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ANNUAL REPORT

THE SCOTTISH HORTICULTURAL RESEARCH INSTITUTE

1959-60

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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Miss S. A. DODD (*Shorthand Typist*).
W. I. A. JACK (*Foreman*).

* Honorary lecturer in the University of Glasgow.

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THE DIRECTOR'S REPORT

The regulation which requires members of the Governing Body to retire at 70 has this year deprived us of the services of Professor J. R. Matthews and Professor T. Wallace. Both were appointed to the Board of Management, when this was formed in 1952, and subsequently to the Governing Body. Professor Matthews was Chairman until his retirement in March 1959.

Despite a very busy life and bouts of ill-health, Professor Matthews missed only one governors' meeting and attended most of the many committee meetings which were needed in the early years of the Institute's life. The appointment and welfare of members of staff were matters of personal concern to him, and it was always his regret that the business of governors' meetings left far too little time for informal contacts with the staff and their work. It is a pleasure to record the award of C.B.E. by Her Majesty the Queen to Professor Matthews in recognition of his many services to Scotland, and the presentation to him by the Royal Caledonian Horticultural Society of its premier award, the Neill Prize, in recognition of his services to Scottish horticulture.

The decision by the Secretary of State for Scotland to purchase the farm of Mylnefield was the outcome of a lengthy search, in the course of which many possible sites for an horticultural research station were examined by the advisory body, of which Professor Wallace was then a member. No one's opinion was more respected than his, and it is characteristic that jubilation over the prospect of acquiring Mylnefield was restrained until he had had an opportunity of inspecting the farm and given his approval. The fact that we now have at our disposal a farm almost ideal for our purpose is perhaps the most fitting tribute to him. Professor Wallace rarely missed a governors' meeting, although attendance meant two successive nights in the train and absence from his own busy research centre, and he nearly always found time before meetings to question members of staff about their work. My own association with Professor Wallace dates back many years, and I would like personally to express my esteem for him and my thanks for much advice and constructive criticism. We wish both him and Professor Matthews a long and happy retirement.

In April, the Secretary of State for Scotland appointed Professor J. H. Burnett, Professor of Botany in the University of St. Andrews, as Chairman of the Governing Body in succession to Professor Matthews. Professor Burnett has been a member of the Governing Body since 1st April 1956 and convenor of the Staff and Research Committee since December 1957. The vacancy created by Professor Matthews' retirement has been filled by his successor to the Regius Chair of Botany in the University of Aberdeen, Professor P. E. Weatherley.

We congratulate Principal M. A. H. Tincker on his election as Fellow of the Royal Society of Edinburgh.

THE YEAR 1959/60

Of several exciting developments this year, perhaps those in virus research and plant physiology deserve prominence because of their obvious scientific as well as practical importance.

Soil-borne viruses which cause serious diseases of raspberry and strawberry in eastern Scotland are now known to be widespread and to cause severe diseases of many other kinds of crop throughout Britain and Continental Europe. How these viruses spread, both from plant to plant and over long distances has been something of a puzzle. Now, however, it seems that the viruses themselves are dispersed in the seeds from infected weed and other plants, whilst eelworms are responsible for transmitting the viruses from plant to plant. Both discoveries may make possible an intelligent approach to the control of these viruses.

Studies on the growth cycle of the strawberry plant have led to the conclusion that this is controlled largely by fluctuations in concentration of a hormone with gibberellin-like properties produced in mature strawberry leaves in response to daylight. Its effect is to stimulate runnering and inhibit flower formation. More of this substance is produced in leaves in long than in short days, and this explains why strawberry plants usually initiate flowers only when the days shorten in late summer and early autumn. Clearly there are advantages in being able to manipulate the behaviour of strawberry plants, and some of the practical applications of this work are reported below.

The yields from Talisman and Regauntlet strawberry were phenomenal again this year, and it is a pleasure to report that Talisman received an Award of Merit from the Royal Horticultural Society. Because of the versatility of the red core fungus, the possibility of producing strawberry seedlings immune from all strains of the pathogen seems remote and efforts are being increasingly concentrated on the production of seedlings which are immune from some races of the fungus and field resistant to others. Some promising selections possess these characters and, although a proportion of roots may become infected, the plants still grow and crop vigorously.

Although grey mould (*Botrytis cinerea*) was less in evidence this year, the dry season made it easier to study the factors which favour outbreaks of this disease in raspberry and strawberry. The results have provided a measure of the difficulties of control and shown that, whilst much depends on differences in varietal susceptibility and in cultural practices, effective chemical control may not be impracticable. A new approach is being made to the troublesome problem of dieback in Malling Promise and other raspberry varieties. There is some indication that fungal attack on the roots may be involved but this is not yet established.

The cytology and genetics of *Rubus* and *Ribes* species have become a major interest of the Genetics Department and information from these studies is aiding the progress of plant breeding work in the Pomology Department. The first results from the black currant seedlings bred during the past four years are highly encouraging and there seem good prospects of producing varieties whose berries ripen evenly on the strig. Experiments on raspberry cultivation continue, and the manurial trials have given striking evidence of the response of raspberries to nitrogen. The use of chemical herbicides may

solve the problem of weed control in raspberries. The most promising chemicals are, however, persistent in soils and the effects of cumulative doses on plant growth are being examined. Apples did well again this year, and the results of the trials suggest that apple-growing in eastern Scotland may have distinct practical possibilities.

The enthusiastic response to a conference, organised last autumn on the production of vegetables for canning and quick-freezing in Scotland is perhaps a measure of the interest created by the work of the Vegetable Crops Department. A vast number of strains of vegetable varieties has been assessed during the past few years, and the results have provided Scottish growers with an abundance of authoritative information. Breeding work with Brussels sprouts, cabbages and dwarf beans was continued, and some selections of each are beginning to show commercial merit.

BUILDINGS

Work on the extension to the main laboratory and office building has proceeded well, and the new laboratories should be ready for occupation in July.

Sundry alterations have been made to the outbuildings. These included subdivision of the electron microscope room to provide accommodation for a new ultracentrifuge, the conversion of part of the steading into a workshop, and the laying of a concrete floor in the farm implement shed.

A new Dutch light house was erected for work on chemical herbicides.

FARM AND PLANTATIONS

The season was the best for some years and, although drought conditions set in in late summer and early autumn, we did not suffer from lack of rain to the same degree as did some other parts of eastern Scotland. The dry weather decreased the yields of hay and oats but those of barley and wheat were unaffected and about average. The sugar beet crop was outstanding and, with a yield of 14·5 tons/acre and a sugar content of 17·31%, gave the highest gross income per acre recorded from any crop so far grown on the farm. Potatoes yielded well but prices were lower than usual. Turnips suffered from mildew in the latter part of the season. During the year, 57 bullocks were fattened.

For once, the soft fruit season was not marred by rain and picking started early. The yields from both strawberries and raspberries were phenomenal: a half-acre block of Talisman in its fifth season yielded 4½ tons of saleable fruit and a one acre block of Redgauntlet in its third season over 6 tons; a block of Malling Promise raspberry in its eighth year cropped at over 5 tons/acre. Like most local growers, we had some difficulty in disposing of raspberries towards the end of the season. The total raspberry crop was 40% above that of 1958, partly because of the good season and partly because of an increase in the proportion of plantations in full bearing, some of the older ones having been grubbed. In total, the soft fruit harvest comprised 16 tons of strawberries, 31½ tons of raspberries and about 1 ton of black currants.

It was another very good year for apples, and 6 tons were harvested and marketed locally. Plums yielded about 1½ tons. Brussels sprouts were the most important vegetable: 7 tons of these and small quantities of other

kinds of vegetable were sold locally. Our first venture in commercial tomato growing gave encouraging results.

Mixed coniferous/deciduous shelter belts were planted along the whole of the west and south-west boundaries of Mylnefield, and plantings of *Cupressocyparis Leylandii* and lombardy poplar were made to complete the subdivision of Quarry Field. The erection of a permanent boundary fence in School and Bullion South fields was begun, and further plantings of ornamental shrubs were made around the main building.

Efficient pest and disease control in the tree fruit plantations is now more exacting because of the increase in tree heights. A "mist-blower" type of spraying machine bought this year is proving a valuable acquisition. Improvements were made to the "Carselea" glasshouse unit by installing a circulating pump in the heating system and a low-level sprinkler system (N.I.A.E. type) in the two 100 ft bays devoted to tomatoes.

The outdoor and glasshouse staff now numbers 25.

STAFF

In the course of the year, 4 members of staff resigned and 9 new ones were appointed. Mr R. J. Stephens came in July to the Pomology Department to work on weeds and their control by means of chemical herbicides. He had been doing similar work in Jamaica. In the Physiology Department, Miss R. N. MacDonald was appointed as Assistant (Scientific), and in October, Dr D. T. Mason came to work on the developmental physiology of the strawberry. He replaced Dr G. L. Hodgson, who resigned in May to take up an appointment with the A.R.C. Weed Control Unit at Oxford. In April, Mr A. B. Wills was given leave of absence from the Genetics Department to work in the Horticultural Department of Rutgers University, New Jersey, where he is now studying various aspects of fruit breeding and genetics. In the Virology Department, Miss M. K. Milne left in May, and her post of Assistant (Scientific) was filled by Miss A. R. C. Sneddon. Dr S. R. Chant left in June, following his appointment to the staff of the Chelsea College of Science and Technology. Dr C. E. Taylor came in September from S. Rhodesia, essentially to work on entomological aspects of plant virus diseases, but he has since become involved in work on nematode transmission of soil-borne viruses. Dr A. F. Murant joined this Department in January to work on the transmission and dissemination of soil-borne viruses through weed seeds. Miss J. G. Forsyth was appointed in June as Assistant (Scientific) in the Laboratory Service Department. Finally, there were three changes in the administrative staff. Miss M. P. Sinclair left in January and her post as shorthand-typist was filled by Miss E. F. Galloway. In September, Miss V. S. C. Jackson was appointed to the new post of librarian.

Mr A. B. Ross qualified as a Fellow of the Corporation of Secretaries, and Miss Jackson qualified as an Associate of the Library Association. Dr G. M. L. Haskell was elected a Fellow of the Linnean Society.

VISITS ABROAD

Dr A. R. Wilson attended Council Meetings of the European Association for Potato Research in Cologne in July and in Zürich in January. While in

Cologne he also attended, by invitation, the 2nd Congress of "Eucarpia" (Europäische Gesellschaft für Züchtungsforschung).

OTHER ACTIVITIES

The year was an unusually busy one. The Genetical Society accepted an invitation to hold their summer meeting at the Institute in July, and in September, the Horticultural Education Association held their summer meeting in Dundee. Several members of staff read papers on each occasion, and the programme of each conference included visits to the Institute where demonstrations of the salient lines of work in progress were arranged. A Fruit-growers' Day held in July was well attended, and, in October, a successful conference on the production of vegetables for canning and quick-freezing in Scotland was organised in conjunction with the Edinburgh and East of Scotland College of Agriculture. Demonstrations of various aspects of the Institute's work were staged at the autumn show of the Royal Caledonian Horticultural Society in Edinburgh, where we again received a David King Gold Medal. The Mycology Department staged exhibits at a conversazione held by the British Mycological Society in London in March.

We were glad to welcome three British Council scholars to the Institute. Miss N. N. Tun, a graduate of Rangoon University, came in August to the Genetics Department, to work on cytological problems in *Ribes* and *Rubus*, and is registered as student for the degree of Ph.D. in the University of St. Andrews. Messrs M. Božić and L. Merić came in June and spent 3 months here studying the culture and marketing of soft fruits. Other notable visitors from overseas included Prof. G. S. Pound, University of Wisconsin; Prof. T. H. Thung, Agricultural University, Wageningen, and Prof. C. C. Sibley, Cornell University, Ithaca.

ACKNOWLEDGMENTS

Two special acknowledgments are needed this year. One is to the Agricultural Research Council and to Dr K. M. Smith for the transfer to the Institute of a Metropolitan-Vickers EM3a electron microscope from the Virus Research Unit in Cambridge. The other is to the Rockefeller Foundation for a grant of $10,000 for the purchase of a new ultracentrifuge. These two pieces of equipment will be major aids to work on the diagnosis and study of plant viruses.

It is also a pleasure to acknowledge many gifts of chemicals for experimental work done by the Pomology, Mycology and Physiology Departments. These include herbicides, supplied by The Du Pont Co. (U.K.) Ltd., May & Baker Ltd., A. H. Marks & Co. Ltd., The Mirvale Chemical Co. Ltd., Plant Protection Ltd., The Stauffer Chemical Co., and Robert Stephenson & Son Ltd.; fungicides for work on the control of grey mould of soft fruit and/or tomatoes supplied by Boots Pure Drug Co. Ltd., Cuprinol Ltd., Cyanamid of Great Britain Ltd., Charles Lennig & Co. (Great Britain) Ltd., May & Baker Ltd., Murphy Chemical Co. Ltd. and Pan Brittanica Industries Ltd. Gibberellic acid was kindly supplied by Dr P. W. Brian, Imperial Chemical Industries Ltd. and by Plant Protection Ltd., and maleic hydrazide by Fisons Ltd.

We also gratefully acknowledge a generous monetary gift from Scottish Agricultural Industries Ltd. Like those of the past two years, this year's donation has been used to increase social amenities for the staff.

For help in the assessment of processing quality of fruits and vegetables, we wish to thank the British Food Manufacturing Industries Research Association, Leatherhead; the Canning & Quick Freezing Research Institute, Chipping Campden; Chivers & Sons Ltd., Montrose; the staff of the Ministry of Agriculture, Fisheries & Food Research Establishment, Aberdeen; John Morrell & Co. Ltd., Dundee and Smedley's Ltd., Dundee.

We are indebted to several growers for their co-operation in some of the herbicide and vegetable trials reported below. Mr E. H. M. Cox again kindly allowed parts of his raspberry plantations to be used for trials of herbicides. Land for trials of carrot varieties was provided by Mr A. G. Porter, Easthaven and by Messrs J. R. Dale, North Berwick and J. Naismith & Sons, Overtown. Trials of leek varieties were made on the farms of Messrs J. Warnock, Wishaw, D. Carmichael, Carluke and J. Murray, Thankerton. Mr T. G. Rubens, Edinburgh and East of Scotland College of Agriculture, helped with the siting and recording of the carrot trials, and Mr J. B. R. Anderson, West of Scotland Agricultural College, similarly helped with the leek trials in Lanarkshire.

The Pomology Department received assistance from the A.R.C. Unit of Agronomy, Oxford, and from the Statistic Section of the East Malling Research Station. It is also much indebted to the Chemistry Department of the Edinburgh and East of Scotland College of Agriculture for analysis of soil and plant material from the raspberry manurial trials, work which the Institute is itself unable to do. Many members of staff are indebted to the A.R.C. Unit of Statistics, University of Aberdeen, for help with the design and analysis of experiments. The Institute's Annual Farm and Plantations Cropping Record is again reproduced in this Report through the kind assistance of the Chief Surveyor of the Department of Agriculture for Scotland.

POMOLOGY

C. A. Wood

Although the 1959 fruit season was fairly dry and exceptionally sunny (see p. 66), the rainfall at Mylnefield in June and July was sufficient to ensure good crops of soft fruit. The picking periods for strawberries (19 June-4 August), black currants (30 June - 3 August) and raspberries (2 July-17 August) were about a fortnight earlier than in the average year of 1956. Strawberry yields were remarkably high, even from plantations which had cropped heavily in 1958. The apple crop also was heavy and dessert varieties again showed excellent colour, but with the high autumn temperatures the storage life of the fruit in the present temporary building was short. Apple varieties showed interesting differences in the extent to which fruit size was affected by the dry conditions in late summer.

RASPBERRY BREEDING

The main emphasis in this wotk is now on the longer-term programme, described previously, in which selected parents are being inbred for several generations to obtain lines breeding true for such characters as good fruit texture and size, to which genes for disease resistance can be added by back-crossing. The most important inbred families now being studied were obtained by self-pollinating firm-fruited selections from crosses of Malling Jewel with Burnetholm Seedling and Baumforth's Seedling B. Many of these families were exceedingly poor in vigour in 1959 and fruited very inadequately, but assessments showed that 3 out of 20 of them contained good proportions of firm-fruited seedlings, and selections were made for further inbreeding. The best selections appeared to retain their firmness under weather conditions in which the fruit of Malling Jewel became distinctly soft.

Most of the new families planted in 1959 were sib-crosses between seedlings of good fruit quality. Early germination enabled planting to be completed by the end of May, with the result that most of the seedlings made growth which should be sufficient to permit a preliminary assessment of their fruit in 1960. The vigour of the sib-crosses approached that of crosses between unrelated parents, whereas families raised by self-pollination again varied in vigour. It appears that the loss of vigour associated with self-pollination varies with different parents, but may in some cases be prohibitive after even a single generation of selfing. In view of this, further tests are being made of sib-crossing as an alternative inbreeding method to self-pollination.

Apart from further pollinations made in the course of the inbreeding programme, new families raised in 1959 included backcrosses to the raspberry of certain interspecific hybrids interesting either for their good vegetative vigour or for the manner of separation of their fruit from the plant. Further interspecific crosses of an exploratory kind were also made. (D. L. Jennings, B. Tulloch.)

Genetics of Resistance to Raspberry Viruses

In the study of the inheritance of immunity to the three soil-borne viruses which affect raspberries, preliminary graft tests have indicated that immunity in each case is a dominant character, probably inherited in a simple manner. The varieties Lloyd George and Malling Landmark both appear to be heterozygous for immunity to raspberry ringspot and tomato black ring viruses, and Malling Jewel is probably heterozygous for immunity to tomato black ring and arabis mosaic viruses. Larger numbers of the seedlings obtained by crossing Malling Jewel with Lloyd George and with Malling Landmark are now being studied to test this hypothesis and to determine whether the genes for the several immunities are linked.

A field experiment was planted to compare the rate of spread of vein-banding disease (caused by aphid-borne viruses) in 27 seedling derivatives of Norfolk Giant and of Malling Exploit and in the two parent varieties. These varieties, though readily colonised by the aphid vector, tend to escape infection by the disease, and a knowledge of the mode of inheritance of this form of resistance will be of value should it become necessary to include it in the breeding programme.

Tetraploid Raspberries

Work with tetraploid raspberries was started after the discovery of occasional tetraploid plants in stocks of the varieties Malling Jewel, Malling Exploit, Malling Promise and the East Malling seedling 69/139. In the last three of these (the comparison has not yet been made in Malling Jewel) the tetraploid was of lower fertility than the diploid, and consequently produced unattractive fruits formed of relatively few, large drupelets. The tetraploids appeared superior to diploids in some vegetative features, however, such as the thickness and strength of the canes and fruiting laterals. Material has now been propagated for a small field trial in which the diploid and tetraploid forms of two of the varieties will be compared. Progenies raised by the self-pollination of tetraploids have also been planted to see if improved fertility and hence better fruit quality, can be obtained from them by selection.

Very little success has been reported by workers who have tried to induce tetraploidy in the raspberry by treating aerial parts of the plant with colchicine. The fact that in each of the varieties mentioned above the mutant tetraploid shoot arose from root tissues, however, suggested that roots might be more responsive to this treatment. This idea was tested in 1958 by immersing the root systems of young rooted shoots, obtained from root cuttings, in 0·1% colchicine solution for 5 or 10 hr. After a re-establishment period in the propagation chamber the treated plants were transferred to the field, where 3 out of 25 produced polyploid shoots from below ground in 1959. This seems to be a potentially useful method of colchicine treatment for plants which can be multiplied from roots, especially where the stem tissues appear resistant.

Further trial was made of a Swedish technique for induction of polyploidy, mentioned in the last Report*, in which pollinated flowers are exposed to nitrous oxide, under pressure, at about the time when the first

* Wills, A. B. *Rept. Scottish hort. Res. Inst.*, 1958-59, 34.

division occurs in the fertilized egg. Variable amounts of seed were set by raspberry plants so treated: some of the plants were severely damaged by the low temperature of the gas.

Physiology of Growth in relation to Breeding

Raspberry breeding could be expedited if seedlings selected in summer could be induced to flower under glass in winter, and if the seed then produced by controlled pollinations could be germinated in time for the seedlings to be planted out in the spring. Experiments have shown that treatment with gibberellic acid cannot completely replace the low temperatures required to break the dormancy either of canes or of seed, although onset of growth can be expedited if the necessary minimum exposure to cold is followed by application of this growth substance at 50 ppm. in the case of cane buds, or 10 ppm. in the case of seed. In the past two winters the cold requirement of canes of the varieties studied at Mylnefield has apparently been satisfied by outdoor exposure until mid-December, and that of seed by stratification for 6-10 weeks at about 5°C. following pre-treatment with sodium hypochlorite. Delay in bringing canes into growth in winter still remains an obstacle to the successful shortening of the raspberry breeding cycle, but work on the problem is continuing. (D. L. Jennings.)

BLACK CURRANT BREEDING

The samples of 25 seedling bushes of black currant families grown from 1956 seed, and planted in spring 1958, fruited for the first time in 1959. This was the first fruit produced under this breeding programme. Among the more promising families were the crosses of the Finnish variety Brödtorp with Baldwin and Silvergieter's Black, and the family raised by self-pollinating Brödtorp. Selections for trial and further breeding were made from five families, particular attention being paid to length and "handle" of strig, size and skin-quality of berry, evenness of ripening, and habit and vigour of growth. Further seedlings of these and other families, numbering about 4,000, were planted in the spring together with seedlings of intervarietal and interspecific crosses raised from seed harvested in 1957.

Mention was made in the last Report of 36 crosses made in 1958, mainly between black currants and a number of species chosen from five sub-genera of *Ribes*. The 32 of these which were successful varied considerably in seed germination in 1959. With one exception (Baldwin black currant x *R. floridum*) ample seedlings were obtained from all the *Eucoreosma* intrasectional crosses, but most of the crosses between black currants and species from the four other sub-genera germinated poorly.

Twenty of the less successful crosses of previous years were repeated in 1959. Five which were intervarietal black currant crosses all gave useful quantities of seed, and seed was also obtained from 11 of 15 interspecific crosses.

Forty seedlings of the cross Baldwin x *Ribes maximowiczii* and the same number from self-pollinated Wellington XXX, all at the cotyledon stage, were used in an attempt to double chromosome numbers by colchicine treatment of the stem apices. Five apparently polyploid or mixoploid plants—

two from the hybrid family and three from the inbred—were obtained by treatment with 1% and 0·6% solutions, and await cytological examination. (M. M. Anderson, W. Fordyce.)

THE CULTIVATION OF RASPBERRIES

Experiments planted in 1952 and 1954

The oldest experiment of this series, comparing the value of planting canes singly with planting in twos ("double" planting), cropped well in its eighth season and again showed no significant differences of yield between the plots originally planted by the two methods. It will be continued for one more year.

In the experiment to compare the growing of raspberry plants as separate stools with that of allowing the rows to form continuous "hedges" of non-stooled canes, the differences of yield between the two systems were not significant in any of the three varieties—Lloyd George, Malling Promise and Norfolk Giant. This was a continuation of the trend noted in 1958. Over the whole six years of the experiment the stooled rows of each variety still exceed the non-stooled in total yield, although the margin is now significant ($P < 0{\cdot}05$) only in Lloyd George.

In the two experiments on systems of supporting and training raspberry canes, also in their sixth year, canes supported by the standard post-and-wire system again cropped substantially better than canes either tied into vertical bunches or arched over from stool to stool. This result has been obtained consistently since 1955.

Experiments planted since 1956

The outstanding result from these more recent experiments was again the effect of increased applications of inorganic nitrogen. The three nitrogen levels tested in one experiment—0, 40 and 80 lb. per acre, supplied by sulphate of ammonia—produced striking differences in leaf-colour, cane growth and yield, greater in Norfolk Giant than in Malling Exploit or Lloyd George but clearly shown by all three varieties. The standard fertilizer dressing applied to raspberries at Mylnefield has recently been modified in the light of the results of this and other experiments.

An experiment to compare six systems of soil management for raspberry plantations—a permanent straw mulch, a cover crop and four variants of the conventional system of clean cultivation—first received its complete treatments in 1959 after an establishment period of two years. The four clean cultivation systems are to compare draw hoe and Dutch hoe cultivation along the rows, and the ploughing-in of farmyard manure alongside the rows as opposed to spreading it in the alley-ways and turning it in by rotary cultivation. In 1959, when conditions became increasingly dry during the picking season, the straw mulch treatment gave the highest fruit yield and the cover crop treatment the lowest.

The last Report described an experiment planted in 1958 to compare eight possible methods of preparing ground for raspberry growing, followed by eight different post-planting systems of manuring. This gave its first substantial crop in 1959. Other experiments, concerned with the performance

of canes lifted from the nursery at different dates in winter, the comparative performance of autumn- and spring-planted canes, and the effects of various treatments of the tops of canes in winter, were continued and gave results in general agreement with those of previous years.

This series also includes the experiment, described in past Reports, in which the performance of virus-free stocks of Malling Jewel and Lloyd George is compared with that of the vigorous but mildly virus-affected stocks previously available. In 1959, the second cropping year, the stocks which were virus-free when planted again out-yielded the older stocks in both varieties and in each of the three planting treatments also compared in the experiment. All the yields, however, were high (65-85 cwt/acre for Malling Jewel and 96-120 cwt/acre for Lloyd George), and the differences between the stocks did not quite attain significance at the 5% level. (C. A. Wood, M. M. Anderson, W. Fordyce, J. P. Sutherland, B. Tulloch, M. J. Martin.)

WEED CONTROL

Raspberries

Work on the chemical control of weeds in raspberry cane nurseries and fruiting plantations was again expanded, with the main emphasis on the use of substituted urea and substituted triazine herbicides. In further "screening" tests on a first-year cane nursery, very good weed control was obtained with atrazine (2-chloro-4-ethylamino-6-isopropylamino-*s*-triazine), applied in mid-April at 2 and 4 lb./acre, with no evidence of damage to the raspberries. Atrazine, however, is more soluble than the related compound simazine, and requires further trial under less dry spring conditions before its safety for surface application can be assumed. It is interesting to note that although simazine at 2 lb./acre again gave excellent weed control, cane growth was undamaged even at a 6 lb. rate of application. Monuron (CMU) was also tested at the high rate of 5 lb./acre, when it suppressed all weed growth apart from a few plants of fumitory and knotgrass. Some of the young raspberry canes developed a marginal leaf-chlorosis, but growth later in the season became normal. Diuron (DCMU) was tested at 2, 4 and 6 lb./acre, and the 4 lb. rate appeared to be necessary to obtain a control of groundsel, henbit (*Lamium amplexicaule*), knotgrass and hempnettle. The raspberry canes showed a slight marginal leaf-chlorosis at this rate of application and a more severe chlorosis at the 6 lb. rate.

The first experiment specifically designed for the long-term trial of chemical methods of weed control in a raspberry fruiting plantation was planted in the spring. The present yearly treatments, in terms of active ingredients per acre, are simazine (2·5 lb.), monuron (3·5 lb.) and mixtures of 2,4-DES (4·6 lb.) with propham (4·0 lb.) and fenuron (0·5 lb.). These were applied early in April, shortly after planting, and all gave excellent weed control until mid-June, by which time the control plots had become very weedy. The entire experiment was then rotary-cultivated, and this cultivation was repeated in mid-August. Although none of the treatments visibly injured the raspberry plants, the control of weeds on the simazine- and monuron-treated plots was very good for the remainder of the season and throughout the winter of 1959/60, in spite of the fact that the ground had twice been disturbed by cultivation

in the summer. Annual treatments were also continued on an older plantation mentioned in the last Report. Both of these experiments are adequately replicated, and it is hoped that they will show the effects of the treatments on growth and cropping over a period of several years.

The annual treatments applied to a Malling Exploit cane nursery planted in 1958 were also continued. Monuron (3 lb./acre) and simazine (1, 2 and 3 lb./acre) gave an almost complete control of weeds, and the simazine-treated plots gave higher yields of cane than any others. The 3 lb./acre monuron plots and all the simazine plots were also outstanding for the high proportions of first-grade canes that they produced. Soil from this experiment is being tested for possible accumulations of monuron or simazine at various depths from the surface.

Early in 1959 an old fruiting plantation of Lloyd George and Malling Promise, heavily matted with annual meadow grass, chickweed and groundsel, was used to investigate the possibility of destroying overwintering weed growth by chemical means alone. On plots sprayed in mid-February with monuron (4 lb./acre) or simazine (2 lb./acre), the weeds completely died out in spring and the ground remained clean until late August. The raspberries were apparently uninjured. An equally good result was obtained with a proprietary phenol-fenuron mixture supplying 4·05 lb. of fenuron per acre; but this may have been due solely to the fenuron, since several phenol compounds tested alone were ineffective. The raspberries were injured in varying degree by treatments involving the use, alone or in mixtures, of dalapon, CIPC and amino triazole, and also by monuron (4 lb./acre) when applied in early May.

Strawberries

A runner-bed used for preliminary trials in 1958 was retained intact until late in the spring of 1959, when it was seen that on the simazine-treated plots some runners formed late in the previous season had developed a severe marginal leaf-scorch. Several of the smallest of these died. Most of the runners present continued to grow normally, however, and the control of weeds remained excellent.

Sprays of simazine, atrazine, monuron and diuron, applied to a prepared soil surface in spring 1959, caused a total loss of strawberry runners planted two days later. A mixture of 2,4-DES (3·6 lb./acre) and fenuron (0·5 lb./acre) similarly applied caused severe marginal leaf-chlorosis, which was attributed to the fenuron.

A Talisman plantation in its fourth cropping year was sprayed in mid-March with simazine at rates of 1·5 and 3 lb./acre. Weed control was good at the lower rate and excellent at the higher, and lasted throughout the season. A few of the older leaves of plants sprayed at the 3 lb. rate developed a slight marginal chlorosis in spring, but no difference of yield was recorded between treated and untreated plots.

Apples

Dalapon at about 5 lb./acre, applied as a directed ground spray around 7-year-old apple trees in mid-June, gave a reasonably good control of grass growing too close to the trees to be reached by the mower. The trees were apparently unharmed.

Potatoes

Weed control experiments were extended to potatoes for the first time, partly from a direct interest in reducing cultivation costs and partly with a view to reducing the amount of clod formation caused by the passage of implements, which can impede the work of mechanical harvesters at lifting time.

A large replicated experiment planted with the varieties Home Guard, Majestic and Redskin was used to test four pre-emergence herbicide treatments selected on the basis of experience with fruit crops on similar land. Three of the treatments, comprising simazine and mixtures of 2,4-DES with propham and fenuron, were unsuccessful, probably because of the dry conditions that followed application combined with the technical difficulty of spraying ridged land evenly. The fourth treatment, consisting of dinoseb amine (6 lb./acre) with dalapon (5 lb./acre) applied shortly before the emergence of the crop, was very successful. The treated plots remained weed-free throughout the season and gave higher yields than the mechanically cultivated controls.

Other treatments were tested in a "screening" trial. Samples of tubers from the trials were supplied to the Ministry of Agriculture, Fisheries and Food's Experimental Factory at Aberdeen, and to the laboratory of the British Food Manufacturing Industries Research Association at Leatherhead. for flavour and cooking tests.

Roadsides and Fences

Small trials were continued to discover the best means of destroying existing vegetation on roadsides and similar sites and leaving the ground weed-sterile for as long as possible. The most successful treatments were mixtures of 5 lb./acre of amino triazole with 10 lb./acre of either atrazine or simazine, applied during March. (J. P. Sutherland.)

STRAWBERRY INVESTIGATIONS

The large observation plots of Talisman (planted 1955) and Redgauntlet (planted 1957) described in past Reports were used to study the effects of post-harvest defoliation applied on three dates in August, with and without an added nitrogen treatment (see also p. 38). The earliest plots to be defoliated were mown on 8-9 August 1958, on which dates both plantations were dressed uniformly with sulphate of potash at the rate of 1½ cwt/acre. Other plots were mown on 18-19 and 28-29 August. On each defoliation date one-half of the plots mown received sulphate of ammonia at 2 cwt/acre, and on the first defoliation date one-half of the unmown control plots received a similar dressing. In spring 1959 the plots of Redgauntlet were halved, and one sub-plot of each received a further application of sulphate of ammonia at 2 cwt./acre.

The effects of defoliation on inflorescence numbers and crop yields in 1959 were smaller than in 1958, due possibly to differences between the weather of the two preceding autumns. The mown plants of Talisman and the earliest-mown plants of Redgauntlet carried more inflorescences than the unmown plants, and the mown Redgauntlet and earliest-mown Talisman were superior in the percentages of their flowers that set fruit and in the average weight of their individual berries. The mown Talisman and the earliest-mown Red-

gauntlet out-yielded the unmown controls, but the yield of the Redgauntlet plots mown on the latest date was 8½ cwt/acre less than that of the controls. The nitrogen applications generally depressed yields, the effect being most marked in the earliest-defoliated plants. (M. M. Anderson.)

Strawberry seedling trials were continued in co-operation with the West of Scotland Unit. (C. A. Wood, M. M. Anderson.)

APPLE VARIETY-ROOTSTOCK TRIALS

Growth in these trials was generally good despite the dry season. The cultivated strips hitherto maintained along the lines of trees in the older trials were sown in late summer with the same timothy/white clover seeds mixture earlier used for the inter-row areas.

Seventy-two trees of Laxton's Fortune were planted to form a second section of the trial of dessert varieties on four Malling and four Malling-Merton rootstocks, and plans were made to add a final set of trees of Exeter Cross, a variety chosen for its performance in an older trial at Mylnefield. Two trials of dwarf pyramid apples were also planted. These will compare the varieties Sunset and Worcester Pearmain on four Malling and three Malling-Merton rootstocks and under two pruning systems.

The trial of dessert varieties on the dwarfing and semi-dwarfing rootstocks M.IX and M.VII produced marketable quantities of fruit, with the trees on M.IX still the heavier in yield. Wagener and Merton Worcester cropped well, but the crop from Red Melba on M.IX was smaller than in 1958. All the other trials gave light crops, Bramley's Seedling yielding for the first time in the trial of culinary varieties on M.I, M.II. M.XVI and Crab C. Wagener and Laxton's Superb did best among dessert varieties on semi-dwarfing and semi-vigorous rootstocks, whilst Beauty of Bath, in trials of desserts, set fruit poorly after flowering early.

Stem canker continued to spread among the eight dessert varieties in the trial on rootstocks M.IX and M.VII, which is not grassed down. Merton Worcester and Wagener were the worst affected, but only Lord Lambourne and Winston were entirely free from infection.

Stem girths and weights of prunings continued to be recorded for all trees in these trials. The information so far accruing from the records is in general agreement with the known behaviour elsewhere of most of the varieties and older rootstocks. (W. Fordyce, J. P. Sutherland.)

OTHER VARIETY TRIALS

Red Currants

Except for Earliest of Fourlands, Ayrshire Queen and Jonkheer van Tets, nearly all the varieties in the red currant trials and observation plots were severely restricted in growth by the dry summer and autumn. In the smaller trial of five varieties, the first three in order of yield were Earliest of Fourlands, Jonkheer van Tets and Laxton's No. 1. The fruit of Jonkheer van Tets, which ripens very early, will hang for several days without deterioration. Red Lake cropped poorly, mainly because of wind damage in 1958. In the trial of 15 varieties, Earliest of Fourlands was second in yield to London Market, a vigorous variety of poor fruit quality. Laxton's Perfection and

Red Dutch also cropped well. Several varieties again suffered severe wind damage: Earliest of Fourlands, Ayrshire Queen, Red Dutch and London Market appear to be more wind-resistant than the majority.

Black Currants

In the black currant variety and pruning trial, cropping for its third season, the heaviest yielding variety was Wallace Seedling, followed by Wellington XXX and Amos Black. The dry season severely restricted new growth, especially in these three varieties. In seven of the eight varieties the winter-pruned bushes again cropped better than the bushes pruned in late summer.

Plums

Eight more trees of the 1953 "elimination" trial of plum varieties and root-stocks died from bacterial canker. For reasons given in the last Report the trial area was sown down in May to a permanent sward, the mixture used again consisting mainly of timothy and white clover.

The season was the best for plums since the trial began. Thirty-seven varieties cropped, 10 for the first time, and the quality of most was better than in previous years. Among the varieties which did well were Blue Rock, Czar, Cox's Emperor, Pond's Seedling and Laxton's Cropper, the last of which again gave the highest yield. Gordon Castle Seedling was outstanding among gages and other high quality plums, most of which were better than usual in flavour and less damaged by splitting.

Apples

The dry weather in summer considerably reduced the fruit size of many apple varieties in the older trials, but some were clearly less affected than others. James Grieve and Lord Lambourne gave heavy crops of good size, whereas the fruit of others which are normally satisfactory, such as Ellison's Orange and Laxton's Superb, was very small. The Canadian varieties in the "elimination" trial were again outstanding for colour and finish. Of these, Lobo, Lawfam and Cortland all cropped well but the fruit of Lawfam was small. Cave's Seedling and Lodi were the best of the early-maturing varieties, Lodi being the first variety of all to ripen.

Nitrogen deficiency, accentuated by lack of rain, affected the trees of most varieties in the grassed-down trials and was associated with the very high fruit colour. The trials still under clean cultivation were less affected by the seasonal conditions and gave fruit of better size but poorer colour and keeping quality. Bramley's Seedling and Howgate Wonder were again the outstanding culinary varieties: both cropped well and seemed little affected by the dry weather.

Under the mild conditions of October and November most of the mid-season and late varieties shrivelled in the store without maturing, but the fruit from the grassed-down trials was least affected in this way. Fairly large crops of Ribston Pippin, Tydeman's Early Worcester, Merton Worcester, Lord Lambourne and Cox's Orange Pippin from the clean-cultivated trial on rootstocks M.IX and M.VII, referred to earlier, completely failed to mature in the store.

In the Apple Variety Collection, 409 varieties cropped, 60 of them for the first time. The collection now contains more than 800 named trees, which,

allowing for duplication and synonymy, probably include at least 700 distinct varieties. In the "elimination" trial of modern and commercial apples, 94 of the 103 varieties cropped.

Pears and Cherries

No further additions were made to the Pear Collection. Fifteen varieties fruited, five for the first time. Louise Bonne of Jersey and Laxton's Superb, closely followed by Conference and Bristol Cross, have so far been the most successful varieties.

The 1955 trial of sweet cherries contains eight standard trees of each of the varieties Early Rivers, Merton Heart, Merton Bigarreau, Napoleon and Géant de Hedelfingen. All made good growth during the year and only Merton Bigarreau failed to fruit. Attempts to scare birds, however, were ineffective, and ripe fruit was picked only from Géant de Hedelfingen. The estimated heaviest crop was on Merton Heart.

Scottish Regional Fruit Trials

The trials in progress under the aegis of the Scottish Fruit Trials Committee were of raspberries, strawberries and plums. In the raspberry trial, planted in 1952, the varieties Malling Promise, Malling Exploit, Norfolk Giant and Malling Jewel cropped more heavily than in 1958, the first two substantially so. The yields of Lloyd George and Malling Enterprise were slightly lower. The crop from Malling Promise, nearly 5¾ tons/acre in the seventh fruiting season, reflected the continued vigour of this very productive trial.

In the 1958 strawberry trial, in its first fruiting year, the eight varieties all cropped exceptionally well. Merton Princess gave a yield of more than 9 tons of saleable fruit per acre, Cambridge Vigour, Talisman, Senga 54 and Senga Sengana each exceeded 8 tons, Redgauntlet and Cambridge Rearguard exceeded 5 tons, and the yield of Royal Sovereign was slightly below 4 tons. Under the very favourable conditions of the season all the varieties showed fairly good quality. The calculated yields of this trial, based on records from small, replicated plots, were supported in some cases by the cropping of nearby larger plantations. A half-acre of Talisman in its fourth cropping year gave 9 tons/acre of saleable fruit, and a single acre of Redgauntlet in its second year yielded more than 6 tons.

In the trial of plums, planted in 1954, several varieties cropped for the first time. Three more trees died from bacterial canker.

MISCELLANEOUS

In the co-operative experiment on the control of plum bacterial canker, started in 1957, maiden trees of the variety Victoria were headed-back in the nursery, grown on for a second year and planted into the field in March 1960. Protective paint treatments were re-applied at the time of leaf-fall. The nursery phase of this experiment having now been completed, future work will be concerned with the behaviour of the trees in the field and measures to prevent their further infection.

Fruit was again supplied to the Ministry of Agriculture, Fisheries and Food's Experimental Factory at Aberdeen, for dehydration tests and deter-

minations of ascorbic acid content. Further samples of soft fruit were sent to the laboratory of the British Food Manufacturing Industries Research Association, Leatherhead, Surrey, for tests concerned with spray residues and with the "blindness" of seeds in raspberry jam, and also to Messrs Chivers & Sons Ltd., Montrose, for canning tests.

PUBLICATIONS

JENNINGS, D. L. (1959). *Manihot melanobasis* Müll. Arg.—A useful parent for cassava breeding. *Euphytica*, **8**, 157.

JENNINGS, D. L. (1960). Observations on virus diseases of cassava in resistant and susceptible varieties. I. Mosaic disease. *Emp. J. exp. Agric.* (In press.)

JENNINGS, D. L. (1960). Observations on virus diseases of cassava in resistant and susceptible varieties. II. Brown Streak disease. *Emp. J. exp. Agric.* (In press.)
(The above papers report work done by the author when serving with the East African Agriculture and Forestry Research Organisation. The first describes the usefulness of *Manihot melanobasis* in cassava breeding. Although producing only rudimentary tuberous roots itself, this species gives hybrids with cassava which produce high yields of roots of improved quality. The second and third papers describe the phenomenon of virus resistance in certain varieties of cassava and some of the factors that influence its expression. In varieties resistant to mosaic, the virus appears to become localised in the roots of infected plants, but symptoms are produced when conditions at the time of infection do not favour the resistance mechanism of the host plant. Resistance to brown streak virus is probably of a similar type.)

WOOD, C. A. (1959). Raspberry Research. *Agriculture, Lond.*, **66**, 279-283.
(An article reviewing the impact upon the raspberry industry of recent research in plant breeding, plant pathology and crop husbandry.)

WOOD, C. A. (1960). Commercial Raspberry Growing: the Integration of Cultural Factors. *Sci. Hort.*, **14**, 97-103.
(This paper surveys the results of experiments of the past nine years on methods and distances of planting, systems of training, the stool and "hedgerow" systems of row management, the selection of fruiting canes and the winter pruning or tipping of newly tied-in canes. Recent work on manuring and soil management, including the use of herbicides for weed control, is briefly discussed, and stress is laid on the importance of combining the use of healthy stocks with the adoption of the most efficient cultural practices.)

WOOD, C. A. (1960). More fresh fruit could be sold. *Grower* **53**, 172-174.

WOOD, C. A. & ANDERSON, M. M. (1959). Raspberry cultivation in the light of recent experiments. *Commercial Grower*, 11th September, 1959, 338.
(These two articles consider some of the problems now affecting the Scottish raspberry industry, and discuss the varieties and stocks available for planting and the results of recent experiments on plantation management.)

WOOD, C. A. & SUTHERLAND, J. P. (1960). Herbicides for the commercial fruitgrower. *Scot. Agric.*, **39**, 214-218.
(A review of progress in the use of chemical herbicides for weed control in raspberries, strawberries, black currants, gooseberries, apples and plums, with special reference to northern and Scottish conditions.)

VEGETABLE CROPS

C. NORTH

Overwintering vegetable crops at Mylnefield were severely damaged by the prolonged frost in January 1959. Most summer crops, however, grew particularly well during the unusually warm weather and few suffered from the lack of rain.

VARIETY TRIALS

French Beans

Of the eight varieties grown in a yield trial, Masterpiece, Double Princess and Prelude were the most productive. Prelude is a promising new variety of Dutch origin with entirely stringless pods and white seed. The yield of Refugee, which usually thrives particularly well during a warm summer, was surprisingly low, and it seems probable that the dry weather affected it more than other varieties. Unfortunately, Record, which has performed so well in earlier trials, could not be compared in the trial as no seed was available.

Forty-five varieties, including for the first time some from Poland, were compared in observation plots for earliness and pod quality. The Polish varieties Bronowicka, Koda, Zlotka, and the American varieties Cornell 14, Pearlgreen and Wade, were selected for further trial. Varieties in the latter group had pods of excellent quality but they matured later than the best varieties included in the yield trial and it is probable that they may not be very productive in an average season.

Stocks of the Czechoslovakian varieties Olomoucka Krekka and Slavia were multiplied so that sufficient seed would be available for a yield trial.

Broad Beans

A new trial series of 21 varieties was commenced. Most strains of Threefold White gave higher yields than Masterpiece and Bunyard's Exhibition, whereas in previous years their yield had been considerably lower than these varieties. It seems probable that Threefold White may be less affected by drought than are most other varieties. Lux and Sugar, which, in common with Threefold White, are suitable for canning, gave relatively low yields.

Brussels Sprouts

The order of yield ranking of the varieties sown in spring 1959 was similar to that for the previous year. The best yield of large sprouts was again given by Irish Elegance which produced very firm but rather pale-coloured sprouts; this is a new variety bred by the late Professor G. O. Sherrard of Dublin and first released in the autumn of 1959. Of the varieties with medium to small sprouts, the most productive were Sanda, Cambridge Special and Marché de Berne, all of which gave firm dark-green sprouts: Sanda is perhaps the best

for quick-freezing as it is the least prone to rotting. Irish Glacier, another of Professor Sherrard's strains, gave sprouts of good quality for quick-freezing, but its yield was low in comparison with that of other varieties.

Nine varieties were grown in observation plots and from them Prominent, Danish Giant and Sapidus were chosen for further testing as varieties suitable for quick-freezing. Plants of the Japanese F_1 hybrid line Jade Cross were very uniform and matured earlier than any of the other varieties tested; they were very productive and gave fewer open sprouts than in 1959 but the sprouts were very prone to rot unless the crop was picked frequently.

Since the commencement of Brussels sprout variety trials at Mylnefield in 1952, all plots have consisted of two rows of 30 plants each. To find whether it might be possible to reduce the size of future trials by growing only a single row of 30 plants per plot, the rows were harvested separately in 1959. The results showed that a loss in trial precision, due to a reduction in the number of plants of each variety tested, could not be compensated by increasing the number of replicates. The inter-block variation in 1959 was due largely to inter-plant variations within the varieties rather than to differences in soil fertility within the area covered by the trial.

All Brussels sprout stocks grown at Mylnefield in 1959 were examined for internal browning of the sprouts. There were significant varietal differences in the frequency of this defect. No significant correlations were found between varietal percentages of internal browning and (1) external rotting of the sprouts, or (2) marginal scorch of the leaves of the main axis.

Cabbage

Thirty-eight autumn-maturing varieties were grown in observation plots. These included three stocks of Christmas Drumhead, which is a standard variety in many parts of England for marketing during September and October. As in previous trials at Mylnefield, the stocks of Christmas Drumhead were all very uneven and 60-70% of the heads tended to split soon after they had matured. However, the varieties Amager Vinter, I av (Hansen) and N-S cross (Takii) were extremely uniform and very resistant to premature splitting of the heads, and the varieties Jåtunsalgets Vinterkål (Jåtun Co-operative Society, Norway) and Toyoda Natsumaki (Shizuoka Exp. Sta., Japan) were nearly as good. Other uniform stocks were Blåtopp, 5601 (Shizuoka), Holland E40 and Rearguard Roundhead. Although heads of the last-mentioned variety tended to split soon after maturing, they were not as bad in this respect as the strains of Christmas Drumhead.

A further trial of Danish Amager type cabbages was conducted. The heads were cut in November 1959 and some were stored in a barn and others in clamps outside. Those in the barn were still in good condition by the end of February, but those in the clamp had not been examined by this time.

Broccoli

Most of the plants sown in spring 1958 were killed during the cold spell of weather in the following January, and only 40% of the plants of the hardiest varieties survived in sufficiently good condition to form marketable curds. Of the stocks compared in the yield trial, the control variety St. George gave better quality curds than any of the strains of Royal Oak.

Eight of the 40 strains grown in observation plots were selected for further trial. The variety Monarch gave the most promising results.

Calabresse

This crop again had a very long harvest season. Seedlings were transplanted on 15 May and commenced cropping on 20 June, two weeks earlier than in 1958. It was necessary to harvest the crop every three or four days until the middle of November, by which time growth had largely ceased. The need for such frequent harvesting may be a drawback to the cultivation of this crop in Scotland for processing. Two of the eight strains tested, Calabresse (Hurst) and Italian Sprouting (Sutton), which commenced to produce shoots earliest, gave significantly higher total yields than the others.

Carrot

Four yield trials were conducted in 1959, two at Mylnefield and one each at North Berwick and Carnoustie. One of the trials at Mylnefield was harvested in early August to find which varieties were most suitable for the "bunching" trade; the other three trials were harvested in late September and October to test varieties for production of "maincrop" carrots. Twenty-three stocks were compared in each trial.

On the sandy soils at North Berwick and Carnoustie growth was severely checked by the long summer drought, but in the medium loam soil at Mylnefield the crop was not adversely affected by the lack of rain, and gave an exceptionally heavy yield.

The most productive variety in the early-harvested trial was New Stump-rooted (Clucas), and in the maincrop trial Flakkese (Rijk Zwaan). Of the varieties which produced relatively short, highly coloured roots of a type suitable for canning whole, New Stump-rooted (Clucas) and Chantenay Red-cored (Ferry Morse) appeared the most promising. The latter has a distinct tendency to bolt whereas the former seems considerably more resistant to this defect than most of the other tested strains of the Chantenay type.

Some varieties grown in the yield trial gave a high proportion of split roots, particularly a strain of Early Scarlet Horn which behaved similarly in 1958. The varieties Flakkese and Regulus, however, did not show this defect.

Fifteen varieties were grown in observation plots and two of them, Royal Chantenay (Cullen) and Stump-rooted Intermediate (Sharpe) were selected for further trial.

Beetroot

The new type of cylindrical-shaped red beet (variety Formanova, previously called Bloodred Cylinder) was compared with globe-beet types at Mylnefield and Lanark. The yield of Formanova was higher than that of the other four strains although the difference between it and one of the Detroit Strains was not significant at Mylnefield. There were fewer bolters in Formanova than in any of the other strains, and the colour of the roots was as good as those of Detroit.

Leek

Variety trials of leeks were conducted at Mylnefield and at three centres in Lanarkshire. Plants for one of the trials in Lanarkshire were raised in frames and harvested during the autumn of 1959. For the other three trials the plants were raised in the open for harvesting in the spring of 1960. Results of the autumn-harvested trial only are available. Thirty strains were tested. The varieties Giant, Northumberland, Royal Favourite, Renton's Monarch and some strains of Musselburgh were the most productive. The yield of Géant de Bulgarie was also high, but the plants were very tall and of a type which is unlikely to be favoured in most markets. The varieties Winterreuzen and a strain of Gennevilliers Improved gave good yields of very dark-leaved, high quality leeks.

Winter Lettuce

Many of the plants raised from seed in the autumn of 1958 were killed during the following winter and no more than 50% of those of the most cold-tolerant varieties survived. The varieties Winter Mombacher and Reichenauer Winter survived best, but both, especially the second, tended to bolt soon after heads had developed. Strains of Arctic King survived fairly well and formed rather small heads which also tended to bolt early. Strains of the Imperial type did not survive the winter as well as those of Arctic King but they produced large, good quality heads which remained in a marketable condition without splitting for several weeks. The best Imperial type was Winter Crop (Clucas) but the strains Imperial (Tozer), Imperial (Clucas) and Winter Pearl (Dickson) were nearly as good.

Ridge Cucumbers

Plants of 33 varieties raised in the greenhouse and transferred to the field on 28 May began to produce marketable fruits during the first week in August. They grew well during the abnormally warm summer weather and harvesting was continued until the end of September. The F_1 hybrid variety Chojit-suochiai (Kyushu Agric. Sta., Japan), gave outstanding results. It was early and productive and the fruits resembled those of a glasshouse cucumber in size and shape. The variety Ulma (Vatter, Switzerland) was especially early and productive although its fruits were rather short and broad.

Miscellaneous Vegetables

A yield trial of celeriac was conducted and the plants grew well in spite of the dry summer weather. The results are given in a paper published in this Report.

Six varieties of spinach were compared in a yield trial. The plants of all varieties began to run to seed at about the same time during the warm dry weather in mid-June and were harvested on the same day. The varietal differences in yield were not significant. (C. North, L. H. Frith, H. Taylor.)

CULTURAL EXPERIMENTS WITH BRUSSELS SPROUT

A field experiment, designed to compare the effect of autumn versus spring sowing of Brussels sprouts, was conducted on similar lines to that

mentioned in the last Report. Autumn-sown plants of all five varieties again gave higher yields of larger and paler-coloured sprouts than those sown in spring. However, in contrast to the results of the earlier experiment, the treatments had no significant effect on the firmness of the sprouts. In spite of the unusually cold weather in January 1959, very few of the overwintering plants were damaged by frost, but there was a pronounced varietal difference in the number of overwintered plants that bolted prematurely. In the trial, about 20% of the plants of Cluseed and Unicum bolted, but very few of Evesham Special, Masterman and Sanda. Since it is important to choose for autumn sowing only those varieties which do not show this tendency, 18 varieties were sown in autumn to observe their behaviour. In about half of these there were very few bolters, but in some varieties, including Marché de Berne and Cambridge Special, there were between 40 and 60%.

It is frequently claimed that Brussels sprouts grow better and produce better quality sprouts when planted in firm than in loose soil. A small scale preliminary experiment was made to test this theory. The results gave no evidence that firm soil was a clear advantage although there were significantly more rotted sprouts from the loose than the firm soil treatments. However, further experiments are necessary before any conclusion can be drawn. (C. North.)

PLANT BREEDING

Brussels Sprout

Eighty-two lines of breeding material, including F_1, F_2 and F_3 progenies were grown in three randomized block layouts. They were tested for yield and quality of the sprouts, and plants were selected within the high yielding lines only. One of the trials was designed to compare the yield of progenies from plants selected within low- and high-yielding lines of interrelated parentage. The results supported the view that it is advantageous to select plants exclusively from high-yielding lines. They also emphasised the importance of basing assessments of the productivity of lines of breeding material on crop weight rather than on eye estimations which can be very misleading.

Further studies were made on the male-sterile material found at Mylnefield in 1957. When partially male-sterile individuals were selfed they gave progenies which included plants with only male-sterile flowers, plants with only hermaphrodite flowers, and a continuous series of intermediate forms with flowers of both types. The problem was further complicated by the modifying effects of environmental conditions. Partially male-sterile plants maintained at a temperature of 70-80°F. during the flowering period had a higher proportion of male-sterile flowers than those kept in an unheated glasshouse.

Preliminary tests of a proprietary substance which has been used to induce male-sterility in cotton, were made on Brussels sprout and cabbage. The substance was applied to the plants as an aqueous spray. High concentrations scorched the plants and inhibited flower-bud development. Lower concentrations prevented stamen development without inducing any visible signs of damage to the gynaecium under field or glasshouse conditions. It is not

known, however, whether treated plants were capable of producing seed after pollination with normal pollen. (G. Priestley, C. North.)

Cabbage

The continuous frost in January 1959 prevented the lifting of selected plants from the field and caused considerable loss of cabbage breeding material. As a result, comparatively few plants were pollinated in the spring of 1959.

Forty lines from the previous year's pollinations were tested in the field. No loss of vigour was apparent in F_3 lines which were extremely uniform. Plants derived from the crosses Danish Keeping x January King and January King x Ormskirk Savoy were selected for pollinating in 1960.

Dwarf Beans

Over 200 lines of F_4 and F_5 generations derived from crosses between the varieties Double Princess, Record, Refugee and Fullcrop were grown in the field. The uniformity of all the lines was good and very few showed signs of continuing segregation. The lines were judged for earliness and pod quality and tested by the Canning and Quick-Freezing Research Institute for suitability for processing. Selections were made from 17% of the lines for inclusion in a yield trial in 1960.

Segregating lines from crosses between Record, Contender, Zenevska Trzni and Early Blue Lake were multiplied in the glasshouse and preliminary selections were made.

A wide range of material of different generations from crosses between *Phaseolus vulgaris* and *P. coccineus* varieties was grown in the field. The lines showed great variation in growth habit, pod quality and uniformity. Single plant selections were made from lines producing dwarf plants with stringless pods, some of them with pink flowers. (G. Priestley.)

VEGETABLES FOR DEHYDRATION EXPERIMENTS

Approximately 1½ acres of vegetables, including broad beans and French beans and 4 varieties of peas, were grown for dehydration experiments at the Ministry of Agriculture, Fisheries & Food's Research Establishment at Aberdeen. In collaboration with Smedley's Ltd. the maturity of the peas was tested from time to time and each variety was harvested when the tenderometer reading was between 90 and 95. (L. H. Frith in collaboration with L. S. Gray.)

PUBLICATIONS

NORTH, C., FRITH, L. H. & TAYLOR, H. (1959). Variety trials of vegetables in Scotland V. Spring-sown broad beans. *Rept. Scottish Hort. Res. Inst.*, 1958-59, 54-60.
(Fifty strains were tested at Mylnefield and Craibstone, Aberdeen. Varieties especially suitable for canning, quick-freezing, the green market and private gardens are noted.)

NORTH, C & TAYLOR, H. (1959). Variety trials of vegetables in Scotland VI. Hamburg parsley, 1957-1958. *Rept. Scottish Hort. Res. Inst.*, 1958-59, 61-63.
(Trials at Mylnefield indicated that this vegetable is quite suitable for cultivation in Scotland. Some of the eight varieties tested gave poor quality roots. Varieties Tidig vit Socker, Tyk Sukker and Berliner were productive and gave roots of good quality.)

NORTH, C. (1959). A review of recent researches on *Brassica oleracea*. *Rept. Scottish Hort. Res. Inst.*, 1958-59, 64-74.
(A review based on a paper given at the N.A.A.S. Inter-regional Horticultural Staff Conference, Keswick, Feb. 1959.)

NORTH, C. (1960). Research on vegetables at the Scottish Horticultural Research Institute *Sci. Hort.*, **14**, 104-109.
(A report of the work at Mylnefield on Brussels sprout, cabbage and French bean, based on a paper read at the Horticultural Educational Association Conference at Dundee, September, 1959.)

PHYSIOLOGY

C. G. GUTTRIDGE

PHYSIOLOGY OF GROWTH OF THE STRAWBERRY PLANT

The strawberry is a perennial, with a seasonal cycle of growth which is regulated mainly by changes in temperature and daylength. The development of the vegetative parts, as well as the formation of flower trusses follows an annual pattern which is broadly similar for all varieties, although there are quantitative differences especially between the flowering habits of perpetual and non-perpetual types. It is possible that both vegetative development and floral responses are controlled by a single growth regulator, since both appear to be affected together by changes in daylength.

In an experiment made in 1955, vegetative development of plants growing in short daylengths was stimulated and flower induction delayed when plants connected to them by stolons were exposed to long daylengths. This result has been confirmed and the stimulus has been shown to be photoperiodically induced, and, therefore, formative rather than nutritive. The transmission of the stimulus along the stolon was most effective under conditions favouring translocation of assimilates from the long-day to the short-day plant. Young or defoliated runner plants in long daylengths initiated flowers when attached to parent plants in short daylengths, but the presence of leaves on the runner plants inhibited flower formation. In the absence of leaves, application of gibberellic acid to the runner plants also inhibited flower formation, a result which suggests that gibberellic acid is a direct substitute at the apical meristem for substances produced in leaves in long daylengths.

On the basis of these results it is suggested that the regulation of growth by daylength is brought about in strawberry by a hormone which promotes vegetative development and inhibits flower-truss formation. Thus in non-perpetual varieties, the vigorous vegetative development and the absence of flower induction in long days is thought to result from a high level of the hormone, while the low level of vegetative growth and the induction of flowering in short days results from a low level of the same substance, flower induction occurring in the absence of sufficient hormone to prevent it.

The defoliation experiments reported below fully support this hypothesis by showing that the removal of leaves promotes flower formation, supposedly by removing or reducing the source of the postulated hormone and thus reducing its supply to the apical meristems. They further indicate that flower-promoting substances, even if present in the strawberry, are not involved in the photoperiodic regulation of flower initiation.

The regulatory system in strawberry seems to be different from that of certain other short-day plants, for which there is evidence of flower promotin substances. Perhaps this is the reason why flower induction in at least som of these species is not inhibited by gibberellic acid.

Gibberellic Acid

It was reported last year that gibberellic acid applied to plants growing in short days resulted in an increase in petiole length, promotion of runnering, inhibition of flower formation and lengthening of the crown stems, which are normally short and give the plant its rosette habit. These results have been confirmed and amplified. The responses induced by gibberellic acid are in many ways similar to those induced by increasing daylengths or by chilling if the plants are dormant.

Responses to gibberellic acid are not, however, confined to the non-perpetual varieties. Weekly sprays of gibberellic acid at 7·5, 15 or 30 ppm. in aqueous solution, applied to plants in short daylengths, caused a similar response in both the non-perpetual variety Talisman and the perpetual flowering variety St. Claude, and also in the runnering and everbearing varieties of *Fragaria vesca*. In another experiment the perpetual flowering variety, Sans Rivale responded in the same way. Treated plants of all varieties showed an increase in petiole length, promotion of runnering, stem elongation and, what is particularly interesting, inhibition of flowering, especially at the two higher rates of application. Although there were small quantitative differences, the broad similarity of response was clear. As natural long daylengths do not inhibit flower initiation in the perpetual flowering varieties, it seems that gibberellic acid may be different from the postulated naturally occurring hormone, although perhaps closely related chemically. The fact that gibberellic acid causes abnormal elongation of the crown stem supports this suggestion.

In earlier work with parent and daughter plants joined by the runner, daughter plants in long days initiated flowers in response to short-day induction of their parents only if the daughters were defoliated or were small and without mature leaves. In a recent experiment in the glasshouse, gibberellic acid, when applied in microdrops at the rate of 3 μg./plant each week to defoliated daughter runners, reduced the number of those with flowers from 91% to 16%, while a weekly application of 1 μg. decreased the number to an intermediate level (47%). This suggests that gibberellic acid acts directly in the growing regions and is not dependent on the presence of leaves.

Other workers have shown that in some short-day plants flower induction is not inhibited by gibberellic acid. This is interesting because the evidence for flower-promoting hormones in some of these species is very strong. The effect of gibberellic acid on the flowering of the short-day species *Perilla nankinensis* and *Chenopodium amaranticolor* was therefore tested. *Perilla* seedlings were sprayed with gibberellic acid at 0·2, 1, 5 or 25 ppm. in aqueous solution three times, at fortnightly intervals during a 6 week short-day (8 hr) induction period at 65°F. All plants except one, which had been sprayed at 0·2 ppm., flowered later, as did unsprayed controls. In a second experiment ethanol/water solution at the rate of 0·2, 1, 5 or 25 μg. per plant each week 5 week-old plants were treated with gibberellic acid in microdrops of 25% during a short-day induction period of 4 weeks' duration. Later, when returned to long days all plants, including untreated controls, flowered. These tests are not conclusive, but the evidence for gibberellic acid having little or no effect on flowering is strong.

With *Chenopodium*, 4 applications, at 4 or 5 day intervals, of gibberellic acid in ethanol at the rate of 10 or 100 μg./plant failed to inhibit flowering in plants subjected to either 8, 6, 4, or 2 consecutive short-day cycles of 8 hr duration at 65°F. in an otherwise unbroken succession of long days. Controls in long days flowered, only very much later as a result of induction in the autumn. This was a more sensitive test than those on *Perilla*.

These results cannot be reconciled at present with those obtained with strawberry and it seems quite likely that in these two species and other short-day plants in which flower induction is not inhibited by gibberellic acid, flowering is regulated by a different hormone system from that in strawberry. The effect of gibberellic acid may provide a simple test for distinguishing between what may well be two fundamentally different systems of regulating flowering.

In the field, gibberellic acid can be used to inhibit the formation of flower trusses in strawberries. Two sprays with an aqueous solution of gibberellic acid at a concentration of 100 ppm. almost completely inhibited flower induction in Royal Sovereign, Talisman and Redgauntlet plants. Runner beds were treated in autumn 1959, so that runners without flower buds may be available for planting in spring. These plants will not require deblossoming in their maiden year. The commercial application of this technique will depend on costs, especially as several spray applications may be necessary to ensure complete barrenness. (C. G. Guttridge.)

Bio-assay of Gibberellins

There is now substantial evidence that the photoperiodically-controlled growth responses in the strawberry are mediated by a hormone produced in the leaves in long days, which promotes vegetative development and inhibits flower initiation. There is reason to believe that this hormone is a gibberellin-like substance, and its activity has been simulated by applications of gibberellic acid to strawberry plants growing in short photoperiods.

It is a characteristic of the activity of gibberellins that they promote elongation of the internodes of dwarf plants, and among such plants, dwarf varieties of *Pisum sativum* have been found to be particularly sensitive, responding to an application of as little as 0·02 μg./plant of gibberellic acid.

Because of their extreme sensitivity, dwarf peas are used as a means of assaying gibberellins, and an attempt was made to transfer sufficient of the naturally occurring hormone directly from strawberry to pea to stimulate internode extension. This was successfully achieved by cutting opposite tongues in the epicotyl of a pea and the petiole of a strawberry and making an approach graft between the two plants.

Dwarf peas of the variety Meteor were sown in pots in the glasshouse, and grown on until the third true leaf was unfolding. They were then selected for uniformity, removed from their pots, and their roots washed free from soil with tap water. Cuts about 1 cm. long were made in the epicotyl of the pea and in the petiole of the strawberry, the two tissues interlocked, and the graft bound firmly with crepe rubber bandage. Immediately after completion of the graft the roots of the peas were placed in 3 in. $\times$ 1$\frac{1}{4}$ in. sample tubes containing a mineral nutrient solution. The grafts were usually left intact for

one week after which the peas were removed from the strawberries and grown on in the sample tubes until the sixth internode was fully elongated. They were then harvested and the length of each internode measured.

In a series of experiments peas grafted to petioles of strawberries nearly always responded by an increase in the length of the internodes elongating after grafting, when compared with similar internodes in an ungrafted series. The magnitude of the response was increased when the strawberry plant had been previously treated with gibberellic acid. Peas grafted in the spring to vigorously growing strawberries which had received a full chilling treatment gave a greater response than did a similar series of peas grafted to unchilled strawberries which were semi-dormant and growing less vigorously.

The pea variety Meteor was used for the greater part of this work, and a trial of six varieties of peas ranging in habit from tall to dwarf confirmed the suitability of this variety. It is possible however that with more extensive trials an even better variety may be found.

In most of the experiments the grafts were left undisturbed for about seven days but in a few instances a response was found after a period of contact of only two days. No graft union was ever formed so that it seems unlikely that the extra elongation of the internodes of the pea resulted from the transfer of nutritional metabolites from the strawberry. An experiment in which Meteor peas were grafted onto plants of French Bean (*Phaseolus vulgaris*) failed to stimulate pea internode extension even though unions were formed in a number of grafts. This result supports the view that the internode extension found after grafting to strawberries is not due to an increase in the general level of nutritional metabolites reaching the pea plant.

Further work is now in progress to investigate the conditions governing the sensitivity of the technique, with a view to evolving a standard procedure suitable for quantitative determination of the graft transmissible substance responsible for the increased elongation of the pea internodes.

This substance reacts on the pea in a way characteristic of the action of gibberellins, and it is hoped that the technique may provide a rapid method of bio-assay for gibberellins in plants without the necessity either to make an extract or to destroy any part of the plant sampled. (P. A. Thompson.)

Effect of Leaf Maturity on Flower Initiation

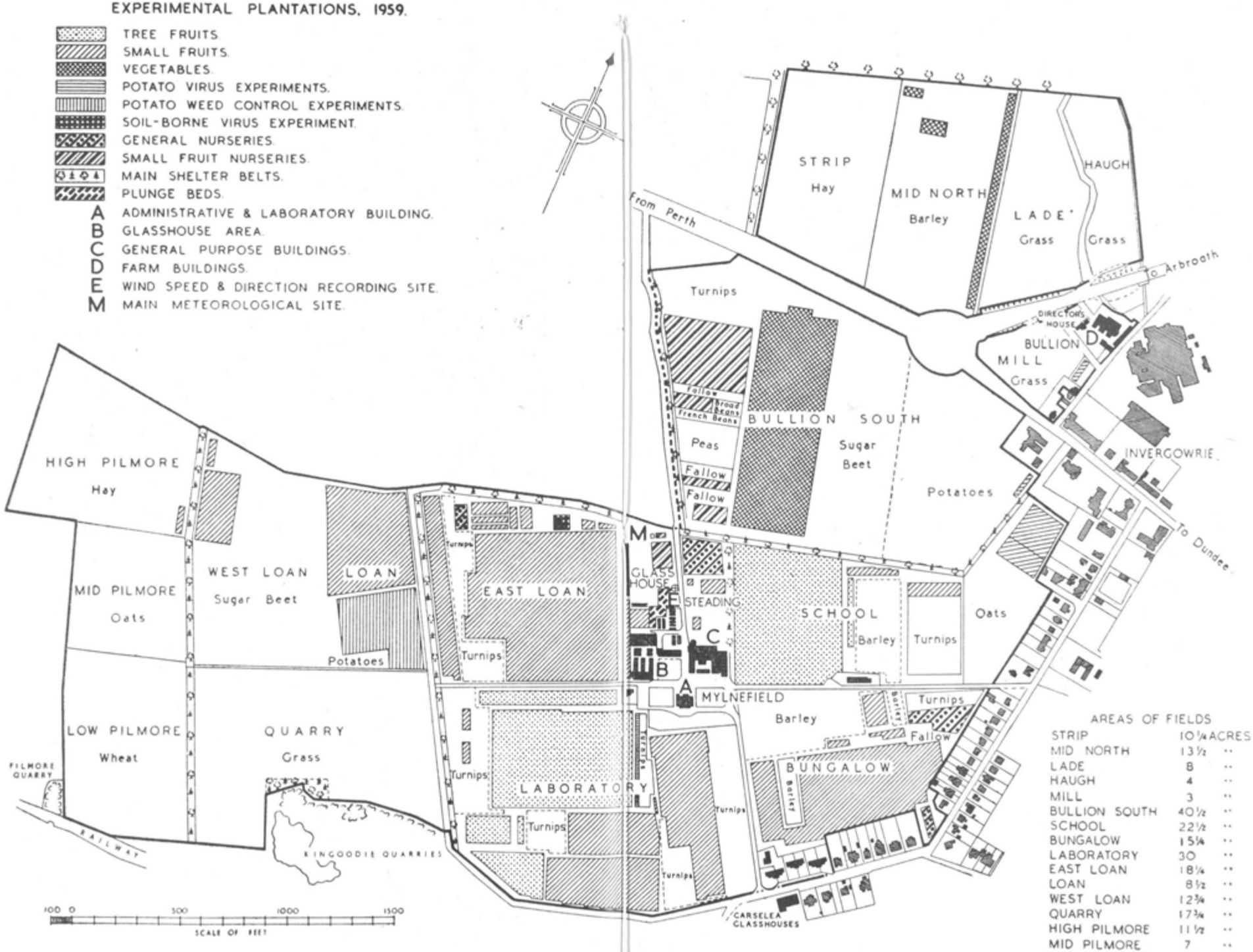
It is an old custom, sometimes practised in Scotland, to defoliate plantations of strawberries after cropping, and experiments at Mylnefield over the past few years have shown that plants treated in this way usually initiate more flower trusses in the autumn than do untreated plants. This suggests that flower initiation may be enhanced by the removal of mature leaves, possibly because such leaves are the producers of a flower-inhibiting substance. Over the past few years a series of experiments has been done to investigate the effect on flower initiation of leaves of different maturity.

In 1959 the effect of leaves of differing maturity on flower initiation was studied in four different daylengths, thus making it possible to determine the critical photoperiod for different leaf treatments. In the first experiment plants from which all leaves had been removed except the two youngest, initiated flowers after fewer short-day cycles and in longer daylengths than

intact plants. This suggests that the old leaves were the source of a flower inhibitor. In a second experiment, in which intact plants were compared with totally defoliated plants and with plants defoliated to either the two youngest leaves or to three mature leaves, it was found that the plants defoliated to three mature leaves failed to flower in daylengths longer than twelve hours. This was the shortest critical photoperiod of any treatment. In the other treatments (comparing "intact," "youngest leaves only," and "totally defoliated" plants) the critical photoperiod was progressively raised from 12 to 14 to 16 hr respectively with the increasing degree of defoliation. This confirms the suggestion that mature leaves are inhibitory and also provides information on the activity of immature leaves. On the one hand, plants from which all immature leaves had been removed had a lower critical photoperiod than intact plants, which suggests that the removal of immature leaves removed a flower-promoting substance. On the other hand, totally defoliated plants flowered in longer daylengths than either intact plants or plants bearing only the two youngest leaves, which did not suggest that young leaves were the source of a flower-promoting substance, but rather that they too were inhibitory in daylengths of 16 hr. or longer. The results of earlier years suggested that in short photoperiods immature leaves might make use of inhibitor produced in mature leaves, and this would account for the apparent promotive activity of such leaves in borderline photoperiods.

The results of these experiments and of the ones reported in earlier years can thus be explained in terms of the regulation of flowering by a flower inhibiting substance produced in the leaves in light. To test this hypothesis and to examine the possibility that a flower-promoting factor might also be operating, a third experiment was done in which plants were grown either in continuous darkness or in continuous light, comparing intact plants with totally defoliated plants. Defoliated plants in continuous light and intact plants in darkness both initiated flowers, and intact plants in continuous light failed to initiate flowers. This is the result which would be expected if flowering were controlled by an inhibitor with the characteristics described above, but not if flowering were dependent upon the presence of a promoter produced in immature leaves. Unfortunately a high proportion of the defoliated plants growing in darkness were killed by *Botrytis cinerea* and no result was obtained from this treatment.

These results suggest that the strawberry is able to initiate flowers under any conditions when the amount of flower inhibitor at the growing point falls below a critical level. It is reasonable to argue that the synthesis of this hormone is photoperiodically controlled so that in short days production is at a low level and flower initiation is permitted. It is also evident that leaves of any age are potentially capable of producing the hormone but that mature leaves are more efficient producers than immature, and that under some conditions the latter may have a promotive effect on flower initiation by competing with the apical meristem for available hormone. Thus in the intact plant, the critical photoperiod for flower initiation is a function of the interaction of photoperiod upon all the leaves on the plant, and in turn of the interaction of all leaves with each other.


EXPERIMENTAL PLANTATIONS, 1959.
TREE FRUITS.
SMALL FRUITS.
VEGETABLES.
POTATO VIRUS EXPERIMENTS.
POTATO WEED CONTROL EXPERIMENTS.
SOIL-BORNE VIRUS EXPERIMENT.
GENERAL NURSERIES.
SMALL FRUIT NURSERIES.
MAIN SHELTER BELTS.
PLUNGE BEDS.
A ADMINISTRATIVE & LABORATORY BUILDING.
B GLASSHOUSE AREA.
C GENERAL PURPOSE BUILDINGS.
D FARM BUILDINGS.
E WIND SPEED & DIRECTION RECORDING SITE.
M MAIN METEOROLOGICAL SITE.
From Perth
To Arbroath
To Dundee
STRIP
Hay
MID NORTH
Barley
LADE
Grass
HAUGH
Grass
Turnips
DIRECTOR'S HOUSE
D
BULLION MILL
Grass
Fallow
Broad Beans
French Beans
Peas
Fallow
Fallow
BULLION SOUTH
Sugar Beet
Potatoes
INVERGOWRIE
HIGH PILMORE
Hay
MID PILMORE
Oats
WEST LOAN
Sugar Beet
LOAN
Potatoes
Turnips
EAST LOAN
Turnips
M
GLASS HOUSE
E
STEADING
B
C
A
SCHOOL
Barley
Turnips
Oats
MYLNEFIELD
Barley
Barley
Turnips
Fallow
BUNGALOW
Barley
LOW PILMORE
Wheat
QUARRY
Grass
PILMORE QUARRY
RAILWAY
RINGOODIE QUARRIES
Turnips
LABORATORY
Turnips
Turnips
Turnips
CARSELEA GLASSHOUSES
100 0 500 1000 1500
SCALE OF FEET
AREAS OF FIELDS
STRIP 10¼ ACRES
MID NORTH 13½ ..
LADE 8 ..
HAUGH 4 ..
MILL 3 ..
BULLION SOUTH 40½ ..
SCHOOL 22½ ..
BUNGALOW 15¼ ..
LABORATORY 30 ..
EAST LOAN 18¼ ..
LOAN 8½ ..
WEST LOAN 12¾ ..
QUARRY 17¾ ..
HIGH PILMORE 11½ ..
MID PILMORE 7 ..
LOW PILMORE 10¾ ..
SCOTTISH HORTICULTURAL RESEARCH INSTITUTE
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The beneficial effect of defoliation on flower initiation outdoors in the autumn may be explained as follows. The defoliated plants, from which young leaves soon emerge, are able to initiate flowers in longer daylengths than the intact plants, so that under suitable temperature conditions flowers may be initiated very soon after defoliation at a time when the daylength is still too long for intact plants to initiate flowers. By the time the defoliated plants have produced more leaves the daylength has decreased sufficiently for both defoliated and undefoliated plants to initiate flowers. Even under these conditions the defoliated plants are more likely to initiate flowers, as they will have a lower ratio of old leaves to young leaves than the intact plants. Defoliated plants therefore continue to be more likely to initiate flowers throughout the autumn. (P. A. Thompson.)

FIELD EXPERIMENTS

Post-harvest Defoliation in the Field

Defoliation of established fruiting beds of Redgauntlet and Talisman after harvest is recommended for commercial practice in Scotland. In 1958, plants were defoliated on 5, 19 and 29 August or were left intact except for the normal cleaning procedure. In 1959 the yield of Talisman was increased significantly from 4·9 tons/acre to about 7 tons/acre by defoliation, and the yield of Redgauntlet from 5·1 to 6 tons/acre. Yields from the three defoliation treatments were not significantly different from one another, although the defoliation on 19 August gave the best result. These plots have now been defoliated for two successive years, without any indication of harmful effects. For the two years, the cumulative increase in crop following defoliation has been at the rate of 3·7 tons/acre for Talisman and 3·3 tons/acre for Redgauntlet. (See also p. 19.)

In order to study the frequency and time of truss initiation with more precision than hitherto, a large number of crowns were dissected under the microscope during autumn 1959. The results again show that defoliation promoted flower-truss formation, almost doubling the number of trusses in Talisman and increasing them by about half in Redgauntlet. Defoliation in late August appears to have given a slightly greater increase than defoliation in either early or mid-August. In 1957 and 1958 defoliation on dates in early or mid-August gave the best results. The fact that August and September were exceptionally warm and dry in 1959, compared with the two earlier years, could well account for this difference. Based on an assessment of three years' results, mid-August is recommended as a suitable time to defoliate beds of Talisman and Redgauntlet in eastern Scotland. Experiments are needed in England where climatic conditions are different before appropriate recommendations can be made.

Strawberry plots included in the Scottish National Fruit trial were defoliated on 5 August. Bud dissections done on 15 December showed that among the varieties Royal Sovereign, Cambridge Vigour, Senga Sengana, Senga 54, Merton Princess and Cambridge Rearguard, only the last named showed a substantial increase in truss formation. This variety was exceptional in that it was the only one in which intact plants were almost all without flower trusses at the time of dissection. Judging by position of the

developing trusses in the bud, initiation in the defoliated plants occurred in early October, about 8 weeks after defoliation. Dissections of Talisman and Redgauntlet showed a similar delayed response in October to defoliation carried out in August, although in these varieties some trusses were initiated in August as well.

An experiment is being planted to study the effect of defoliation on different dates on several varieties. (C. G. Guttridge, D. T. Mason.)

Runner Inhibition with Maleic Hydrazide

The last report contained details of an experiment on the control of runners in maiden plantations of strawberries by spraying the parent plant with maleic hydrazide. The varieties used were Redgauntlet and Talisman, and plants were sprayed on 8 July 1958 with 0·05, 0·1, 0·2 or 0·3% w/v in water of maleic hydrazide as the triethanolamine salt. On 12 August, half the plots of each treatment were given a second spray at a concentration of 0·1%. Plants sprayed at 0·2%, and especially at 0·3% MH showed signs of toxicity, which were particularly severe in Talisman, and it was feared that the damage done might reduce the level of cropping in the following year. In the summer of 1959 flower trusses were counted and the weight of crop on the original parent plants recorded; all runners produced in the maiden year had been removed during the winter. Both the number of trusses and the yield were proportional to the level of runner inhibition achieved, and the crop was not seriously reduced as a result of spray damage in the previous year. Plants of both varieties sprayed at 0·3% concentration cropped as well as controls from which all runners had been removed by hand at regular intervals through the season, and treatment with any level of maleic hydrazide resulted in an increase in the weight of crop picked, when compared with controls in which runners had been allowed to grow without restriction throughout the previous summer.

In 1959, plants of Talisman, Redgauntlet, Cambridge Vigour, and Cambridge Favourite were planted in the spring. They were sprayed on 23 June with either 0·1, 0·15 or 0·2% MH as the triethanolamine salt. Runners in which the second internode was elongating were removed just before treatment, because in 1958 it had been found that runners rooted or about to root at the time of treatment resisted inhibition and soon produced chains of secondary runners. The sprays were repeated when healthy young runners could again be seen emerging from the parent plants. With concentrations of 0·1% and 0·15% it was necessary to repeat the spray on 22 July; at 0·2% spraying could be delayed until 13 August, on which date Redgauntlet sprayed previously with a 0·1% solution had to be sprayed a third time.

A high level of runner inhibition was achieved in all four varieties by treatment at all concentrations. In Talisman and Cambridge Vigour very few primary runners rooted after treatment at any concentration of maleic hydrazide and secondary runner development from those which did root was very limited. All treatments of Redgauntlet and Cambridge Favourite produced rather more primary runners and it seems likely that they require a slightly higher level of maleic hydrazide for complete runner suppression than any used in this experiment.

Little or no effect on plant vigour was noticeable after treatment with 0·1% solutions of maleic hydrazide. At 0·15% temporary chlorosis followed the first spray application but by the end of the season no signs of spray damage were visible. Plants treated at a concentration of 0·2% showed marked chlorosis and some stunting after four weeks; eight weeks after spraying, a slight reduction in the height of treated plants was visible in Talisman and Cambridge Favourite when compared with controls from which all runners had been removed by hand at regular intervals. These toxic effects were much less marked than in the previous year.

Although it is still too early to recommend an optimum concentration of maleic hydrazide for control of runnering, the results to date show that a high level of inhibition can be obtained by the use of this material, without loss of crop in the following year, and with no more than two spray applications. (P. A. Thompson.)

The Cold Storage of Strawberry Runner Plants

Runner plants lifted in February stored well, but some small batches of plants lifted only some 2 weeks later, in early March, rotted in storage and were valueless. At the time of lifting a little new leaf growth was noticed in the later batch but not in the earlier. The rotting in storage appeared to originate in the new growth. Early lifting and, as previously shown, the maintenance of freezing temperatures during storage seem to be esssential if the plants are to be kept in good condition and rotting is to be avoided.

The cold-stored runners were planted in the field at the end of July for cropping in 1960. Survival rates for cold-stored Talisman (93%) and Redgauntlet (97%) were a little better than those for freshly-dug runners planted 2½ weeks later. Very dry conditions persisted for several weeks after planting.

Cold-stored runners planted in 1958 cropped satisfactorily. Talisman and Redgauntlet planted on 7 July yielded 16·6 oz and 13·2 oz of sound fruit/plant respectively. Planting 3 weeks later reduced the yield to 9·8 and 5·7 oz respectively which again emphasises the importance of early planting. (Significant difference, (P=0·05) 1·1 oz/plant). These plants were spaced 10 in. apart in rows 3 ft apart so that the yields per acre were at the rate 8·1 tons and 6·4 tons respectively for the early July plantings of Talisman and Redgauntlet.

Cold-stored runners of the variety Redgauntlet were planted on 7 July 1958, 6 in. apart in single rows, for cloching in spring. Picking commenced on 26 May and continued until 18 July, the plants yielding 3·6 oz/plant under the low-level cloches or about 14 oz per 2 ft run of cloche. Judging by plant size, Redgauntlet could be spaced more closely to give increased yields per cloche. (C. G. Guttridge.)

PUBLICATIONS

Research Papers

Thompson, P. A. (1960). The control of runnering in strawberries with maleic hydrazide. *J. hort. Sci.*, (In press.)

(The use of maleic hydrazide for the control of runner development in maiden plantations of strawberries was investigated, together with its effect on subsequent cropping. The spray concentration required for inhibition of runner growth increased with the

maturity of the runner. An increase in branch-crown initiation at the expense of runners followed treatment. The crop in the following year was increased as a result of the increase in sites available for flower initiation.

Plants of the varieties Redgauntlet and Talisman were sprayed at 500, 1,000, 2,000 and 3,000 ppm. of maleic hydrazide as the triethanolamine salt on 8 July. On 12 August an additional spray at 1,000 ppm. was applied to some of the plants treated previously. Runners already rooted were resistant to inhibition, and acted as "sinks" for maleic hydrazide, reducing its effectiveness. In Talisman a high level of control was only achieved by spraying at 2,000 ppm., but in Redgauntlet runners were adequately controlled by all sprays containing 1,000 ppm. or more of maleic hydrazide.

Cropping in the following year was proportional to the degree of runner control achieved. All treated plants cropped better than controls in which runners had been allowed to grow unchecked, and, at the higher concentrations, cropped as well as controls from which all runners had been removed by hand at intervals throughout the season.)

THOMPSON, P. A. (1960). Direct transmission of a growth-promoting substance from strawberry to pea. *Nature, Lond.* (In press.)

(Attempts were made to effect direct transfer of the growth-stimulating hormone in strawberry to plants of *Pisum sativum* by means of an approach graft between the two. Two experiments are described in which the internodes of peas elongating subsequent to grafting were longer than similar internodes of ungrafted peas. The response to grafting was increased when the strawberry plants had been treated one week previously with gibberellic acid. In a trial in which six varieties of peas, ranging in habit from tall to dwarf, were grafted, it was found that the dwarf varieties showed a greater response to grafting than tall, and that their response to grafting was very similar to their response to applications of gibberellic acid. In a third experiment, peas grafted to plants of strawberry which had received their full winter chilling requirement responded more than those grafted to unchilled strawberries.

The stimulus, transferred as a result of grafting, reacts on the pea in a way characteristic of the action of gibberellins, and it is hoped that the method may provide a rapid quantitative technique for the bio-assay of gibberellin-like substances.)

GENERAL PAPERS

THOMPSON, P. A. (1960). Maleic hydrazide could improve your yields. *Grower*, **53**, 535-537.

GUTTRIDGE, C. G. (1960). Cold storage keeps runners for months. *Grower*, **53**, 339-340.

GUTTRIDGE, C. G. (1960). Cold-stored plants allow summer planting. *Grower*, **53**, 402-403.

GENETICS

G. HASKELL

ADAPTATION AND DISTRIBUTION OF WILD BLACKBERRIES

The genus *Rubus* in Britain is subdivided into five subgenera, of which two are not of horticultural importance. The subgenus Idaeobatus includes the economically valuable raspberries, the subgenus Rubus the true blackberries, of which several cultivated strains are grown horticulturally, and the subgenus Glaucobatus, the dewberry (*R. caesius*) and its natural hybrids with raspberries and blackberries; this last subgenus has so far not been used in horticulture.

The true blackberries (known collectively as *R. fruticosus* agg.) have been divided into five sections, separated on taxonomic characters, particularly those relating to the armature. The Sylvatici and Discolores have more or less equal sized prickles seated on the angles of the stem, and are lacking in stalked glands, acicles and pricklets. These are the "simple" blackberries. The Sprengeliani may very occasionally have this type of armature. Most of the blackberries belong to the section Appendiculati which have stalked glands, acicles and pricklets very thinly distributed on the stem. The section Glandulosi contains the "complex" blackberries, in which the stem prickles are very unequally distributed over the stem, and there are numerous stalked glands, acicles and pricklets of different lengths.

To gain a better understanding of the problem of adaptation to environment in the subgenus Rubus the relative frequencies of these various sections of apomictic polyploid *Rubus fruticosus* agg. across Europe and in Great Britain have been studied. The north western countries of Europe have a higher frequency of simpler forms of blackberries, whereas south eastern regions, such as the Caucasus and Hungary, have a higher proportion of complex types.

The distribution of the 344 "species" of blackberries in Britain have been determined for the five sections, the analyses being based upon Watson's posthumously published data. The centre of diversity is in south-east England; this may be related, however, to the proximity to the Continent, or to greater numbers of botanists in this area. The general pattern of distribution appears to reflect the limits of glaciation, with the diversity of species north of the original limits of glaciation falling off very rapidly. The sections comprising the simpler forms are more widely distributed than those comprising complex types.

"Vice-counties" are botanical divisions of administrative counties, and the relative abundance of Rubus species in the vice-counties of Great Britain has been determined. The number of species plotted against the vice-committal frequency shows a log series. The number of species per vice-county grouped in geometric $\times 3$ classes shows a close fit with the theoretical Poisson distribution. The basis for the variation in these apomictic polyploid Rubi

may stem partly from differences in the cytological origin of the apomictic mechanism.

Collections of fruit have been made from plants growing wild in north Fife, eastern Perthshire and south Angus, because the local wild blackberries may be useful in genetical studies on adaptation and apomixis. The seeds harvested from 33 plants have now been sown.

Table 1 shows the local frequency of wild species relative to the total in each of the 5 sections of the subgenus Rubus known in Great Britian. The Sylvatici predominate. The paucity of those blackberries growing wild at latitude 56° 30 N suggests that amongst this collection there may be some very hardy species. It is hoped to classify, test and select these wild families in the field. Ultimately it is intended to introduce the thornless character into the best of them, with the aim of producing a hardy, thornless variety having commercial qualities. (G. Haskell.)

TABLE 1. Frequency of wild blackberry species in Fife, parts of Perthshire and Angus

Section	Fife (Vice-County 85)	Mid Perth (V.C. 88)	East Perth (V.C. 89)	Angus and Carse of Gowrie (V.C. 90)	Total species in Britain
Sylvatici	3 (3·3%)	9 (9·9%)	5 (5·5%)	4 (4·4%)	91
Discolores ...	1 (7·1%)	1 (7·1%)	1 (7·1%)	1 (7·1%)	14
Sprengeliani ...	0	0	0	0	7
Appendiculati ...	1 (0·6%)	3 (1·7%)	0	4 (2·3%)	173
Glandulosi ...	1 (1·7%)	1 (1·7%)	1 (1·7%)	1 (1·7%)	59

SEGREGATION IN TETRAPLOID BLACKBERRIES

Many species of cultivated plants are diploid, and the 3:1 ratio is expected in the F_2 of a diploid species for a single gene segregation. This ratio is obtained for several genes in raspberry. In a tetraploid the F_2 segregation is more complicated, and the expected ratio is 35:1, providing there is random segregation amongst the four chromosomes. This chromosome assortment will occur where loci are very near the centromere. The situation is more complicated when the locus of a gene is sufficiently distant from the centromere, so that crossing over occurs between them. When the assortment at meiosis of the chromatid segments is at random, then the ratio expected is approximately 21:1.

Most of the cultivated blackberries with which plant breeders are concerned are tetraploids. Therefore, it is of interest to determine the actual ratios obtained in such segregations, providing the results are not confused by the additional complication of apomixis, which is widely spread amongst them. The mean ratios for three F_2 progenies of *R. craniensis* crossed with *R. procerus*, *R. calvatus* and *R. laciniatus* are 19·87:1, 26·33:1 and 24·31:1 respectively for the thorned-thornless gene. (Two F_2 exceptional families are omitted in the figures for the *R. laciniatus* F_2 progeny). The amount of

genetical non-disjunction can be determined, and is denoted by α. This statistic indicates that genetical non-disjunction is significantly greater in the cross with *R. procerus* when compared with either of the other two crosses. This indicates that it is this cross which gives unusually high numbers of thornless individuals.

Thus although the gene locus is at the same position on the chromosome in the three hybrids, the segregations may differ owing to the influences of other factors. What these are remains to be determined.

This investigation is being carried out in collaboration with Mr J. Hill, at the Department of Genetics, University of Birmingham, through the courtesy of Professor K. Mather, F.R.S. (G. Haskell.)

SELECTION WITHIN INBRED LINES

British varieties of tomatoes, through their exceptional inbreeding system, evolved since their introduction into Europe from the New World, have possibly now become gene-eroded. Little selection is therefore to be expected without the introduction of new germplasm. This is borne out by the varieties in Britain being maintained by the natural self-pollination of glasshouse grown plants. Each variety is highly uniform, although a few regularly throw "rogues," a plasmagenic condition, and the amount of hybrid vigour between varieties is very small.

Tomato breeders usually select and fix the succeeding generations from a varietal cross. Hence, except for the occurrence of a major mutant, there is little opportunity within a variety of improving it by discerning the subtle recombinants most suitable for selection, other than by disturbing its genetical constitution through out-crossing. An easily determined biometrical character must be used for selection within an inbred line, and cotyledon number (pleiocotyly) is particularly suitable, as selection can then be practised on large populations of seedlings. This character has already been used successfully as a criterion for selection in the outbreeding species of Cruciferae.

A start has been made with selecting for pleiocotyly in three commercial varieties of tomato. This will test whether recombinations of new polygenic variations are produced, and determine whether, ultimately, correlated responses in other characters to such selection will appear in inbred material. It is expected that a large number of generations will have to be raised before selection is effective. (G. Haskell.)

CYTOLOGICAL INVESTIGATIONS

Rubus

Somatic chromosomes were examined in the root-tips of several *Rubus* species, *viz.*, *R. tomentosus* (2*x*), *R. ulmifolius* (2*x*), *R. caesius* (4*x*) and *R. procerus* (4*x*). Special attention has been paid to their karyotypes and the frequency of satellites. The karyotype study of these chromosomes is difficult owing to their very small size.

Study of the haploid genome ($n=7$) in a diploid plant of *R. tomentosus* from Switzerland shows that, with the exception of the nucleolar or satellited chromosome where the centromere is subterminal, six chromosomes are very regular with median or submedian centromeres. The chromosomes differ

little from each other in size and form. The karyotype is symmetrical, using Stebbins' terminology. Regarding the satellited chromosomes, usually a pair is observed in diploid species, but in polyploids the number does not seem to correspond with the degree of ploidy.

Among the F_2 progeny of a hybrid of Merton Thornless (*R. craniensis*) x Himalaya Giant (*R. procerus*), a seedling was discovered which differed greatly from its sibs. This seedling is very stunted, having grown only 11 cm. in 11 months; it is very dark green with very short internodes, has thickened, rugose leaves and is densely covered with hairs. Cytological examinations of its root tips revealed a mosaic pattern of chromosomes, with numbers ranging from 9 to 46 per cell. Variations in the chromosome number were even found within the same root-tip.

Ribes

Chromosome counts on root-tip cells have been made on several cultivated varieties and species of *Ribes* including Baldwin, Amos Black and *R. maximowiczii*. The chromosome number was consistently diploid ($2n=16$). The chromosome complement consists of a pair of satellited and 14 symmetrical chromosomes.

Blackcurrant (*R. nigrum*) and *R. maximowiczii* genomes could not be differentiated in the somatic tissue of hybrids between the two. The leaf shape of the F_1 is intermediate, but the hairs are the same as those of the *maximowiczii* parent. Absent in the F_1 hybrid are the glands found on leaves of the blackcurrant, which give it the characteristic odour.

Only one satellited chromosome is observed in the chromosome complement of the F_1 of blackcurrant x gooseberry. As a pair of satellited chromosomes is always present in the blackcurrant parent, it could be assumed either that the genome from the gooseberry parent is lacking in satellited chromosomes, or the satellites are inconspicuous. This will be decided when the chromosomes of gooseberry are available for study. (N. N. Tun.)

SPRING CHLOROSIS OF STRAWBERRY

Observations of June Yellows were continued on seedling families which have been planted in the field each year since 1956. The families represent selfs of the green varieties Early Cambridge, Perle de Prague, Talisman, Royal Sovereign, and Huxley, and reciprocal crosses of these with Auchincruive Climax, all plants of which showed June Yellows. Auchincruive Climax was also selfed and crossed with the green, male-sterile variety Tardive de Leopold.

Approximately one quarter of the hybrid families showed slight reductions in incidence of June Yellows in 1959 compared with the 1958 level, while about one-third showed some increase. Families with reduced values occur haphazardly among the various crosses. It is possible that environmental conditions were not the most favourable for symptom expression at the time records were made.

Values for separate progenies within a cross are moderately consistent, but the mean values vary widely between crosses. The highest incidence was recorded for Tardive de Leopold x Climax with 95% affected seedlings.

Climax x Talisman and Climax x Perle de Prague have similar values, respectively 76% and 72% of seedlings affected, with slightly lower percentages in the reciprocal crosses. The lowest incidence occurred in Climax x Royal Sovereign with 10% and the reciprocal cross with 21% June Yellows.

The two remaining crosses do not fit into this graded scheme because of a large difference between reciprocal crosses. Thus Climax x Early Cambridge showed 58% seedlings with June Yellows, while Early Cambridge x Climax showed only 25%; and Climax x Huxley showed 79% affected seedlings, while Huxley x Climax showed only 12%.

On selfing, only Climax and Talisman gave seedlings with June Yellows 95% for the former and less than 1% for the latter variety. Some seedlings of Perle de Prague selfed showed a condition which resembles June Yellows to some extent. Despite the high incidence of June Yellows in the cross Tardive de Leopold x Climax none was seen in crosses of Tardive de Leopold with green varieties. (A. B. Wills.)

PUBLICATIONS

HASKELL, G. (1959). Further evidence against pleiotropic gene action in correlated responses to selection. *Genetica* **30**, 140-151.
(Selection for earliness in American inbred and hybrid sweetcorn is shown to have been accompanied by a decrease in plant height and in number of leaves, while other quantitative characters studied showed no change. Progenies from maize seedlings surviving germination at low temperatures showed no correlated responses, but seeds of the earliest and hardiest line were duller and less wrinkled. Seeds from maize selections for low oil or low protein were heavier than those for high and remained viable for a shorter time. As in the first example, both plant height and leaf number regress on earliness, while the ratio of plant height to leaf number, *i.e.*, mean internode length, does not, it is suggested that in this case the genes for earliness have no pleiotropic effect.)

HASKELL, G. (1959).* Selection, correlated responses and speciation in sub-sexual *Rubus*. *Genetica* **30**, 240-260.
(Selections were made of single plants from a large, apparently constant, population of apomictic *Rubus nitidioides* Watson. The characters selected were high and low numbers of prickles and early flowering. The progenies of one high prickle selection and one low selection differed greatly in the quality of their armature. Selection for early flowering produced a very early flowering progeny. Associated with these selections were other characteristics, such as delay in first flowering (except for the early flowering strain), a general decrease in heights and plant vigour, changes in leaf colour and shape, and partial sterility. These associated differences were also carried over to the third selection. An unselected progeny remained highly vigorous, prolific, and with healthy green leaves true to type. In the high prickle selection, the associated taxonomic differences of the leaves showed resemblances to those of other species taxonomically related to *R. nitidioides*. The bearing of these selections on the evolution and speciation of apomictic Rubi is discussed. It is possible that the diplosporous mechanism is associated with the polytopical origins of apomictic microspecies.)

HASKELL, G. (1960).* The raspberry wild in Britain. *Watsonia*, **4**, 238-255.
(Progenies from raspberry plants whose seeds were collected wild in England and Scotland were studied. No new genes were found. Seedlings were diploid ($2n = 14$); one rosette plant had diploid and tetraploid shoots. Frequencies of spine colour, habit, leaf colour and leaflet number varied. One family segregated spineless plants. Most plants were hairy. Five families segregated for antumn flowering. Analyses were made of die-back, vegetative bud-break, flower-bud development, flowering times and fruit ripening; these characters are not related to geographical origin. Fertile

male plants occurred in three families, and are possibly more sensitive to environment; a possible breeding cycle shows how males are perpetuated. Six families segregated non-red fruits. Ripe fruits are mostly deep purplish-red and smaller than cultivated ones. Some families had large, good flavoured fruits, suggesting derivation or introgression from cultivated varieties. The frequencies with which 7 genes segregated show a Poisson distribution. Wild raspberries are remarkably homozygous, the maximum heterozygous genes being four. Differences between wild and cultivated strains throw some light on the origin of Lloyd George. Wild plants have many short, hairy canes, whereas cultivated varieties have few, tall, subglabrous canes. Absence of clines may be because Great Britain represents a relatively small area of the natural distribution.)

HASKELL, G. (1960).* Role of the male parent in crosses involving apomictic *Rubus* species. *Heredity*, **14**, 101-113.
(Three pseudogamous Rubus species were pollinated by their own pollen, and by pollen from *R. nitidioides*. Two of the apomictic progenies from self-pollinations were weaker than those resulting from pollinations by *R. nitidioides*; this was also reflected the following year in their later flowering and in the proportion that flowered. Pseudogamous *R. laciniatus* was pollinated by a polyploid series of apomictic species. There was an improvement in early germination and in first-year germination of seeds with increase in the ploidy of the pollen parent; but pollination by the sexual diploid *R. ulmifolius* gave the most vigorous germinations. Generally there was marked stimulation of the pseudogamous vigour of the apomictic progenies of *R. laciniatus* from pollinations with other species. This is termed pseudogamous heterosis. It varies with the pollen source, and is affected by the degree of ploidy and genetic differences between the pollen parents. The pollen parent affects seed shape in *R. laciniatus*. Lengths and breadths of seeds were correlated for most cross-pollinations, but self-pollinations may decrease the correlation through increasing the variation in seed shape, particularly their lengths. This could be related to the sexual origin of the endosperm in pseudogamous *Rubi*. The occurrence of hybrid endosperm in *R. laciniatus* was tested by pollinations with British species of known taxonomic position. Lidforss' conclusion was confirmed that the frequency of sexual seedlings is not related to the relative taxonomy of the parents. The sexual hybrids are generally weaker than the apomicts.)

HASKELL, G. (1960).* Biometrical characters and selection in cultivated raspberry. *Euphytica* **9**, 1-18.
(A biometrical investigation has been made of the behaviour and inter-relations of the most important quantitative characters in selfed, sibbed and backcrossed families of raspberries (*Rubus idaeus* L.). Plant characters analysed were height, vigour, armature, susceptibility to mildew and vegetative bud break; inbreeding depression particularly affects height and susceptibility to mildew. Flowering and fruiting characteristics included flowering ability, fruit colour, first-year fruiting ability, time of ripening and maturity rate. Some families segregated for double bearing. Fruit qualities, including size, shape and texture, were assessed: heterosis may influence size, but large fruited inbreds are obtainable. Conical shape may be associated with advantageous fruit qualities. Texture depends partly on ability of drupelets to adhere and not to collapse under slight pressure; these two qualities are not necessarily correlated. There are no correlations between fruit size, or plug shape, with ease of picking. Flavour was assigned organoleptically to five classes. Backcrossing to a good flavoured clone increased the frequency of good flavoured seedlings and reduced that of more acid types, but segregations for all classes occurred in sibs, selfs and backcrosses. Taste trials showed that people are generally agreed on the flavour they least like, but are unreliable in their preference. Thirty-six seedlings with the best "all-round" biometrical assessments, out of a total population of 841, were tested for yield over two years; two died in the first winter. Twenty-one seedlings had higher yields, four had the same and nine had less than their controls. Hence such an assessment is of value in assorting out potentially high yielding types from the bulk of a breeding population.)

*Practical work carried out at the John Innes Horticultural Institution, Hertford.

VIROLOGY

C. H. CADMAN

SOIL-BORNE VIRUSES

A most important development in this field was the joint discovery by workers at East Malling Research Station Rothamsted Experimental Station, and ourselves, that the soil-borne arabis mosaic virus is transmitted by a dagger nematode (*Xiphinema* sp.). This has stimulated the search for vectors of other soil-borne viruses, and recent results strongly suggest that raspberry ringspot, tomato black ring and tobacco rattle viruses are also transmitted by nematodes.

Ringspot Viruses

IDENTIFICATION AND PROPERTIES

Tests made with diseased plant material sent to us for diagnosis, suggested that soil-borne viruses of the ringspot type commonly infect strawberry, and therefore presumably other crops, throughout Great Britain. Visits made in May to the principal strawberry-growing areas in England confirmed this. By contrast to Scotland, where outbreaks of ringspot diseases in strawberry are usually caused by raspberry ringspot and tomato black ring viruses, nearly all the outbreaks sampled in England were associated with infection by arabis mosaic virus. (R. M. Lister.)

Because the symptoms caused by any of these and similar ringspot viruses in their various hosts and in herbaceous test plants are usually unreliable means of identifying the viruses, serological techniques were investigated as a means of accurate diagnosis. Two such techniques which might be useful in routine work have been tested. In one, infective sap is allowed to react with standard antiserum by double diffusion in agar. Specific precipitation lines usually form only with viruses which reach high concentrations in infective saps. Arabis mosaic virus is one which can usually be identified by this method, using crude sap from the tip leaves of systemically infected *Chenopodium amaranticolor* plants as the source of virus. In the other method, diagnosis depends on the specific abolition of infectivity which occurs when diluted infective sap is mixed with the homologous antiserum, suitably diluted, before inoculation to test plants. This seems the more promising technique for routine use. (R. M. Lister, Ann Bulloch.)

Arabis mosaic, raspberry ringspot and tomato black ring viruses all possess similar biological and physical properties, and electron microscopy has shown that all three viruses have isometric particles of the order of 250 Å diameter. Evidence was obtained that the protein shell of arabis mosaic virus has a sub-unit structure. (C. H. Cadman, J. Cathro.)

Viruses of the ringspot type were readily transmitted to herbaceous plants by mechanical transmission of sap from leaves of grape vine infected with fanleaf virus sent from California by Prof. W. B. Hewitt. Viruses were

similarly transmitted from leaves of vines affected by fanleaf and panachure diseases sent from Switzerland by Dr R. Bovey, Nyon, and from France by Mr A. Vuittenez, Colmar. The properties and relationships of these viruses are being investigated.

The results of plant-protection and serological tests have shown that the North American tomato ringspot virus, whose mode of spread is unknown, is related to peach yellow bud mosaic, a soil-borne virus recently shown to be transmitted by a nematode, *Xiphinema americanum*.

Serological relationship was also detected between a soil-borne virus associated with the Eckelrader disease of cherry in the Netherlands and a virus, whose mode of spread was unknown, associated with leaf roll disease of cherry in Kent. The virus cultures used were kindly supplied by Miss H. J. Pfaeltzer, Institute for Phytopathological Research, Wageningen, and Mr R. Cropley, East Malling Research Station, respectively. This virus is serologically unrelated to arabis mosaic, raspberry ringspot, or tomato black ring viruses. (C. H. Cadman.)

Transmission and Dissemination

Glasshouse experiments showed that pea seedlings grown in pots of sterilized sand became infected with arabis mosaic virus when watered with suspensions of dagger nematodes (*Xiphinema diversicaudatum*), hand-picked from infective soil from Hampshire. No infections occurred in pots of pea seedlings that received soil extracts from which all the *Xiphinema* had been removed. In England, the distribution of arabis mosaic and its nematode vector seem closely correlated. In Scotland, the virus seems rare and no *Xiphinema* was found in soils where apparently indigenous outbreaks of the virus occurred in strawberry in Lanarkshire, in raspberry in Aberdeen and in elderberry in Perthshire. (C. H. Cadman, W. P. Mowat.)

Further work has confirmed that soil-living agents are concerned in the transmission of raspberry ringspot and tomato black ring viruses, and several species of nematodes are being tested as vectors. (W. P. Mowat, C. E. Taylor.)

The wide distribution of arabis mosaic, raspberry ringspot and tomato black ring viruses implies that they have efficient means of dissemination. As none of the viruses survives in air-dried soil, their dissemination in dry soil, by wind for example seems unlikely. Tomato black ring virus can be introduced into certain ("receptive") soils by planting virus-infected potato tubers, and the same seems true when strawberry plants containing this virus are planted. However, the virus became established in "receptive" soil only when unwashed strawberry plants were used, suggesting that infectivity was introduced by soil adhering to the roots. Thus, soil-borne viruses may be introduced to soils through the distribution and use of infected plants. However, the discovery that arabis mosaic, raspberry ringspot and tomato black ring viruses are seed-borne in at least some of their hosts offers a more plausible explanation for the widespread distribution of these viruses. Most of the evidence relates to tomato black ring virus, which is transmitted through a high proportion of the seed of infected plants of 9 species in 6 families. These include strawberry, legumes and weeds, such as shepherd's purse (*Capsella bursa-pastoris*) and groundsel (*Senecio vulgaris*). (R. M. Lister.)

CONTROL

Experiments were made at three sites in Perthshire and two in Lanarkshire to find whether infectivity could be abolished from or decreased in soils containing raspberry ringspot and tomato black ring viruses by treatment with DD or with mercuric oxide. The treatments were applied in late August and sugar beet seeds planted two weeks later. Tests made two months later, by inoculating *C. amaranticolor* plants with sap from samples of sugar beet roots harvested from treated and untreated plots, showed that neither treatment had decreased the level of soil infectivity at any of the five sites. (C. H. Cadman, J. Chambers, R. M. Lister.)

A field experiment was begun to find whether the level of infectivity of a soil containing tomato black ring virus is affected by the kind and sequence of crops grown in it. (J. Chambers, R. M. Lister.)

Tobacco Rattle Virus

Soils containing tobacco rattle virus seem to lose infectivity on storage more rapidly and to vary more erratically in infectivity than comparable soils containing raspberry ringspot or tomato black ring viruses. In other respects, tobacco rattle virus behaves in soils like the two ringspot viruses. Infectivity is abolished when infective soil is air-dried at 20°C. for a week or treated with ethylene dibromide, pentachloronitrobenzene or tetramethylthiuram disulphide, chemicals which have little or no effect on the infectivity of the virus *in vitro*. (C. H. Cadman.)

Other kinds of evidence also suggest that a soil-living agent is concerned in the transmission of tobacco rattle virus, and several kinds of nematodes are being tested as vectors. (W. P. Mowat, C. E. Taylor.)

Tobacco rattle virus was found infecting rhubarb in Perthshire. (R. M. Lister.)

Tobacco Necrosis Viruses

Studies were begun on the properties and behaviour in soil of a virus of the tobacco-necrosis type found infecting weed plants systemically in several localities in eastern Scotland. (Ann Bulloch.)

APHID-BORNE VIRUSES

Spread of Viruses in Strawberry

The results of exposing successive batches of runnerless *Fragaria vesca* plants, from mid-March onwards, to infection by viruses spreading from diseased Cambridge Favourite plants confirmed those reported in 1958 and 1959. Most spread of virus occurred in August, September and October.

A field experiment, begun in October 1957, has so far given no evidence of long-distance spread of virus in Royal Sovereign strawberry. By October 1959, spread of viruses causing visual symptoms had occurred in plots which contained infected Cambridge Favourite plants but not in plots devoid of and remote from sources of infection. (R. M. Lister.)

Mechanical Transmission of Viruses from Raspberry

Viruses were readily transmitted to herbaceous plants by mechanical inoculation of sap from black raspberry (*Rubus occidentalis*) seedlings which

had been infected with raspberry leaf mottle and other similar latent viruses by means of aphids (*Amphorophora rubi*). No such viruses were detected in healthy black raspberry seedlings. The properties and relationships of these viruses are being investigated. (C. H. Cadman.)

Virus-free Raspberry Stocks

Raspberry canes distributed from the heat-treated stocks to growers in Great Britain, under the aegis of the Department of Agriculture for Scotland, totalled 36,000 this year, compared with 28,000 last year. The totals of first size canes of each variety distributed were: Lloyd George (SH_1/59) 4,500; Malling Promise (SH_2/59) 1,800; Malling Exploit (SH_3/59) 3,400; Norfolk Giant (SH_4/59) 500; Malling Enterprise (SH_5/59) 2,500; Malling Jewel (SH_6/58) 6,000, (SH_6/59) 15,000; Burnetholm Seedling (SH_7/59) 3,200. The demand for Malling Jewel again far exceeded the supply.

Evidence of spread of aphid-borne latent viruses into 2-year-old cane nurseries of Malling Jewel and Malling Promise served as a salutary reminder that raspberry plants freed from virus are susceptible to re-infection and that long-distance spread of aphid-borne viruses occurs. (J. Chambers.)

Spread of Potato Leaf Roll and Y Viruses

When leaf roll infectors, heavily infested by *Myzus persicae*, were exposed for fortnightly periods, from June to August, in a crop of healthy Majestic potato the results again showed that virus spread most from infectors exposed in late June and early July and not at all from those exposed after mid-July.

The field work on spread of potato Y and leaf roll viruses was concluded and the results prepared for publication. (J. Chambers.)

OTHER VIRUSES

Bushy dwarf disease, the principal cause of failure in growth and cropping of Lloyd Geroge raspberry throughout Great Britain, is associated with a virus mechanically transmissible to herbaceous hosts. An apparently identical virus occurs widely in plum and ornamental *Prunus* spp. No aphid vectors have been found and there is no evidence that the virus is soil-borne. (C. H. Cadman.)

Ability to cause systemic infection in French bean has been regarded as a pecularity of one or two strains of tobacco mosaic virus. However, as isolates of the virus cultured from samples of cured tobacco leaf infected French bean systemically this property may be commoner among strains of tobacco mosaic virus than previously supposed.

Studies on the properties of cassava brown streak virus were continued. (R. M. Lister.)

PUBLICATIONS

Research Papers

Cadman, C. H. (1959). Potato stem-mottle disease in Scotland. *Eur. Potato J.* **2**, 165-175. (Potato stem-mottle, a disease of potato haulms, is well known on the Continent but seems not to have been noticed before in Scotland. A connection between this disease and spraing, a necrotic disease of potato tubers, has long been suspected, and evidence that the soil-borne tobacco rattle virus is the cause of both diseases is reported.

Severe symptoms in potato haulms and tubers are usually associated with a form of the virus which is difficult to transmit mechanically from potato to other plants. In infective soil, potato roots quickly become infected by tobacco rattle virus but the virus seems usually to remain localised there. Partial infection of both haulms and tubers is characteristic, and the virus seems inefficiently transmitted through the tubers of most potato varieties.)

(HARRISON, B. D. &) CADMAN, C. H. (1959). Role of a dagger nematode (*Xiphinema* sp.) in outbreaks of plant diseases caused by arabis mosaic virus. *Nature*, **184,** 1624-1626.
(Arabis mosaic is one of three soil-borne viruses of the ringspot type which occur widely in Britain, infect many kinds of crop and weed plants and are patchily distributed in fields. Observations on samples of soil taken from inside and outside disease outbreaks in raspberry, strawberry and white clover caused by arabis mosaic virus, showed that soil infectivity was closely correlated with the presence of dagger nematodes (*Xiphinema* sp.). Infectivity was conferred on virus-free soil by the addition of nematodes handpicked from infective soil but not by the addition of soil extracts from which all the dagger nematodes had been removed. Infections occurred in pots that received either male, female or larval *Xiphinema*. The infectivity of soil containing arabis mosaic virus is abolished and the *Xiphinema* killed by air-drying the soil at 20°C for a week or by treatment with tetramethyl-thiuram-disulphide or pentachloronitrobenzene, substances commonly used as fungicides and not as nematicides. The evidence leads to the conclusion that *Xiphinema diversicaudatum* is the vector of arabis mosaic virus.

CADMAN, C. H. (& HARRISON, B. D.) (1960). Studies on the behaviour in soils of tomato black ring, raspberry ringspot, and arabis mosaic viruses. *Virology*, **10,** 1-20.
(Experiments made to study the factors which affect infection of plants by soil-borne viruses of the ringspot type are described. The presence of the viruses in soils was detected by growing bait seedlings in them, but not by inoculating leaves of test plants with soil extracts. Infectivity seemed erratically distributed in soils, and in those containing tomato black ring virus, was associated with particles that sedimented through 7 cm. water in 5 min. Infectivity was abolished by air-drying the soils at 20°C. for a week, or by treating the soils with pentachloronitrobenzene, tetramethyl-thiuram-disulphide, ethylene dibromide and Nemagon, but not by griseofulvin or by mixing the soils with lime or ammonium sulphate.
Tomato black ring virus became established in non-infective soils when these were watered with crude eelworm preparations from infective soils or cropped with artificially infected sugar beet, but not when the soils were watered with highly infective sap or mixed with washed roots of naturally infected plants. The results suggest that a soil-living organism is concerned in the transmission of tomato black ring virus.)

LISTER, R. M. (1960). Transmission of soil-borne viruses through seed. *Virology*, **10,** 547-549.
(Arabis mosaic, raspberry ringspot and tomato black ring viruses are seed-borne in at least some of their hosts. So far, most of the evidence relates to tomato black ring virus, which is transmitted through the seed of at least 9 species in 6 families. Because these viruses appear to have only limited other means of dissemination, their dispersal in widely disseminated seeds would explain both their wide distribution and the means by which they are introduced to soils. The viruses presumably become established only in soils which contain the appropriate vectors. This mode of spread may have wider application among soil-borne viruses.)

LISTER, R. M. (1960). Occurrence of soil-borne virus diseases of strawberry in Britain. *Plant Pathology*. (In press.)
(To assess the incidence and importance of soil-borne viruses in the major strawberry-growing areas in England, visits were made in May to the Wisbech, Kent, Hampshire, Devon, Cheddar, West Midland and Dee Valley areas. Strains of arabis mosaic virus were isolated from strawberry collected in all areas except Wisbech. Together with previous records, this suggests that arabis mosaic virus is widespread and of local importance in strawberry throughout England.)

(THRESH, J. M. &) LISTER, R. M. (1960). Coppicing experiments on the spread and control of cacaos wollen-shoot disease in Nigeria. Ann. appl. Biol. 48 (1), 65-74.
(This paper reports work done at the West African Cocoa Research Institute. Coppicing was used to determine the incidence and distribution of latent and unrecognised infection around naturally-occurring outbreaks of cacao swollen-shoot virus disease in Western Nigeria. Detailed studies on the distribution of infected stumps around thirty-five of the outbreaks showed that efficient control can be achieved by cutting-out fewer trees than was previously done.)

GENERAL PAPERS

CADMAN, C. H. (1960). Inhibition of plant virus infection by tannins in *Phenolics in Plants in Health and Disease, Pergamon Press, Lond.* (In press.)

LISTER, R. M. (1959). Soil-borne viruses in strawberry—the present position. *Commercial Grower*, 1959, 678-80.

LISTER, R. M. (1960). Soil-borne virus diseases. *Scientific Horticulture*, **14**, 90-96.

LISTER, R. M. (1960). Strawberries and soil-borne virus diseases. *Agriculture*, **67**, 25-29.

MYCOLOGY

A. R. WILSON

GREY MOULD OF SOFT FRUIT

Autecology of Botrytis cinerea

The dry summer of 1959 and the earliness of the picking season enabled the bulk of the soft fruit crops in eastern Scotland to escape serious epidemics of grey mould. In observation plots of the raspberry varieties Malling Promise and Lloyd George at Mylnefield, which were picked according to local commercial practice, fruit infected by *Botrytis cinerea* amounted to less than 1% of the crop by weight throughout the greater part of the season.

The progress of the disease was assessed by daily counts of sound and infected fruit and plugs. When these records were compared with those of macroclimate, airborne spore concentration, picking frequency, and crop yields, the effects of certain factors on disease incidence became apparent.

For most of the season, temperatures were generally low, particularly at night, so that the rate of sporulation was very low; furthermore, relative humidity values only occasionally rose above 85% for short periods, and did not fluctuate rapidly in the manner associated with a high rate of spore release. Conditions for infection from germinating spores were also poor. Throughout this early period the crop was picked frequently, and infected berries, the chief source of inoculum for the remaining fruit were also removed. They amounted to less than 1% of the total crop. Plugs dried quickly after the fruit was removed, and sporulation on these was at a low level.

Near the end of the season, a number of factors combined to give rise to a minor epidemic. No fruit was picked between 21 July and 5 August, and the proportion of infected fruit and plugs began to rise slowly. On 27 July when this level had risen to about 7%, the minimum relative humidity value rose to 70% and remained high for 3 days. Within 24 hr after the onset of these conditions there was a fourfold increase in the proportion of infected fruit and plugs, sporulation being enhanced by high night and day temperatures. Although conditions for spore dispersal were not optimal, *i.e.*, relative humidity fluctuating between 80% and 65%, there was nevertheless a fourfold increase in the airborne spore concentration two days after the onset of high humidity. After two dry days in which spore concentration fell and the level of infection rose slightly, warm humid conditions again set in on 1 August, and the progress of the epidemic was greatly accelerated by continuing good conditions for sporulation, as was evident from the rapidly increasing numbers of spore-bearing lesions. On 4 and 5 August the conditions for spore dispersal were optimal, and the airborne spore count rose from about 500 spores/cu.m. to 6,000 spores/cu.m. The concentration was reduced by about 20% immediately after picking on 5 August when 45% fruit was infected, but sporulation was sufficiently heavy on remaining plugs (61% infected) to maintain a

high concentration on the following day. A fall from 16°C to 10°C in the minimum night temperature then so retarded the rate of sporulation that despite optimal conditions for release the following day, there was a 70% reduction in the airborne spore concentration, and very few new infections were noted on the remaining sound fruit.

From these observations it is evident that fruit should be picked as frequently as possible in order to reduce the establishment of possible centres of infection within the crop, and that the removal of infected fruit is most desirable although usually impracticable on a commercial scale. The rapidity with which the disease appears after the onset of favourable conditions leaves very little time for the application of prophylactics, but this was attempted in an experiment described below in the section on control.

In contrast to experience in 1958, it was found in 1959 that in the latter part of the season much of the fruit became infected from spores germinating in persistent water drops, and the scope of the physico-chemical investigations has been widened to include detailed analysis of infection drops. Paper chromatograms have shown that at least three sugars and citric and malic acids appear in the infection drop within one hour, and that the amounts vary with the ripeness of the fruit and to a lesser extent, with variety.

Varietal Susceptibility

Differences in varietal susceptibility of strawberries and raspberries were again noted, although the low levels of grey mould infection made such differences much less marked than in previous years.

Studies are being made of the physical and chemical properties of fruit of different varieties and of different physiological age, to find how susceptibility is correlated with physico-chemical factors. Particular attention is being paid to sugars, acids and polyphenols.

Work is also continuing on the influence of plant habit on micro-climate and susceptibility.

Control

A number of fungicides were again tested in plots of Malling Exploit raspberry and Talisman strawberry. The normal commercial practice of three applications at 10-day intervals was followed starting at the petal-fall stage. At the time of the first application in the first series of trials, weather conditions indicated the likelihood of a mildew epidemic, and dinitrocaprylphenyl crotonate was therefore included, but mildew was not seen subsequently on fruit, and only rarely on leaves. Although captan is not recommended for application to fruit destined for canning, it was included for comparison with other materials, and again proved superior. Two alginate formulations were used, it being suggested by the manufacturers that they might form a mechanical barrier to infection. Of these, an ammonium alginate formulation slightly reduced infection in Malling Exploit. Laboratory experiments, however, showed that the alginates do not provide a barrier to the germ tubes of *B. cinerea*, and can in fact serve very adequately as the sole carbon source in the nutrition of this fungus. The effect of the alginates on *Sphaerotheca humuli* is unknown.

In a further trial, previously untreated plots of Malling Exploit were

sprayed with griseofulvin and alginate formulations each time the fruit was picked. It was found quite practicable to use a motorised knapsack sprayer without damage to the mature crop. The griseofulvin treatment significantly reduced infection, in contrast to its lack of effect when used prior to the beginning of the picking season. It is emphasised that the treatment of fruit with griseofulvin and alginates has not been approved by the Ministry of Agriculture, and that this work is in an experimental stage only.

The trial with Talisman included a comparison of the effects of straw, polythene sheet and uncovered ground beneath the fruit on the incidence of grey mould. In fruit over both types of ground cover there was significantly more grey mould ($P=0{\cdot}05$) than where the ground was uncovered. Further work is being undertaken on this and other factors likely to influence the microclimate and thus the incidence of grey mould.

The level of grey mould infection in Malling Exploit was very low for most of the picking season, and rose only at the end. The level in Talisman was fairly constant throughout the season.

The results of the various trials are summarized in the following table.

Treatment	Rate	Mean % fruit infected by *B. cinerea*	
		M. Exploit	Talisman
Captan 50% wettable powder	2½ lb./30 gal. water/acre	4·9*	6·4*
Captan 3% dust	21 lb./acre	9·3	6·9*
Griseofulvin oxime liquid concentrate[1] ...	280 g./30 gal. water/acre	9·9*	10·4*
Griseofulvin 3% dust[1]	21 lb./acre	9·1	12·6
Sodium alginate[2]	3 lb./30 gal. water/acre	8·6	12·4
Ammonium alginate[2]	3 lb./30 gal. water/acre	6·7*	12 7
Dinitrocaprylphenyl crotonate, 25% wettable powder	2½ lb./30 gal. water/acre	8·1*	10·5
Griseofulvin oxime liquid concentrate throughout picking season	280 g./30 gal. water/acre	6·5*	—
Ammonium alginate throughout picking season	3 lb./30 gal. water/acre	8·9	—
Straw ground cover, no fungicide ...	—	—	14·9*
Polythene sheet ground cover, no fungicide	—	—	14·5*
Control, no fungicide (and in strawberries no ground cover)	—	9·0	12·8

* Significant difference from Control, $P=0{\cdot}05$

[1] Supplied by Murphy Chemical Co. Ltd.

[2] Supplied by Alginate Industries Ltd.

Storage Rots

Observations made in 1958 on the usefulness of copper-8-quinolinolate* in prolonging the life of chip baskets and in reducing the amount of fruit debris and fungal growth on the debris were confirmed but considerable taint in the fruit touching the baskets was noticed for the first time. Investigations at the M.A.F.F. Experimental Factory, Aberdeen, attributed this to impurities in the organic solvent used. It is important to use a freshly-prepared odourless solvent and to dry the baskets thoroughly before use.

In 1959 there was no significant reduction ($P=0{\cdot}05$) in the amount of fruit rotting when stored in treated baskets against that in untreated baskets. (W. R. Jarvis.)

TOMATO GREY MOULD

Measures for the control of stem infection of glasshouse tomatoes by *Botrytis cinerea* can be divided into two main types; chemical and management. Chemical control can be further sub-divided into prophylactic and therapeutic. Control by management can be sub-divided into manipulation of above ground factors, *e.g.*, ventilation, air movement and the timing of operations such as de-leafing, and manipulation of below-ground factors, *e.g.*, manuring, about which relatively little is known but which is believed to influence susceptibility. Work at Mylnefield has so far been concerned only with the two forms of chemical control.

Trials of various chemical compounds to control infection of leaf scars following de-leafing have been vitiated by the poor and erratic infection obtained in the controls, despite atomisation with spore suspension and maintenance of air conditions apparently favourable for infection. The technique of cauterising a part of the leaf scar to provide an area of dead tissue on which the fungus can establish itself, reported last year, was not employed, as it was considered at the time to be too drastic for use in trials of prophylactic treatments. These results indicate the desirability of obtaining information on factors affecting host susceptibility.

Work on tar derivatives for therapeutic application to stem lesions has been continued. Preliminary trials indicate that a wide range of other fungicides may be effective for this purpose. These included chlorinated nitro-benzenes, Captan, griseofulvin, n-dodecylguanidine acetate and copper-8-quinolinolate. (A. R. Wilson.)

POWDERY MILDEW OF SOFT FRUIT

Powdery mildew was virtually absent from raspberry and strawberry plantations and spores of *Sphaerotheca humuli* occurred only rarely in records from the Hirst spore trap. (W. R. Jarvis.)

STRAWBERRY RED CORE

Further work on the effect of various polyphenols on the growth of *Phytophthora fragariae* has demonstrated that within each of three pathogenic races, isolates show considerable differences in their pattern of tolerance to a

* Cunilate Wood Seal supplied by Cuprinol Ltd.

given set of polyphenols; these patterns appear to be quite unrelated to pathogenicity. This investigation has shown that it is necessary to define the method of measuring growth in any attempt to index isolates or races by their polyphenol relationships, because the patterns of growth on a given set of polyphenols differ widely when measured by dry weights of mycelium from liquid cultures, where the mycelium is always submerged, and by radial growth on agar media, where growth is largely superficial. (W. R. Jarvis.)

A DIE-BACK OF RASPBERRIES

During the course of the year an investigation has been made of some mycological aspects of a form of die-back prevalent in certain varieties of raspberry, particularly Malling Promise, in Angus and Perthshire. During field observations in affected plantations in spring and early summer, lesions were found on young, white, fibrous roots. Those parts of the roots distal to the lesions had often died and there was some indication that the total amount of fibrous roots had been reduced. Similar lesions were subsequently found in roots from healthy plantations, though they appeared less numerous and were not accompanied by any obvious macroscopic signs of root damage. Preliminary histological examination showed the presence of both septate and aseptate mycelium in these lesions.

Some 500 isolations were attempted on material taken from both apparently healthy and diseased plantations. Approximately 65% of these yielded fungi, of which 42·5% proved to be *Cylindrocarpon radicicola* and 14·7% *Pythium* sp., both frequently in pure culture. The remaining 42·8% covered a wide range of types, none of which was present to a greater extent than 3% of the total number of fungal isolates. Many in this latter category have not been identified.

Preliminary experiments in which rooted cuttings were inoculated with *C. radicicola* and *Pythium* sp. showed that both these fungi can infect raspberry roots. These results are in agreement with those obtained by Berkeley in Canada over 20 years ago. In conjunction with field studies, further inoculation experiments will be made with these and other fungi isolated, particular attention being paid to the conditions favouring infection, and the possible role of such infection in the die-back complex. (A. R. Wilson, W. R. Jarvis, T. G. Rubens*.)

POTATO STORAGE

In collaboration with the Agricultural Research Council's Ditton Laboratory two potato stores have been designed for commercial use in Scotland, each of 1,000 tons nominal capacity. Both are for the purpose of storing potatoes at a "holding" temperature of about 50°F. for processing, and provide for fumigation with nonanol or other volatile compounds to control sprouting. The first of these, employing bulk storage, is already in operation; the second, designed for crate pallet storage, is under construction. Information obtained in these stores will assist in the solution of various design and management problems associated with the storage requirements of the processing industry. (A. R. Wilson.)

* Edinburgh and East of Scotland College of Agriculture.

PUBLICATIONS

Research Papers

JARVIS, W. R. (1960). An apparatus for studying hygroscopic responses in fungal conidiophores. *Trans. Brit. myc. Soc.* (In press.)
(A simple inexpensive apparatus is described in which fungal cultures can be observed in atmospheres of different relative humidity. Eight cultures can be moved rapidly and simultaneously from one atmosphere to another without exposure to the air of the laboratory. The method is discussed in relation to the limitations of established methods of investigation hygroscopic responses in fungi.)

JARVIS, W. R. (1960). The preservation of fruit chip baskets with copper-8-quinolinolate. *Plant Pathology*, **9**. (In press.)
(The life of chip baskets in continuous use for picking soft fruit has been prolonged from 10 days to 10 weeks by treatment with copper-8-quinolinolate. In some cases the rotting of strawberries stored in treated baskets was significantly reduced but no such effect was observed with raspberries.)

General Papers

WILSON, A. R. (& TWISS, P. T. G.) (1960). Bulk storage of potatoes in buildings. *Ministry of Agriculture, Fisheries and Food, Bulletin No. 173.* (In press.)

WEST OF SCOTLAND UNIT (AUCHINCRUIVE)

R. D. REID

STRAWBERRY BREEDING

The warm dry summer of 1959 made the season a very early one and some fruit ripened under cloches on 18 May, about two weeks earlier than usual. A few ripe fruits were observed in the open on 30 May, the earliest ever seen in this locality. A violent thunderstorm accompanied by torrential rain on 25 June caused considerable loss to the main crop then at its peak.

An important section of the fruiting trials this year consisted of a series of field trials containing 63 selections made from seedlings raised in the years 1951-53. These also provided useful material for observing the extent of "field resistance" to red core disease which is very marked in some of these selections. The fruiting results were somewhat inconclusive and it was impossible to recommend any selection for development and future release; a few of the best are now being cropped on a much larger scale. In cloche trials, 8 selections were compared with Talisman and Redgauntlet.

The 120 selections which had been made in 1958 were not fruited in 1959 but small plots of each were planted in the spring of 1959 and should provide useful fruiting trials in 1960. Four-plant units of each were also propagated under disease-free conditions and the progeny planted in fruiting trials at Mylnefield.

Approximately 2,890 seedlings were fruited as single-plant units in 1959. These had been retained from the 1956 and 1957 crossings, and all had been "screened" at least twice for resistance to red core disease. Work will be continued with 184 of these, which include 125 good enough to merit more extended trial. The remaining 59 selections are intended for use only in breeding work. In an attempt to speed up assessment of fruiting merits, all 125 selections mentioned above were propagated and 4 plants of each were planted under cloches for fruiting in 1960.

The crosses made in 1958 yielded 9,186 seedlings all of which were bench-tested for resistance to red core; 5,569 of these have survived and will later be tested in the field. In 1959, a total of 90 crosses and selfs was made.

Field Resistance

There are no grounds for expecting that we shall obtain commercial varieties immune from all races of *P. fragariae* in the foreseeable future. Earlier resistant varieties are usually immune from a number of races of the fungus but when they eventually prove susceptible to a biologic race, infection is severe, root destruction extensive and the resulting collapse is comparable with that of older susceptible varieties.

In more recent work there is increasing evidence of what appears to be field resistance to all races as distinct from immunity from a specific few. Some families of seedlings raised in 1952 provide a typical example. All seedlings

were initially exposed to infection in benches or in the field and susceptible ones discarded. The survivors were planted in our heavily infected field. Following upon the very wet summer of 1954, every plant had some infected roots. In the summer of 1955 several hundreds of these seedlings were recorded as showing vigour above average and no above-ground evidence of disease. After fruiting trials, those selected for further test were propagated and tested under a variety of conditions. One of the most outstanding selections, and one of which virus-free stocks are in existence, has now been grown in infected soil in a yearly increasing number of plots and has at no time shown any diminution of vigour or other above-ground symptoms of disease. Examination of the root systems, has each year, confirmed the presence of some root infection, but only a small amount of root tissue is destroyed and growth of the plants is not adversely affected. Thus after six successive years of known infection, there is no apparent progressive increase of infection nor any visible impairment of vigour in succeeding vegetative generations.

In pot trials, runners of this selection have been grown under identical conditions with carefully matched runners of the varieties Talisman and Redgauntlet for periods of up to 18 months. In each batch, plants of all three varieties were grown in the same 12 in. pot of infected soil and the plants were examined at intervals. In every instance, the selection produced at least twice as much root per plant as the best of the control varieties. Although some roots of all plants were infected, the proportions of clean roots produced by the selection (52AC18), Talisman and Redgauntlet were in the ratio 10 : 5 : 2. The foliage, etc., of the plants was in approximately the same proportions. Mycological tests made by Dr Montgomerie confirmed that runners of this clone are susceptible to all three races of *P. fragariae* but showed that, unlike earlier resistant varieties where susceptibility or resistance to each specific race is clear cut, the roots of 52AC18 become infected only to a limited degree. This type of field resistance or tolerance obviously requires many years testing to confirm that the character persists despite repeated vegetative propagation. But we now have in our collection, clonal stocks produced from 1951 onwards which appear to have behaved consistently.

Progenies which possess field resistance are of diverse genetic origin but most derive either from (1) Cambridge Vigour, (2) a cross made with Little Scarlet over 20 years ago, or (3) more recent crosses made with several strains of species especially *F. virginiana*.

Those in group (1) are nearest the stage of being developed for release. Of the many selections being tested, several may be suitable for early development. A much better assessment should be possible in 1960. Of those in group (2) the most advanced selections fruited up to the present have been obtained from the F_5 but further back-crossing may still be necessary. More advanced families will be fruiting in 1960. Progenies in group (3) show the highest degree of field resistance, but they are not so advanced pomologically. We are now handling the F_2 of this series.

Future varieties of strawberry are therefore likely to be either completely susceptible to red core, such as Huxley for example, immune from some races

of the fungus but susceptible to others, for example, Talisman, Vigour, Redgauntlet, or field resistant to the disease, combining immunity to some races with tolerance to all. It may be several years before new varieties in the third group will become commercially available.

Use of Fragaria *species*

Because of the increased attention now being given to the use of species in crossing, it may be of interest to indicate the extent to which species have been used in breeding work at Auchincruive. The octoploid *Fragaria chiloensis* was first used in 1936 and proved of no particular value. In 1938 the variety Little Scarlet, generally believed to be a strain of *F. virginiana*, was crossed with the resistant variety Aberdeen. The resulting hybrids were more vigorous and apparently more highly resistant than those from inter-varietal crosses. Unfortunately the fruit of the most resistant seedlings was soft and small like that of the *virginiana* parent and so this line was maintained for long-term work.

In 1954 several other strains of *F. virginiana* were obtained. These differed considerably in their pomological characters but possessed no unique factors for resistance. Further species material was obtained in 1951 and subsequently, particularly in 1954 following a visit to the U.S.A., when the most resistant of our own selections were crossed with *F. virginiana* and Little Scarlet the progeny showed the high degree of field resistance already observed in the cross made in 1938. Derivatives of the 1938 cross are now being used mainly in the F_5 generation. Field resistance still persists but seems very difficult to separate from the softness of fruit associated with the parent species. Derivatives of later crosses made in 1953 and 1954 are now being used in the F_2 and F_3 generations with encouraging results. New stocks of *F. chiloensis* from various countries have been used as sources of other genes but we have little reason to expect extra genes for red core resistance from this species. The third octoploid species, *F. ovalis* has also been used on a more limited scale, but as yet there is little evidence of anything of value emerging.

TABLE 1. Genetic origins of 184 selections made in 1959 from 2,890 seedlings

Source	No. families	No. selections	Purpose of selection			
			Pomological merit		Breeding value only	
			No. families	No. selections	No. families	No. selections
Species ...	25	62	7	17	18	45
Varieties ...	23	122	14	108	9	14

The figures in Table 1 seem typical of the results likely to be obtained when species are used in work which aims at the production of varieties which are acceptable commercially. They show that the use of species tends to result in a decrease in the proportion of seedlings which attain the necessary standard. (R. D. Reid, A. M. Sutherland, K. C. McConnell.)

MYCOLOGICAL INVESTIGATIONS

Physiologic races of Phytophthora fragariae

In previous Reports it has been noted that runners from the same clone may not react alike when inoculated with one and the same isolate of the fungus. This occurs only with clones which are resistant, not with those which are immune or susceptible. When several runners from the same clone are inoculated, some do not become infected, whereas some become slightly infected and others moderately infected. For example, when twelve runners of one variety were inoculated with a particular isolate of the fungus, 10 did not become infected and two were moderately infected. When the runners from another variety were inoculated, four did not become infected and 15 became slightly infected. Such variability in results might be explained in a number of ways, but experiments have given no clear indication of its cause.

Conditions optimal for infection of susceptible clones, may not necessarily be so for resistant ones. For example, the latter may require a higher concentration of zoospores and a longer period of exposure to infection. During 1959, therefore, the inoculation period for all material was increased from 24 hr to 48 hr. This not only lengthened the time of exposure to infection but increased the number of zoospores to which the roots were exposed because zoospores are emitted continuously from the inoculum. However, this modification of technique resulted in a slight increase and not a decrease in the proportion of clones which behaved inconsistently.

It seemed possible that the pathogenicity of the zoospores may be affected when roots of plants from different clones are immersed in the same zoospore suspension. Zoospores might be unable to infect the roots of a slightly susceptible plant if these were in close proximity to those of an immune plant. During 1959, therefore, each clone was placed in a separate zoospore suspension for inoculation. However, comparison of the results obtained with those of previous years, when clones had been mixed in the same zoospore suspension, showed there was little difference in the proportion of clones giving variable results.

Such differences in behaviour between runners from the same clone make any permanent classification of physiologic races virtually impossible. However, the four varieties, Huxley, Auchincruive No. 11, American Aberdeen and Climax have given sufficiently consistent results with 21 isolates for three races to be identified. One race, later referred to as the Huxley race, infects Huxley but not the other three varieties. A second infects all the varieties except Climax, while a third, later referred to as the Climax race, infects all four varieties. These three races have been used extensively during the last few years in testing sources of immunity in *Fragaria*.

The isolate from roots of loganberry, obtained by McKeen in Canada, has proved pathogenic to Royal Sovereign, Huxley, Perle de Prague, and non-pathogenic to Climax but further tests are needed before this isolate can definitely be assigned to any physiologic race.

The identification of physiologic races is limited by the varieties or selections available as hosts, and as none of the cultivated varieties so far tested

has proved immune to the Climax race, there is at the moment no method of detecting a race with a wider pathogenic range in *Fragaria* than the Climax race should such exist.

New Sources of Red Core Immunity

No new seed collections were acquired. Testing of seedlings from some of the collections obtained in 1957 was continued. These included *Fragaria chiloensis* from three localities in Chile, the American variety Lassen and 12 Japanese varieties. The Huxley race was used to inoculate 1,474 seedlings of which 6% were immune. Just over 1% of these were obtained from one of the *F. chiloensis* collections.

Inheritance of Immunity

This work has two main objectives. The first is to obtain, by continuous self-pollination of cultivated varieties and species, plants with genes conferring immunity from specific races of the fungus and breeding true for this character. Such plants would serve two valuable purposes. They would allow a study of the interaction of the various genes involved, and they would provide a set of standard genotypes for the identification of races of *P. fragariae*. There can be no exact comparison of races in different areas or countries so long as each worker selects a different set of indicator varieties. Use of a set of standard genotypes would also make possible a uniform system of classification of races and enable workers in different countries to compare their results.

The second objective is to make available to the plant breeder, plants possessing the same genes for immunity but differing in other characters. The widest possible range of material is being studied, to increase the chances of obtaining seedlings possessing desirable genes for immunity unlinked with

TABLE 2. Segregation of immunity from red core disease

Origin	Generation	No. of seedlings		
		Tested	Immune	Susc.
Auchincruive No. 11	F_2	25	17	8
Aberdeen	F_2	22	22	0
Cambridge Vigour	F_2	22	13	9
Little Scarlet	F_2	20	13	7
Oberschlesien	F_2	27	7	20
F. ovalis III...	F_2	21	15	6
F. virginiana III	F_2	50	34	16
F. virginiana III	F_2	180	56	124
F. virginiana VII	F_2	126	101	25
F. virginiana VII	F_3	26	7	19

undesirable genes for characters such as small fruits and susceptibility to other diseases.

During the last five years a wide range of *Fragaria* material has been tested for immunity from the Huxley race, and cultivated varieties and wild species which transmit immunity to their progeny are now known. Self-pollination of plants which are susceptible to the disease has always resulted in susceptible progeny and this would suggest that immunity is dominant rather than recessive. Some plants, on selfing, have given only immune seedlings in the F_2 generation but the families are too small to conclude that plants breeding true for immunity from the Huxley race have been obtained. In some lines the F_4 generation has been reached.

Seedlings derived from self-pollinations carried out in 1958 were inoculated with the Huxley race and the results obtained with some of the families are shown in Table 2.

In order to index material for reaction to infection by races other than the Huxley race, it is necessary for the immune seedlings to produce runners. In addition to inoculating runners with the other two races, namely, the second race and the Climax race, runners are also inoculated with the Huxley race as a check on the seedling reaction to this race.

Plants which are immune from the second race and the Climax race now number 107 and 34 respectively. These were derived from varieties, *F. ovalis* and *F. virginiana*. (I. G. Montgomerie.)

METEOROLOGICAL RECORDS 1959

J. SUNDERLAND

Daily meteorological observations were made at 09·00 G.M.T. throughout 1959. Week-end and holiday observations were made by Mr A. Fenwick of the outdoor staff.

The meteorological records for 1959 from Mylnefield and Auchincruive are summarized 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 1959

Month	Temperature		Rainfall		Sunshine		Ground frost
	Mean* °F	Deviation from average†	Inches	Deviation from average‡	Hours	Deviation from average†	Days
Jan.	32·5	−5·0	0·84	−1·09	101	+51	29
Feb.	38·0	−0·5	0·28	−1·57	43	−33	14
Mar.	43·2	+2·0	1·14	−0·71	83	−22	11
April	46·8	+2·0	1·90	+0·29	154	+14	12
May	51·6	+2·2	0·44	−1·56	194	+28	7
June	56·0	+0·7	2·43	+0·74	190	+ 8	0
July	59·3	+0·3	2·90	+0·34	183	+29	0
Aug.	60·2	+2·3	0·44	−2·83	160	+19	0
Sept.	55·5	+1·5	0·52	−1·48	161	+39	0
Oct.	52·3	+4·4	1·80	−0·80	95	0	5
Nov.	43·9	+2·2	4·83	+2·51	51	−12	10
Dec.	39·6	+0·6	5·18	+2·66	24	−17	20
Year	48·2	+1·1	22·70	−3·50	1439	+104	108

* 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 1959

Month	Temperature (°F)	Rainfall (Inches)	Sunshine (Hours)	Ground Frost (Days)
January	34·9	1·41	96	29
February	40·9	1·54	72	17
March	44·5	1·90	109	16
April	46·7	1·83	139	0
May	54·1	1·41	254	0
June	56·3	3·50	193	0
July	58·9	4·41	148	0
August	59·5	0·57	167	0
September	55·9	1·46	145	0
October	53·5	5·53	116	1
November	44·3	3·67	53	11
December	41·7	4·49	25	12
Year	49·3	31·72	1517	86

WEATHER SUMMARY

JANUARY

Persistently cold but with no extremely low temperatures. Slight snow showers fell on the 8th, 9th, 11th and 23rd: the total depth was $\frac{1}{2}$ in.

(Highest max. 47°F on 30th)
(Lowest min. 17°F on 15th)

FEBRUARY

Cold, dry and cloudy during the first three weeks. The fourth week was warmer and slight rain occurred frequently.

(Highest max. 53°F on 26th)
(Lowest min. 16°F on 2nd and 3rd)

MARCH

Warmer, with slight rain well scattered throughout. Generally cloudy.

(Highest max. 55°F on 21st)
(Lowest min. 30°F on 13th)

APRIL

Warm with scattered and sometimes heavy showers. There was a shower of hail on the 6th.

(Highest max. 62°F on 22nd and 23rd)
(Lowest min. 31°F on 4th)

MAY

Warm, becoming very warm during the last few days. Generally very dry, with variable cloud and some long sunny periods.

(Highest max. 69°F on 30th)
(Lowest min. 31°F on 4th)

JUNE

Warm to very warm. Thunderstorms with heavy rain occurred on the 23rd and 28th. There was variable cloud throughout.

(Highest max. 82°F on 14th)
(Lowest min. 39°F on 19th)

JULY

Generally warm but rather changeable. There were several days with heavy showers and sunny intervals.

(Highest max. 75°F on 4th)
(Lowest min. 41°F on 14th)

AUGUST

Warm and very dry but with no period of absolute drought (*i.e.*, at least 15 consecutive days without measurable rain). Any rain which fell was well scattered.

(Highest max. 74°F on 5th, 19th, 20th and 25th)
(Lowest min. 44°F on 29th)

SEPTEMBER

Warm and dry. Absolute drought 28th August–11th September. Many sunny days except during the third week which was cloudy with slight intermittent rain.

(Highest max. 77°F on 11th)
(Lowest min. 37°F on 18th)

OCTOBER

Warm throughout. No measurable rain 27th September–10th October. Slight to moderate rain well scattered throughout the remainder of the month. North west gale on the 27th.

(Highest max. 69°F on 4th)
(Lowest min. 35°F on 29th)

NOVEMBER

Very wet. There are only six days without measurable rain. Thunderstorms with heavy rain occurred on the 16th and 17th.

(Highest max. 57°F on 23rd)
(Lowest min. 22°F on 12th)

DECEMBER

Very wet. There were only four days without measurable rain. Slight snow showers on the 20th and south easterly gales on the 7th and 8th.

(Highest max. 55°F on 31st)
(Lowest min. 26°F on 4th)

VARIETY TRIALS OF VEGETABLES IN SCOTLAND

VII. Celeriac, 1957-1959

C. NORTH AND L. H. FRITH

Celeriac, or turnip-rooted celery, has been developed from the same species as the garden celery, namely *Apium graveolens* L. It is cultivated for the more or less spherical root or bulb of 2-6 in. diameter, which grows mainly above ground level and consists largely of the swollen base of the main stem. Although celeriac is not well known in Britain, it is highly esteemed in some European countries where it is produced on a commercial scale for the fresh market and for processing.

In France, celeriac roots are frequently shredded and eaten raw. In other countries celeriac is often preferred as a cooked vegetable, either served hot or used in mixed salads when cold. The flavour of the root is similar to that of celery, but is, nevertheless, distinct.

Celeriac seedlings, like those of celery, must be raised in a heated glasshouse and planted outside when there is no risk of hard frost. However, the crop is rather less exacting than celery, for it will flourish under fairly dry conditions and does not require soil which is rich in humus. Moreover, the elaborate cultivations associated with the "earthing up" of non-blanching types of celery are unnecessary.

This vegetable does not appear to have received much attention from research workers, but variety trials have been reported recently from Denmark and Holland by Sørensen (1951) and Banga *et al.* (1955). Field trials of 18 varieties, conducted at Invergowrie over the past three years, are described below.

Method

Seed was sown in a glasshouse at 55-65°F, and the seedlings pricked out 1 in. apart in boxes as soon as they were large enough to handle. Planting out in the field was done in rows 2 ft apart with 1 ft between the plants. Dates of sowing, planting out and harvesting were as follows:—

	Sown	Planted out	Harvested
1957	15 March	27 May	14 Oct.
1958	7 March	8 May	16 Sept.
1959	14 March	25 May	26 Nov.

The sites for the trials were prepared, before planting, by working into the ground the equivalent of 15 tons per acre of composted straw and 6 cwt per acre of a complete fertilizer.

Each trial was a randomized-block layout with 5 replications and one row of ten plants in each plot. Single guard rows were planted round the outsides of the trials.

During the growing season, soil was periodically scraped away from the base of the swelling bulbs, and any side shoots that formed were removed. These customary operations are intended to ensure that the bulb develops to a uniform shape and with a comparatively smooth surface.

At harvest time the tops were removed and the bulbs were trimmed by cutting off the branched basal roots. Bolters, and any badly split or rotted bulbs were discarded; the remainder were weighed as saleable produce. Random samples of ten saleable bulbs from each variety were examined for shape and general appearance and then cut open to observe the internal quality. In 1959 the external shape and internal quality were recorded on a numerical scale by six observers, and the results were analysed statistically.

Results

There was a distinct tendency for the plants to run to seed prematurely, particularly in 1958 when all the plants of most varieties were thus affected. Bolting may well have been influenced by the times of sowing and planting out, as its incidence was highest in 1958, when both operations were carried out earlier than in the other two trials. There were fairly well-defined varietal differences in the tendency to bolt, it being least in the varieties Imperator, Invictus, Celeriac (Thompson & Morgan), and Globus. Yields of marketable bulbs were considerably influenced by the number of bolters, especially in 1958 and 1959.

Banga *et al.* (1955) have classified varieties according to the shape of the bulbs. The best varieties have almost spherical bulbs with thin roots confined to a relatively small area at the base. The bulbs of most varieties however are roughly conical above and have a mass of fairly thick true roots arising from the broad base, and are sometimes badly misshapen. The higher the score for shape in Table 1 the nearer the bulbs were to the desirable shape described. The variety Invictus had the best shaped bulbs in 1959, and they were also clearly better in this respect than those of any of the other varieties both in 1957 and 1958.

Good quality bulbs should have firm white flesh without a central internal cavity or excessive pithiness, and without woody fibres. On the whole the colour of the flesh of all varieties was good and few bulbs showed overall grey discolouration or blackish and rust-coloured flecking. The assessment of quality was therefore based largely on the presence or absence of hollowness and freedom from coarse fibres. The bulbs of most varieties had cavities but those of Prager Kaempe (Hansen) were especially solid, both in 1957 and 1959. Bulbs of the varieties Trés gros de Reuil and Chalons had a large number of woody fibres.

Conclusions

The trials confirm that celeriac may be successfully grown in parts of eastern Scotland, even during such a dry summer as that of 1959.

TABLE 1. Yield trials of celeriac 1957-1959

Variety	Yield of saleable "bulbs" cwt/acre			Bolters per cent.			"Bulb" quality 1959	
	1957	1958	1959	1957	1958	1959	*Internal quality	*Shape
Invictus ...	200	417	312	0	42	2	2·5	5·0
Saxa	—	102	324	—	82	0	3·2	2·2
Celeriac (TM)	—	206	258	—	70	2	3·0	4·2
Globus ...	—	468	237	—	4	0	3·2	4·2
Chalons ...	—	47	298	—	92	6	1·7	1·5
Imperator ...	128	549	250	0	24	0	2·2	3·2
Trés gros de Reuil ...	118	82	353	0	94	0	1·7	3·7
Alabaster II ...	227	0	240	70	100	24	2·0	2·5
Alabaster ...	194	0	215	0	100	22	2·5	3·6
Prager Kaempe	155	0	219	0	100	22	5·0	2·7
Giant Prague (1)	—	0	221	—	98	22	3·0	1·0
Giant Prague (2)	173	0	200	30	100	24	3·5	2·0
R. V. Zwijndrecht ...	146	28	211	0	86	32	2·0	3·0
Balder (1) ...	199	0	116	2	100	56	3·0	3·2
Balder (2) ...	163	0	136	20	100	50	2·0	2·5
Balder (3) ...	186	0	174	20	100	36	3·0	2·5
Large Erfurt ...	—	19	194	—	100	32	3·0	2·0
Blangstedgaard	—	0	194	—	100	34	3·5	4·0
LSD (P=0·05)	26	—	70	—	—	—	0·9	0·8

*Based on an arbitrary scale 1-5, the higher the score the more desirable the internal quality or shape.

Many varieties tend to run to seed prematurely. This trouble might be overcome by sowing and planting out in the field later in the year, but such treatment would almost certainly lead to a reduction in the weight of individual bulbs. It would seem important, therefore, to choose a strain for Scottish conditions which is not prone to bolting.

Taking into account lack of tendency to bolt, yield, shape, and quality of bulb, the variety Invictus from Gebrüder Dippe, Zimmerstrasse 3, Herford, Germany, gave the best results, although the internal quality of its bulbs was not as good as that of some of the other tested strains. Two other stocks which gave good results were Celeriac from Thompson & Morgan of Ipswich

and Globus from Vatter Samen, Berne, Switzerland, although these were tested for two years only.

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