants doubled annually. Most new infections occurred in plants immediately adjacent to infected plants. The virus spread less in plots sprayed with insecticides, least of all in those sprayed with Systox.

Raspberry varieties again differed in the frequency with which they became infected with leaf spot virus when interplanted with diseased Lloyd George plants. After two years, none of the Norfolk Giant, 11 Malling Landmark, 33 Malling Promise, 36 Lloyd George and 37 Malling Exploit became infected out of a total of 50 plants of each variety used. Preliminary tests with the same varieties showed that they also differ in susceptibility to veinbanding virus although the order of susceptibility seems different.

(C. H. CADMAN and K. S. ANDERSON.)

Virus-Free Stocks

New arrangements for the production and maintenance of virus-free raspberry stocks were agreed with the Department of Agriculture for Scotland and this work is now the responsibility of the Plant Pathology Department. A new system of propagating virus-free plants from root cuttings is being used and this should enable stocks to be propagated more intensively than the orthodox method. The new technique is being used to produce bulk stocks of virus-free Lloyd George, Malling Jewel, Malling Promise and Norfolk Giant. Since last year, plants of Malling Enterprise and Malling Seedlings V and T have been freed from virus by heat treatment.

Raspberry plants were not freed from vein chlorosis, veinbanding or yellows viruses by exposing them at 35°C for 30 days. This result requires confirmation but suggests that some raspberry viruses cannot be eliminated from stocks by heat treatment. The results of other experiments confirmed the conclusion that there is little correlation between temperature, time of exposure and percentage of plants freed from latent viruses.

(J. CHAMBERS.)

POTATO VIRUSES

Transmission of Leaf Roll Virus

The aphid species that have been recorded as vectors of potato leaf roll virus include *Myzus persicae*, *M. ascalonicus* and *Macrosiphum euphorbiae* but in our tests, only *M. persicae* transmitted the virus from infected potato to *Physalis floridana* plants. *M. persicae* occasionally transmitted the virus after feeding for an hour on infected potato but did so more regularly after longer acquisition feeding periods. When these were less than 36-40 hr. aphids

were usually unable to transmit the virus immediately but did so after periods that varied inversely with the length of time spent on infected potato.

It is known that potato tubers can be freed from leaf roll virus by keeping them at 36°C for three weeks and experiments were made to investigate the effects of high temperature on the persistence of the virus in *M. persicae*. The ability of infective aphids to transmit the virus was greatly decreased by exposing them at 32°C for three or six days. The ability to transmit more regularly did not return when the aphids were kept for a further period at 20°C; these results provide no evidence that this virus multiplies in its insect vector. (C. H. CADMAN and B. D. HARRISON.)

Field Spread of Y and Leaf Roll Viruses

In 1954, both viruses spread little in experimental plots at Mylnefield or in field crops sampled in Angus and the Lothians. However, there was more spread in crops near the market gardening area at Musselburgh than elsewhere. As in 1953, plants next to the leaf roll or Y infectors became infected oftener than those more distant and tuber progenies from individual plants were often only partially infected.

Tests of the effects of times of planting and roguing on virus spread were repeated at Mylnefield in 1954 but so few infections occurred that the results were inconclusive. These experiments were repeated in 1955, modified somewhat to give more information on the time of spread of the viruses. Twenty-six field crops were sampled this year in Angus, Perth, Fife and the Lothians to determine the amount of virus spread in different localities. The aphid populations on these crops were also recorded (see below). (J. CHAMBERS.)

Experiments were started to investigate, using plants in the field, the time needed for aphid-transmitted leaf roll virus to reach the tubers, the variations in susceptibility during the summer of potato plants to infection, and to compare young and old leaves as sources of virus and sites for infection.

(A. G. FISKEN.)

Potato Aphids

To see whether the course of infestation of potato crops in eastern Scotland by *M. persicae* is associated with the dispersal of this aphid from populations overwintering in Mid- and East Lothian, crops were selected at Musselburgh and in localities up to 40 miles distant. Forty-seven crops were surveyed, 16 of these in co-operation with Mr J. M. Todd of the Scottish Department of Agriculture. Water traps were set up in the Musselburgh area, in Angus and in W. Perthshire.

The full results are not yet known but the pattern of crop infestation resembled that of 1954. It was a very favourable year for aphids, and potato crops at Musselburgh became infested in late May or early June. Very large populations (8,000 per plant) were present there in early August, particularly on crops adjacent to overwintering Brassicae. Despite this, crops more than 5 miles distant were not infested until mid- or late July and few crops had populations greater than 200 aphids per plant. Parasites and predators were abundant on heavily infested crops and aphid populations declined rapidly in September. (A. G. FISKEN.)

CABBAGE ROOT FLY

In 1955, Dieldrin again significantly (P=0.05) increased the yield of summer cauliflower. Spraying plants with insecticide after planting was as effective as puddling them in a slurry of soil and insecticide at transplanting.

(A. G. FISKEN.)

GREEN CAPSID BUG (*Lygus Pabulinus L.*)

The economic importance of this raspberry pest has decreased in recent years, probably because the use of insecticides has increased. Work was begun because of conflicting statements concerning important details of the life-cycle of this insect on raspberry in Scotland.

Winter eggs, laid on raspberry, hatched over a prolonged period both in the laboratory (7 weeks) and in the field (estimated 11 weeks). First instar nymphs were found on raspberry, at Longforgan, on 23rd April though not in appreciable numbers there until 5th May. This plantation was kept free from weeds until picking time and there was no evidence that first generation nymphs migrated from raspberry. In insectory experiments, however, nymphs reared on raspberry readily migrated to potato in preference to other raspberry plants.

Adults were found at Longforgan from 14th July onwards and, in August, eggs and first and second instar nymphs of a second generation appeared on *Chenopodium album*. The eggs were hatched in the laboratory and the nymphs identified as *L. pabulinus*. Eggs were not found on raspberry until late August and these did not hatch in the laboratory. In experiments made at Mylnefield, however, some eggs laid on raspberry early in July did in fact hatch a few weeks later.

These observations suggest that, when weed hosts are available, the insects migrate to them and there lay eggs that develop immediately, the offspring from which return to raspberry in late summer and there lay diapause eggs that do not hatch until the following spring. It also seems probable that a second generation may sometimes hatch out on raspberry. Experiments to find whether day-length or migatory behaviour of the females affected the ability of the eggs laid to develop immediately, gave inconclusive results. Females given 13 hr. day-length laid only non-diapause eggs in the high temperature prevailing during the experiment and diapause eggs were laid on raspberry by females which, in the nymphal stages had migrated to potato.

(A. G. RICHARDSON.)

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MYCOLOGY

by W. R. JARVIS

HOST-PARASITE RELATIONSHIPS IN STRAWBERRY RED CORE ROOT DISEASE

Most of the year's work was concerned with studies on the mechanisms of resistance of certain commercial strawberry varieties to various physiologic races of the fungus, *Phytophthora fragariae* Hickman. Histological investigations showed that, compared with healthy roots, there was an increase in phenolic compounds and their oxidation products, melanins, in both stele and cortex of diseased roots of potted runners. A study was therefore made of polyphenol oxidase systems in uninfected roots, in root-tissue cultures, in cultures of races of the parasite and in various host-parasite combinations. This showed that, in uninfected roots, the terminal oxidase is cytochrome oxidase but little polyphenol oxidase activity was detected in either uninfected roots or culture filtrates of the pathogen. Paper chromatography was employed in analyses for substrates of polyphenol oxidase in roots, the substrates being visualised by spraying and incubating developed papers with an enzyme preparation from potato tubers. Three substrates were detected by this method. One is provisionally identified as chlorogenic acid, and this together with a second, invariably occurred in the three varieties examined, namely Talisman, Royal Sovereign and Climax. The third substrate was detected only during the summer months. The identity and fungal metabolism of the isolated substrates is being determined.

Because the metabolism of ascorbic acid is frequently linked with that of polyphenols in other plants, a study is being made of the role and distribution of ascorbic acid and its oxidase in strawberry roots. *In vitro* studies of fungal cellulase, pectinase and tannase activity in autolysed fungal mycelium and culture filtrates are being made as a preliminary to a study of the role of these enzymes in the infection process.

AIR SPORA OF SOFT-FRUIT PLANTATIONS

This year, observations were made on the distribution of spores of the grey-mould pathogen, *Botrytis cinerea* in strawberry plantations. The Gregory portable spore trap was used to take air samples of the order of a hundred litres at various positions in and above plots and in various climatic conditions. Because of the dry summer of 1955, the disease did not reach epiphytotic levels and because the volume and number of air samples were restricted by the design of the apparatus, the results obtained were of limited value. They indicated, however, that spores were most abundant in conditions of high humidity and temperature and that the concentration of spores decreased rapidly with increasing distance from the sporulation site. Distribution

patterns were affected by wind speed and by the relative positions of neighbouring plants as these appeared to have some spore-filtering effect. An automatic, continuously-operating Hirst trap has been installed and this work will be expanded.

In addition to mycological work arising from the activities of other departments, trials were made of streptomycin (donated by Glaxo Laboratories Ltd.), applied as a foliage spray and as a seed-treatment. The results showed that it effectively decreased the amount of halo-blight, (*Pseudomonas medicaginis* f. *phaseolicola*), on French bean varieties both in the field and glasshouse.

In conjunction with the Edinburgh and East of Scotland College of Agriculture a potato-blight observation plot is being established near the meteorological site.

WEST OF SCOTLAND UNIT (AUCHINCRUIVE)

by R. D. REID

The unusually wet weather of 1954 followed by the very dry summer of 1955 combined to affect the health and cropping of strawberry plants in a manner unique in our experience. Following upon the heavy winter rains of 1954, red core infection reached an abnormally high level and caused serious losses. The hot dry summer made fruit ripen rapidly. Fruit was small in size, the season abnormally short and crops were light. For several years in succession, losses from *Botrytis* fruit rot have been very serious, but in 1955 losses from this cause were negligible. Mildew, though troublesome in other districts, was unimportant at Auchincruive. The season was favourable to aphids and there was more spread of virus than usual. The higher temperatures also affected symptom expression of June Yellows. Whilst symptoms were acute in spring, recovery of the less severely affected plants in summer was more complete, and the recurrence of symptoms in autumn much less evident than usual.

With red core disease the relations between host and parasite are such that variations in rainfall vitally affect the behaviour both of the fungus and of infected strawberry plants. The fungus is most active during the period August to January and any increase in soil moisture then, increases its rate of multiplication and dispersal. Strawberry plants on the other hand, grow rapidly and draw heavily on water during the period February to June and if their root systems are seriously depleted by disease the plants wilt and die from lack of water. It follows therefore that the amount and effects of red core disease will be least in years where a moderately dry autumn and winter are followed by a cool and moist spring.

TABLE 1. Rainfall at Auchincruive

	Average preceding 10 years	1954	1955
Total inches	37·70	47·94	31·17
Inches Feb. to July (incl.)	15·41	17·17	12·49
Inches Aug. to Jan. (incl.)	22·80	33·33	—

(Abstracted from Auchincruive records by courtesy of Dr John Grainger, West of Scotland Agric. College).

As Table 1 shows, exactly the opposite conditions prevailed in 1954 and 1955. During the period August, 1954, to January, 1955, over 33 inches of rain fell, 50 per cent. above the ten-year average. Large numbers of plants were severely infected and many seedlings, hitherto resistant, succumbed,

suggesting that considerable spread of some of the rarer physiologic races had occurred. The low rainfall and high temperature of the following spring and early summer intensified the effects of the disease. Badly diseased plants wilted and collapsed on a scale unknown since the introduction of resistant varieties, and the contrast between the condition of these and the vigorous growth made by plants with relatively undamaged root systems was quite spectacular.

This unusual sequence of weather has, at least, emphasised the value of field-testing as a technique. Differences in degree of infection were revealed which would have passed undetected by more rigorous laboratory techniques and these differences offer practical possibilities of producing varieties that may be termed "field-resistant" to red core disease.

STRAWBERRY BREEDING

Objectives

The general breeding programme falls under two heads; short term, with the object of producing varieties suitable for early introduction, and long term, involving exploratory work with strawberry species and hybrids.

As a rule, about ten years elapse between making a cross and introducing a selection. The position at present is that 6 selections from seedlings raised in 1945 have been retained for breeding purposes and 2 of these are under consideration for possible release. From the 1946 seedlings, one variety (Talisman) has been released, 2 others are under consideration and 6 more retained for breeding.

New sources of resistance to red core are being sought among *Fragaria* species and hybrids and some of the products of this search seem of likely value to the short term breeding work. Some strains of *F. virginiana* seemed specially promising but it has proved difficult to break up the close linkage between resistance and undesirable characters, such as small fruits. However, some success has now been obtained by repeated back-crossing to large-fruited hybrids. Other aspects of this work are referred to again below.

With the advent of new techniques of testing for resistance, the turn-over of seedlings has been at least trebled. From the crosses made in 1954, for example, 8,314 seedlings were raised and these have already been reduced to 2,755 preparatory to field testing. The 1955 crosses should yield about 12,000 seedlings and the handling of this material can now be spread over the whole year.

(R. D. REID, A. M. SUTHERLAND and K. C. MCCONNELL.)

Techniques of Testing

With the experience we now have it is possible to assess the relative merits of the three principal techniques of testing seedlings for resistance.

The spore suspension dip is a very quick method of detecting susceptibility to particular races of the fungus but, at present degrees of susceptibility are indistinguishable by this technique. It is being applied mainly to testing seedlings raised from crosses and selfs of species and in 1955, 4,496 seedlings were so tested by this technique.

Bench testing, which involves growing seedlings in troughs filled with field soil containing mixed inoculum, has proved of great value as a supplement to field testing. Results requiring about 18 months of field testing can be obtained in a few months. In America, where this method was first used, the work is done mostly during the winter months and only one batch of seedlings is tested per year. By manipulation of the environment we have been able to run three consecutive batches of seedlings through the benches in one year. The technique is more difficult to operate in summer, because of high temperature and the results (Table 2) show that fewer seedlings became infected then.

TABLE 2. Bench Testing 1954-1956

No. of Seedlings	Date Planted	Date Examined	Percentage discarded for red core
1629	Dec. 1953	April 1954	35
684	Sept. 1954	Jan. 1955	39
1918	May 1955	Aug. 1955	16
1861	Oct. 1955	Jan. 1956	38
2971	Jan. 1956	April 1956	54

The proportion of susceptible seedlings among batches tested at other times was fairly constant. Comparable results from field tests (Table 3) are much more variable because annual variations in rainfall greatly affect the incidence of red core.

TABLE 3. Field Testing 1945-1950

Year of Crossing	Percentage of seedlings discarded for red core
1945	27
1946	44
1947	22
1948	12
1949	17
1950	18

The bench test provides a means of eliminating susceptible seedlings quickly and of obtaining information on the segregation of resistance in seedling families tested under uniform conditions. As with all quick methods of testing, a serious limitation is that degrees of "field resistance" cannot be distinguished and the technique can therefore never completely displace field testing. This conclusion is reinforced by the events of the 1954-55 season.

In the early days of this work results were reasonably clear cut and there seemed to be few races of the fungus. The indications now are that there is an

apparently unlimited number of physiologic races and that the prospects of obtaining immunity from all is very remote. Moreover, actual susceptibility and resistance are themselves matters of degree and it would seem that a variety can be styled resistant only under a prescribed set of conditions. It is becoming increasingly evident that there are many border-line cases where infection is limited to a "trace" and where the amount of root system penetrated by the fungus is such that health and vigour of the plant are unimpaired even when the plant is grown under environmental conditions favourable to the most intense expression of the disease. This is borne out by the history of the crop of seedlings raised from the 1952 crossings (Table 4).

TABLE 4. Red core in seedlings raised in 1952

	Discarded		Retained		
	Red core	Deaths: Other causes	Red core (trace)	Uninfected	Total
Bench tested 1953/54 ...	540	105	—	984	1629
Field tested 1953/54 ...	3321	756	397	1161	5635
Total raised					7264

Those retained from each trial were planted out for further field testing and were subjected to very heavy infection during the winter of 1954/55. Out of 2,434 plants examined in March 1955, just over 100 were completely free from infection and the distribution of these in the plot was such as to suggest that they might have been " escapes." Many plants had only a very small portion of the root-tips infected and it was decided to retain all plants for further observation. During 1955, many plants died or showed typical symptoms of red core disease, including severe restriction of growth or general collapse, but a substantial number made perfectly normal or even excessively vigorous growth and showed no evidence of red core disease. The plants were surveyed in September 1955 and graded for vigour as shown in Table 5.

TABLE 5. Vigour of seedlings of 1952 crosses in September, 1955

O Dead or vigour below average; obviously affected by red core ...	1101
X Apparently healthy; vigour equal to healthy seedlings grown in clean land	940
XX Apparently completely healthy; vigour above average of healthy seedlings	356
XXX Vigour outstanding	37
Total	2434

From these observations it is clear that " field resistance," which seems associated with a small amount of penetration of the fungus into the root tissues, and possibly also with the ability of the plant to produce new roots rapidly, offers promise of field control of red core disease and increasing

attention is being devoted to this aspect of the work both in making selections and in laboratory studies. This conclusion has made thorough field testing in infected land an indispensable part of the later stages of breeding work.

(R. D. REID, A. M. SUTHERLAND, K. C. MCCONNELL and I. G. MONTGOMERIE.)

MYCOLOGICAL INVESTIGATIONS

Physiologic Races of Phytophthora fragariae

Further indexing of the collection of isolates obtained in 1954 has been carried out. Of the eight strawberry varieties originally used as indicators only four are now considered necessary for the differentiation of races. These are Perle de Prague, Climax, Auchincruive No. 11 and Aberdeen. Using these four indicators, four distinct physiologic races have been distinguished though individual isolates within races differ from one another in the degree of infection they cause in some varieties.

Testing New Sources of Red Core Resistance

Collections of seeds of *Fragaria* species were made or obtained by Mr R. D. Reid while on a visit to America in 1954. Seeds of four species, *F. virginiana*, *F. ovalis*, *F. chiloensis*, and *F. nilgherrensis* came from different localities in America, *F. elatior* and *F. nilgherrensis* from sources in the United Kingdom and *F. nipponica* from Portugal. Seedlings from these collections were tested by inoculating for 24 hours with a zoospore suspension of an isolate pathogenic to Huxley and Perle de Prague and non-pathogenic to Climax, Auchincruive No. 11 and Aberdeen. Over 3,000 seedlings were tested, and 10 per cent. proved resistant. *F. virginiana*, (all sources) gave a larger number of resistant seedlings than any of the other species; *F. nilgherrensis* and *F. nipponica* gave no resistant seedlings. The susceptible individuals were discarded and resistant seedlings grown on to provide runners. Further tests were made with these runners using other physiologic races of the pathogen, one of which is pathogenic to all the indicator varieties. Only 26 resistant seedlings have been fully tested, and of these, 7 have proved immune from all the races of the fungus tested. These individuals are all seedlings of *F. virginiana*.

Field Resistance

Seedlings are rated as susceptible if their roots become invaded by the fungus but the extent of this invasion varies greatly. In most instances, this is of no practical interest because, in the field, the roots are exposed to infection for so long that, ultimately, sufficient of the root system is destroyed seriously to affect the vigour of the plant. The roots of some varieties become invaded to such a slight extent that it seems likely such varieties would, in the field, show a very high degree of resistance although they possess no immunity to the various physiologic races of the fungus. The behaviour of the fungus may be influenced by temperature and by the physiological state of the plants and these inter-relationships are now being studied.

(I. G. MONTGOMERIE.)

JUNE YELLOWS

Climax was again severely affected by June Yellows in spring 1955, but symptoms largely disappeared on all but the most severely affected plants during the very warm summer, and did not recur in September and October on anything like the usual scale. Consequently, stocks that have never been severely affected went into the winter in better condition than they have done for some years. Pursuing the attempts to re-select "green" clones, samples from two of the best stocks to which we have had access were planted as single plant units in order that progeny from individual plants could be kept separate. All plants which showed even the slightest symptoms of transient yellows were discarded and the remainder propagated on a limited scale as sub-clones. One sample of 268 plants had 217 plants slightly affected, and another sample of 175 had 64 affected. We have therefore 162 sub-clones from these two stocks each of which has to date consistently remained green but further re-selection will probably be necessary.

The view has been expressed that rapid multiplication of stocks by runner propagation hastens the onset of June Yellows and the maintenance of stock reserve plants, propagated solely by crown division has been proposed as a means of delaying this. A "green" plant of Climax which had been maintained in this way was divided into seven crowns and re-potted in April, 1955. Some weeks later one of these new crowns became yellow whilst the other six remained green, thus indicating that the condition can arise in plants so propagated as well as in plants originating from stolons.

In much of the published work on June Yellows it has been assumed that the appearance of variegated seedlings in the progeny of selfs and crosses is evidence for the existence of a latent factor for June Yellows in the parent varieties. In our last Annual Report it was mentioned that considerable numbers of variegated seedlings occurred in families raised in 1954 from different sources, including varieties that had not shown any tendency to variegation. These variegations took different forms, and affected the young seedlings at different stages and in different ways. A considerable number of these chlorotic seedlings have been retained for observation to see whether any evidence could be obtained of their association with the typical June Yellows as we know it in such varieties as Climax. Observations are very incomplete and in the majority of instances, symptoms have disappeared entirely, possibly because of the high summer temperatures, but they will be closely watched during 1956.

The numbers of these variegated seedlings were much larger in families raised by selfing than in families from crosses. Variegated seedlings were recorded in 27 families out of 60 raised from selfings whereas they occurred in only 4 out of 31 families raised from crosses. In fact, many of the selfings were of species or species hybrids and of unnamed seedlings both from our own collection and from breeders overseas. At the time of writing, far fewer variegated seedlings have appeared in the crop of seedlings raised from 1955 crossings and selfings than in that of 1954.

When plants visibly affected with the severe form of June Yellows (*i.e.*, "streak") were selfed or crossed the incidence of "yellows" in the young

seedlings was exceedingly high. An affected plant of Climax pollinated by an unnamed seedling, which also showed the severe form of streak, produced 31 seedlings; 18 developed variegation in the first true leaves, and 11 more in the second or subsequent sets of true leaves. Two plants only have remained completely green at time of writing. From seed obtained by selfing the above unnamed seedling, 35 seedlings germinated from a sowing made in August 1954. Between October 1954 and March 1955, 34 of these developed some form of variegation and only one has remained completely green. The present evidence supports the view that the frequency of yellow seedlings is influenced by the condition of the parent plant.

(R. D. REID, A. M. SUTHERLAND and K. C. MCCONNELL.)

NUTRITIONAL TRIALS

Some years ago, before June Yellows became prevalent in Climax, occasional reports were received of intermittent cropping. This took the form of a heavy crop in one year being followed by a very light crop in the following year. This was usually associated with very vigorous growth and, as the case histories usually showed that very heavy dressings of farmyard manure had been given, it was suspected that a nutritional unbalance caused by excess nitrogen might be responsible. In 1952 therefore, some plots were laid out to test the effect of extra nitrogen. The whole area received the same basic manurial treatment and an annual top dressing of a complete fertiliser. In addition, the treated plots were given an annual dressing of 4 cwt. per acre of sulphate of ammonia, a total of 12 cwt. per acre over the three year period. The results were less spectacular than in the commercial fields mentioned and there was no year in which any of the treated plots failed to crop. Over the three cropping years, the plots that received extra nitrogen produced 11.5 per cent. less fruit than the controls and more of this (2-2.5 per cent.) was damaged by *Botrytis*.

(A. M. SUTHERLAND and K. C. MCCONNELL.)

RASPBERRY BREEDING

The raspberry breeding programme was continued, further families of seedlings were raised and selections made from earlier crossings.

The selection made from seedlings raised in 1946 is being multiplied and tested on a larger scale. While no decision can yet be made about its future, there is already evidence that this seedling possesses some quite exceptional breeding qualities including excellent flavour, quality of fruit and thornlessness.

(R. D. REID, A. M. SUTHERLAND and K. C. MCCONNELL.)

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METEOROLOGICAL RECORDS 1955

by J. SUNDERLAND

Daily meteorological observations were made at 09·00 G.M.T. throughout 1955. Weekend and holiday observations were done by the glasshouse staff.

In April the main site was inspected by Mr R. Cranna, Superintendent at the Meteorological Office, Edinburgh. As a result of his visit it was decided that more accurate records of rainfall would be obtained if a turf wall were built around the rain gauge, thus making it less exposed. This has now been done.

Observations were continued on the five smaller meteorological sites established to survey the temperature distribution at Mylnefield and North Bullion.

The results obtained at the main site for the year 1955 are summarised in the following tables.

METEOROLOGICAL RECORDS AT MYLNEFIELD, 1955

Month	Temperature		Rainfall		Sunshine	
	°F Average Monthly (1)	Deviation from mean (2) 1921-1950	Total Inches	Deviation from mean (2) 1881-1915	Total hours	Deviation from mean (2) 1921-1950
Jan.	34·2	−3·3	1·18	−0·75	46·6	− 3·4
Feb.	32·1	−6·4	0·97	−0·88	84·9	+ 8·9
Mar.	37·5	−3·7	1·09	−0·76	131·4	+ 26·4
April	47·3	+2·5	0·79	−0·82	189·3	+ 49·3
May	47·5	−1·9	1·775	−0·225	213·6	+ 47·6
June	54·3	−1·0	1·13	−0·56	183·1	+ 1·1
July	60·9	+1·9	1·04	−1·52	267·9	+113·9
Aug.	60·6	+2·7	0·32	−2·95	186·9	+ 45·9
Sept.	55·8	+1·8	1·07	−0·93	151·4	+ 29·4
Oct.	46·1	−1·8	1·60	−1·00	112·0	+ 17·0
Nov.	44·2	+2·5	1·47	−0·85	63·2	+ 0·2
Dec.	38·5	−0·5	5·07	+2·55	56·1	+ 15·1
Year	46·6	−0·6	17·505	−8·695	1686·4	+351·4

(1) Computed from daily mean of maximum and minimum temperature at 09·00 G.T.M.

(2) Recorded at official Dundee meteorological station.

February was a very cold month with a minimum air temperature of 09°F on the 23rd. Snow covered the ground from 12th February to 5th March. Early spring was warm and sunny, and was followed by a cold spell in May with several days on which snow and hail were recorded.

During the summer growing season the weather was unusually dry and sunny. No measurable rain fell during the periods 22nd May to 8th June and 4th July to 7th August. The greatest rainfall recorded on any single day in August was 0·08 inches. Extremes of temperature occurred with the maximum rising to 83°F on 22nd July and 1st August and night frosts in all months except July and August.

VARIETY TRIALS OF VEGETABLES IN SCOTLAND

I. SUMMER SPINACH AT INVERGOWRIE 1953-1955

by C. NORTH AND L. H. FRITH

Most canning factories in the east of Scotland were established to utilise the produce of the well-developed raspberry growing industry and, with the exception of peas, some carrots and beetroot, much of the horticultural produce which is canned outside the raspberry season has to be imported to the district. It would be an advantage to the local horticultural and canning industries if more of this produce was grown locally. Spinach (*Spinacea oleracea*) could be made available for canning in June before the raspberry picking season commences, but many strains fail to give adequate financial returns because the plants tend to run to seed before they have formed a reasonable crop of leaves. This paper describes field trials designed to ascertain which strains are likely to give good yields in Scotland.

Method

All the trials were grown on deep medium loam, which was subsoiled, limed and manured with farmyard manure or composted straw at the rate of 16 tons per acre. Six cwt. per acre of balanced fertilizer was raked into the surface shortly before sowing and a top dressing of 2 cwt. per acre nitro-chalk was given when the plants were a few inches high.

During each of the three years, varieties were grown in small-scale observation plots consisting of single rows 12 ft. long; the plants were thinned to stand 12 in. apart in the rows. The strains selected for inclusion in a yield trial were those that produced the largest proportion of late-bolting, vigorously-growing and smooth-leaved plants.

The yield trials, conducted in 1954 and 1955, were designed as randomised-block layouts with 5 or 6 replications. Each plot had four rows 33 ft. long and spaced 15 in. apart and there was a single guard row round the outside of each trial. The plants were singled to stand 12 in. apart in the rows. Two yield trials were sown each year: in April and again in June.

To ensure that all varieties were harvested at a comparable stage of development, counts of the number of plants commencing to bolt (*i.e.*, plants on which the main stem had grown 3 in. long) were made every 2 or 3 days and when a certain percentage (varying between 18 and 40 per cent.) of the plants of a variety had bolted, all the plants of that variety were cut at ground level and weighed. The percentage leaf weight of total fresh weight per variety in each trial was also recorded.

VARIETIES TESTED

The following 49 strains were grown in observation plots: Bloomsdale (Nutting) and (Zwaan and de Wiljes, Holland); d'Ete de la Ferte (Driancourt, France); Fillbasket (Yates); Forste Snit (Daehnfeldt, Denmark); Gaudray (Daehnfeldt, Denmark) and (Ohlsens Enke, Denmark); Gaudray Winter (Alnarp Research Station, Sweden); Geant d'Hiver (Driancourt, France); Hercules (Olson, Sweden); Hollandia (Cullen); Juliana (Zwaan and de Wiljes, Holland); King of Denmark (Gehlin, Sweden), (Watkins and Simpson), (Zwaan and de Wiljes, Holland), (Clibran), (Cooper Taber), (Cullen), (Hurst), (Nutting) and (Sharpe); Long Standing (Sharpe); Long Standing Round (Sutton); Matador (Olson, Sweden), (Daehnfeldt, Denmark); Monstrous Viroflay (D. T. Brown); Nobel (Watkins and Simpson) and (Ohlsens Enke, Denmark); Noorman (R. Zwaan, Holland); Northland (Zwaan and de Wiljes, Holland); Prickly, long-standing (Sutton); Prickly, thick-leaved (Yates); Reliance (Watkins and Simpson) and (Tozer); Savoy-leaved Giant (D. T. Brown); Supra (Zwaan and de Wiljes, Holland); Standwell (Sharpe); Thialf (R. Zwaan, Holland); Triumph (Nutting); Triumph, long-standing (Nutting); Troubadour (Zwaan and de Wiljes, Holland); Verina (Olson, Sweden); Vert de Massy (Simon Louis, France); Victoria (Sutton); Viking (Gehlin, Sweden), (Weibull, Sweden) and (Olson, Sweden); Weibulls Vinter (Weibull, Sweden).

Seven strains were selected for inclusion in yield trials in 1954; one of these was discarded because of its low yield and four previously untested strains were added to make a total of ten in the 1955 yield trial.

RESULTS OF YIELD TRIALS

Plants in the later-sown 1955 trial made such poor growth on account of the prolonged dry spell that they were not harvested.

An examination of the results of the 1954 trials and the early-sown 1955 trial showed that differences in plant population had slightly affected the weight per plant and it was therefore decided to analyse the yield figures by covariance. The corrected yield figures are given in Tables 1, 2 and 3 together with the number of days between sowing and harvest, percentage "bolters" at harvest time, and estimated yield of leaf. The mean standard errors of the yield figures are shown in each table as a guide to the significance of the results.

CONCLUSIONS

These trials show that, provided suitable strains are chosen, good yields of spinach may be obtained in Scotland from seed sown under field conditions in late March or early April. Crops sown at this time are ready for processing before the raspberry crop is picked in July. Seed sown during the second or third week in June, for cutting after the raspberry season, however, may fail to give a profitable crop in a dry season.

King of Denmark (Zwaan and de Wiljes) was cut at a later stage of development than other strains in the first trial and the yield figure is consequently too high. King of Denmark (Gehlin) was harvested too early in

TABLE 1. Spinach Yield Trial Sown 2nd April 1954

Variety (In order of yield)	Adjusted yield cwt./acre	No. days from sowing to harvest	% "Bolters" at harvest	Estimated yield of leaf cwt./acre
King of Denmark (Zwaan and de Wiljes)	138·5	75	39	80·3
King of Denmark GeF/50 (Gehlin)	126·7	75	17	82·3
Troubadour (Zwaan and de Wiljes)	122·4	75	17	78·3
Noorman (Rijk Zwaan) ...	105·2	73	19	72·6
Viking (Gehlin)	104·5	69	18	69·0
Matador (Daehnfeldt) ...	84·9	69	11	52·6
Gaudray (Ohlsens Enke) ...	75·5	67	18	50·5
Mean S.E.	8·8	—	—	—

the second trial, but the order of yields was not affected because this strain gave the highest return in spite of early cutting. In the 1955 trial there was considerable variation in the stage at which strains were harvested; this discrepancy was unavoidable because the onset of a spell of unusually warm weather caused a rapid increase in the rate of bolting. The main order of yield, however, in the 1955 trial is not likely to have been affected, for the differences in maturity represent only one or two days development.

TABLE 2. Spinach Yield Trial Sown 29th June 1954

Variety (In order of yield)	Adjusted yield cwt./acre	No. days from sowing to harvest	% "Bolters" at harvest	Estimated yield of leaf cwt./acre
King of Denmark GeF/50 (Gehlin)	152·9	76	24	90·2
King of Denmark (Zwaan and de Wiljes)	141·7	67	34	83·6
Viking (Gehlin)	124·8	62	35	58·6
Troubadour (Zwaan and de Wiljes)	122·9	64	32	62·6
Matador (Daehnfeldt) ...	120·1	62	35	70·8
Noorman (Rijk Zwaan) ...	114·5	62	32	61·8
Gaudray (Ohlsens Enke) ...	78·3	49	33	43·1
Mean S.E.	10·0	—	—	—

TABLE 3. Spinach Yield Trial Sown 30th March 1955

Variety (In order of yield)	Adjusted yield cwt./acre	No. days from sowing to harvest	% "Bolters" at harvest	Estimated yield of leaf cwt./acre
Verina OJO/53 (Olson) ...	113·3	91	42	68·0
Troubadour (Zwaan and de Wiljes)	85·9	85	45	52·3
King of Denmark GeF/50 (Gehlin)	75·1	85	32	45·1
Viking (Olson)	74·7	85	47	44·8
Noorman (Rijk Zwaan) ...	69·0	85	46	41·4
King of Denmark (Hurst) ...	66·4	82	36	38·5
Matador (Daehnfeldt) ...	63·9	82	27	40·9
King of Denmark (Zwaan and de Wiljes)	56·7	79	26	35·1
King of Denmark (Sharpe) ...	55·3	79	28	34·3
Viking (Gehlin)	54·9	79	21	36·7
Mean S.E.	10·7	—	—	—

The results show that those varieties which bolted latest gave the highest yields. A similar relationship may be noted from figures recorded for Spinach trials in Sweden by Lamm, Tometorp and Avall (1955).

King of Denmark GeF/50 from A. B. Gehlins Fröhandel, Malmö, Sweden and Verina OJO/53 from Otto J. Olson & Sons A.B., Hammanhög, Sweden gave the best yields. Troubadour and King of Denmark (both from Zwaan and de Wiljes, Scheemda, Holland) gave high, but more variable yields.

The variety King of Denmark has very dark green, halberd-shaped leaves which are held close to the ground on long stalks. It was introduced in 1919 by Thomas Madsen of Denmark under the name Antvorskov.

Verina has bright green, broad leaves on fairly short stalks. It was introduced recently by Otto J. Olson and Sons and is a selection from a cross (Juliana x Supra) x King of Denmark. Juliana is a savoy-leaved type and Supra is a selection from Gaudray.

Troubadour has thick dark green leaves which are not very shiny and are similar in shape to King of Denmark but with shorter stalks. It derives from a cross between King of Denmark and El-de-Es and was introduced recently by Zwaan and de Wiljes.

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A MAP OF THE DISTRICT SHOWING THE MAIN ROADS TO THE INSTITUTE