THE SCOTTISH HORTICULTURAL RESEARCH INSTITUTE

ELEVENTH
ANNUAL REPORT

1963 - 1964

(April 1963 — March 1964)

MYLNEFIELD, INVERGOWRIE, DUNDEE
Tel: INVERGOWRIE 441

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THE SCOTTISH HORTICULTURAL RESEARCH INSTITUTE

The Scottish Horticultural Research Institute was incorporated on 31 March 1953 as a company limited by guarantee without share capital. The business of the Institute is managed by a Governing Body, the members of which 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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W. I. A. JACK, *Foreman.*

†Honorary Lecturer in the University of Glasgow.

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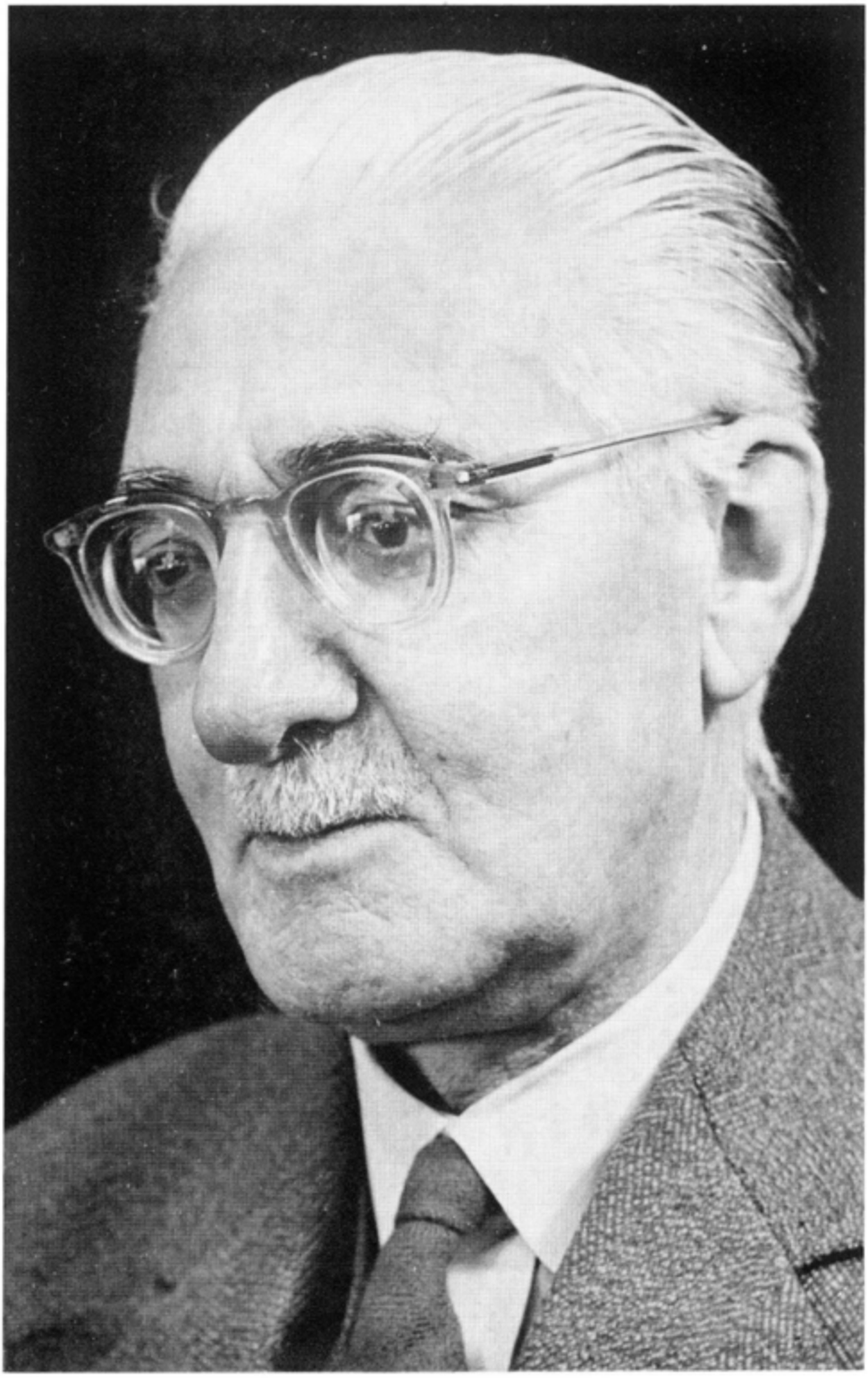


THOMAS SWARBRICK, C.B.E., M.Sc., Ph.D., S.H.M.
Director, 1951-1965.

firmly, kept me to my tasks ever since. Our discussions have been completely frank; on the rare occasions when we have disagreed, the final criterion he has always accepted has been the good of the Institute.

In all these achievements he has been sustained by Mrs. Swarbrick, who has also contributed notably to the cultural life of the region.

Despite the present indisposition of the Director, all who know them must wish Dr. and Mrs. Swarbrick a full and happy life in retirement. His work will not be forgotten, nor will the man, either at the Institute, in Scotland, or in horticultural science. Mylnefield's roots are planted deep; its first gardener has done his task well.

J. H. BURNETT.

A FAREWELL MESSAGE FROM THE RETIRING DIRECTOR

In January 1965 I retire from my post as the first Director of the Scottish Horticultural Research Institute, having reached the full age-limit of sixty-five, and in making my farewell I should like to couple with it a personal expression of appreciation to those with whom I have worked so closely for almost fourteen years.

Had anyone suggested in 1951 that by 1964 we should have developed to the extent that we have, I should have regarded it as gross over-optimism. It is well known that the two world wars and the intervening economic depression caused postponement of the establishment of a horticultural research centre in Scotland, so that when finally it was set up in 1951 it received every encouragement. The Institute today provides visible evidence of the generous support it has received from the Agricultural Research Council and the Department of Agriculture and Fisheries for Scotland, and we may hope that such modest success as we have achieved in the first developmental phase will be accepted by these bodies as some justification of this support, as well as of the confidence placed in 1951 in such a small team of untried men.

No Institute can have been more fortunate in its Governing Body than we, and I continue to be amazed that such busy men are willing, on a voluntary basis, to give so much of their time to the management of our affairs. At the risk of being slightly invidious I should like to single-out four governors for special mention, the first and foremost being the first Chairman, Professor J. R. Matthews. Although not always in the best of health, and with many other important duties to carry, he always gave priority to his commitment to the Institute, and we owe him a great debt of gratitude. His insistence that only the best men available should be appointed to the staff is in large measure responsible for the present high calibre of the staff of an Institute still so young. Secondly, I would refer to Professor T. Wallace, who was my own Director during my last years at Long Ashton.

Professor Wallace went out of his way to sustain me with wise counsel during the early and difficult years when so much depended on each single decision, and to him we also largely owe the choice of the actual site for the Institute at Mylnefield. Those of us who know him at all well realize that in a matter like the selection of a research site he is most difficult to please, and the fact that we do have an almost ideal site is not a matter of chance or good fortune: we owe it to the considered judgement of Professor Wallace. Then thirdly, without the practical, down-to-earth help of Major-General D. N. Wimberley, who at that time was Principal of the then University College, Dundee, it would have taken very much longer than it did in 1951 to make the Institute functional. With Principal Wimberley, action to be effective must be undertaken immediately and with vigour. He first provided us with accommodation that could ill be spared in the College itself, and then with much more spacious accommodation at Vernonholme until we could move out to Mylnefield. And lastly, I count it as most fortunate to have had as a member of the Governing Body Mr. Robert L. Scarlett. Although he is honoured most as a leading grower it is not his practical and horticultural contribution that I wish especially to acknowledge, but rather his kindly and profound interest in everything connected with the Institute's staff. The staff was always his first concern, and for this above all I should like to record my gratitude at having been privileged to work with this great Scottish gentleman.

It is a pleasure to acknowledge the support and loyalty shown to me personally and to the Institute as a whole by the three founder staff members, Dr. C. H. Cadman, Mr. R. D. Reid and Dr. C. A. Wood. It would be idle to expect men of this calibre always to see eye-to-eye with a Director who also has his own ideas of the ways in which things should go: but I am sure that the loyalty of these men has set a pattern which will be continued into the future, and which is essential if the Institute is to develop more fully a life of its own. Loyalty and understanding, however, have not been confined to the founder members but have been shown by the entire staff of the Institute—scientific, glasshouse, plantation, farm, and administrative. The knowledge of this will form one of my more precious memories of my period as Director.

I cannot let this occasion pass without acknowledging in particular my indebtedness to Mr. Ross, the Institute's Secretary. Indeed, we all of us owe him a great deal; but only he and I know what has been involved in building the administrative organization of the Institute during years of such rapid expansion.

My task of establishing the Institute as a going concern is now completed, and the next chapter must begin. In saying farewell, I do so with a curious mixture of pride, nostalgia and hope. The past is now behind us, well beyond the point of no return. The future is still ours, and there is little or nothing to be gained by making frequent backward glances over the shoulder. The future is for he who can keep his eyes firmly on the front horizon.

T. SWARBRICK.

T. SWARBRICK, C.B.E., M.Sc., Ph.D., S.H.M.

DIRECTOR, 1951-1965

For fourteen years Thomas Swarbrick has directed and served the Scottish Horticultural Research Institute with unswerving loyalty, enthusiasm and success. His rewards, now that the time for retiral has come, are the flourishing acres, the active laboratories and glasshouses, the national and international scientific reputation of the Institute and the enthusiasm and gratitude of the horticultural industry for its work. To have developed this from two small research groups on raspberries and strawberries in fourteen years is a major and impressive achievement. It is wholly fitting, therefore, that the Royal Caledonian Horticultural Society should this year have given public recognition to Dr. Swarbrick by awarding him the Scottish Horticultural Medal. The present contribution, however, is of a more intimate kind, on behalf of the Governing Body and the members of the Institute.

After the first days of phenomenally rapid decisions (on sites for glasshouses and laboratories: on co-ordination of existing research programmes and the development of new projects: on new buildings and new staff) the tempo slowed a little. Over the years, however, facilities and staff have expanded steadily. In 1954 the new building was occupied, in 1958 additional glasshouses were erected, in 1960 a new laboratory wing was added and, at the time of writing, a new general-purpose building is being completed which will include extensive growth cabinet facilities. The scientific staff, over the same period, rose from four to over thirty. He has brought the Institute to a point where it is ripe for further major development, and typical of the man is his pleasure that his successor will have the same type of opportunity for development that he himself enjoyed.

Dr. Swarbrick is always the first to insist that his achievements are founded on the help and advice of others. Although he has never shirked taking decisions, he is always eager to apportion the praise to those who have helped him. The really significant feature, however, is that those who help him do so with genuine enthusiasm. This is perhaps the first Director's greatest gift; his capacity to generate enthusiasm and to maintain it, despite shortages and restrictions. Much of the advice he sought came from associates of his earlier days, such as Professor Wallace; clear evidence of the persistence of the enthusiasm and affection which he has engendered.

I should like to end on a personal note. A Governing Body has, in many ways, to play a difficult role. Their encouragement or disapproval of the Director's policy and plans may greatly help or harm the Institute. I was acutely aware of this when I became Chairman of the Governing Body. Typically, in our first discussions, the Director made this point: typically, he put me on my mettle; typically, he encouraged me to share his great care and enthusiasm for Mylnefield and, equally typically, he has cheerfully, yet

THE DIRECTOR'S REPORT

Periodically, the Royal Caledonian Horticultural Society makes its premier award—the Neill Prize—to 'a distinguished Scottish botanist or cultivator', and in 1963 chose to confer this on Mr. David L. Storrie. We offer our warm congratulations to him and should perhaps extend these to the Society for the wisdom of its choice, for there can have been few more worthy recipients of this award. Mr. Storrie's eminence as a cultivator needs no substantiation here, but we as an Institute know better than most the extent to which Scottish horticulture is indebted to his enthusiastic promotion of its interests. He was among the first to advocate the setting-up of a centre for horticultural research in Scotland, and since the foundation of the Institute in 1951 he has given very generously of his time in the management of its affairs.

We also congratulate Professor J. M. Robertson on the honorary degree of Doctor of Laws conferred upon him in September by the University of Aberdeen.

In the spring of 1964 the Institute's new strawberry variety 'Templar' was introduced to commerce. It will be recalled that the two previous introductions, Talisman (1955) and Redgauntlet (1957), which are today still holding their places in competition with other recent British and continental varieties, were released at a time when there was a dearth of acceptable commercial strawberries available to the industry. It was stressed at that time that whilst these two varieties had good records for yield, they were not equal to Auchincruive Climax in all commercial qualities. However, the success of Talisman and Redgauntlet and the release by East Malling Research Station of healthy (heat-treated) stocks of other varieties, notably of Cambridge Favourite, now gives the present-day grower a fairly wide choice. Whilst no extravagant claims are made on behalf of Templar, we believe it to have a satisfactory cropping potential combined with good flavour, colour and texture.

It is well known that the Institute's present strawberry breeding programme is a direct continuation of the work begun at Auchincruive in 1933 by Mr. R. D. Reid, who still leads this very successful endeavour. In earlier work only those selections which showed an apparent complete immunity from the red core fungus (*Phytophthora fragariae*) were considered for release, but the frequent development of new physiologic races of the pathogen to some extent restricted the value of this approach. Of late years it has been found that many selections, though not immune from all races, may nevertheless show a high degree of what is termed 'field resistance'. That is to say, although their roots may become slightly infected, the development of the attack is so restricted and the production of new roots so profuse that the plants continue to grow and crop well. Experience up to the time of writing tends to suggest that Templar has these qualities.

In the 1962-63 Report some brief comments were made on the Institute's fruit breeding work as a whole. Attention was drawn to the difficulty of improving quickly upon existing high varietal standards and also to the need for breeders to take account of recent new advances in knowledge, particularly in the field of disease resistance. Despite these reservations, however, it is reasonable to expect a number of new varieties to come forward during the next few years from each of the established breeding programmes—in strawberries, raspberries and black currants. A policy of expediting new releases in response to the demand now so evident from growers and processors might result in the introduction of varieties not in the topmost rank for each and every purpose, but this is a risk which the present situation may justify. Whilst no firm commitment can be made, it is possible that a further new strawberry, ripening slightly earlier than Redgauntlet, will be available for release in the spring of 1966.

Results are also beginning to come forward from the vegetable breeding programme. Two new varieties of French bean bred at the Institute have given promising results in trials at Mylnefield and at the trial grounds of the National Institute of Agricultural Botany, Cambridge, and seed of each will be multiplied abroad during 1964. Small quantities will be available for testing by *bona fide* seed firms, growers and processors in 1965, and it is possible that one or both of these varieties will be available for release in 1966. Both are very early-maturing dwarf varieties with stringless pods, and with an upright growth habit which permits mechanical harvesting. The original objective of this work was to raise varieties both suitable for processing and sufficiently early and productive to be grown in Scotland. It is thought that these aims have probably been achieved, and steps are now in progress to introduce into this material resistance to anthracnose (caused by the fungus *Colletotrichum lindemuthianum*), a disease which can cause serious damage to bean crops in Scotland.

Tomato breeding too is making useful progress. One true-breeding selection raised here has given high yields and shown advantages in grading quality over the standard hybrid variety Ware Cross, its parent, although like the latter it is a 'greenback' type. Further breeding in the immediate future will place more emphasis on 'non-greenback' tomatoes of the Moneymaker type.

The previous Report also outlined the current position of work on the production of virus-free raspberry stocks, and pointed out that for health reasons the first field stage of propagation had been discontinued at Mylnefield, leaving the Institute's task confined to the raising each year of some 3,000-4,000 virus-free plants in small pots under glass. The correct use of this material should be to plant cane nurseries ('spawn-beds') for producing high-grade stock in the first field stage of propagation, and in 1962 and 1963 the whole output of plants from the glasshouse was distributed for this purpose, partly to selected private growers and partly to the Department of Agriculture and Fisheries for Scotland. These arrangements, however, proved unsatisfactory, mainly because the numbers of plants available to individual growers were so small. In spring 1964, therefore, the Institute itself arranged to resume the bulk propagation of canes, using for this pur-

pose rented land near Invergowrie which, it is hoped, will be sufficiently isolated from disease sources. This stage of the propagation programme will be shared with the Agricultural Scientific Services Station of the Department of Agriculture and Fisheries, at East Craigs, Edinburgh, and it is hoped that the two centres together will produce canes in quantities adequate to enable growers to plant commercial cane nurseries. The Institute's own new nurseries, however, will not yield their first cane crops until autumn 1965.

These new arrangements alone cannot be expected to dispel all the difficulties of recent years. The Institute's present facilities limit the annual glasshouse production of virus-free plants to a maximum of 5,000, and this number must be divided between the main commercial varieties on the basis of a highly fluctuating demand which is very difficult to forecast two years ahead. More frequent discussions with growers' representatives, however, may help us in future to form better estimates of the industry's requirements.

STAFF

It is with sorrow that we report the death in October of Mr. J. Stewart, who had been employed as a joiner and plumber on the Laboratory Service staff since January 1959.

There were no staff changes in the Scientific Officer grades but several departures and new appointments among Scientific Assistants and the administrative staff. Four Scientific Assistants of fairly long service, Mrs. A. M. Millar (West of Scotland Unit), Mrs. M. J. Taylor (Vegetable Crops), Miss H. B. Oswald (Mycology) and Mrs. R. N. Smith (Physiology), resigned during the year, and others who left were Dr. L. G. de S. Correia (Scientific Assistant, Mycology) and Miss E. F. Galloway (shorthand typist).

New appointees in the Scientific Assistant grade were Mr. H. McC. Anderson and Mr. W. Scott Stewart (Physiology), Miss I. Duncan, Miss S. C. Fergusson and Mr. C. D. Mason (Vegetable Crops), Mr J. B. Garrie (Genetics), Miss I. G. Stockdale (Mycology) and Mr. M. McK. K. Willock (Pomology). On the administrative side Mr. D. L. McIntosh was appointed as clerical officer, Miss M. A. Hay as shorthand typist and Mrs. M. A. B. Mitchell as typist. Mr. R. G. Watson succeeded the late J. Stewart as joiner in Laboratory Service.

Under the new arrangements to transfer the mycological work on strawberry red core disease from the West of Scotland Unit to Mylnefield, Dr. I. G. Montgomerie terminated her work at Auchincruive at the end of the year in preparation to move to Mylnefield on 1 April 1964.

Two staff members were awarded the degree of Doctor of Philosophy of the University of St. Andrews, Mr. R. M. Lister for a thesis entitled 'Studies on viruses and virus diseases affecting strawberry in Scotland' and Mr. A. B. Wills for a thesis entitled 'Studies in inheritance of the June Yellows complex in the cultivated strawberry'.

Mr. W. Fordyce was awarded the National Diploma in Horticulture in the Fruit Crop Husbandry section of the Royal Horticultural Society's Final Examination.

At the Triennial General Meeting of the European Association for Potato Research, held at Pisa in September, Dr. A. R. Wilson was elected Vice-President of the Association for a further period of three years. He was also, during the year, appointed Joint Editor of the *European Potato Journal*, and in April became a member of the Potato Marketing Board's Sutton Bridge Experimental Station Working Party on Storage Experiments.

In January Mr. L. S. Gray became President of the Dundee branch of the National Farmers' Union of Scotland.

Dr. C. A. Wood again served as an Examiner in the Royal Horticultural Society's Final Examination for the National Diploma in Horticulture.

THE STAFF ASSOCIATION

In the early years of the Institute a Social Club was formed by the then fairly small staff, and many enjoyable functions were organized. With the steady growth in number of staff, however, the feeling developed that there would be advantages if a properly constituted Staff Association could be set up, capable not only of organizing social occasions but of representing the interests of the staff in negotiations with the Institute's management. This was achieved in October 1959, when, at an inaugural general meeting, the staff ratified the constitution and rules of the Scottish Horticultural Research Institute Staff Association. The considerable amount of work involved in bringing affairs to this stage was undertaken by Dr. A. R. Wilson and Mr. A. B. Ross, and the part that the Association now plays in the life of the Institute is evidence that their efforts were worth while.

After some years of progressively stronger campaigning, funds were made available in the year just ended for the erection of a canteen. The Staff Association undertook the planning of this building and many members of staff gave their services in the fitting-out and decoration of the interior. The completed building is one of which both the Association and the Institute can be proud, and the catering service for so long so sorely missed is proving of great value to the staff.

It seems right at this time to set these developments on record, although it is not possible to catalogue all of the Association's activities. A very wide range of social functions is offered, but the role of the Association in acting as the representative body of the staff is equally important. The officers of the Staff Association give their services voluntarily, and the amount of work and responsibility now involved is quite considerable.

VISITS ABROAD

This year two staff members were enabled to work for periods in the United States of America. Dr. R. M. Lister went to the Department of Botany and Plant Pathology at Purdue University, Indiana, to study virus diseases of apple in co-operation with Dr. J. B. Bancroft and Dr. J. R. Shay, and spent altogether about 15 months there. Dr. W. R. Jarvis spent six months working under Professor C. E. Yarwood at the Plant Pathology Department of the University of California at Berkeley, on physiological factors which predispose plants to infection by powdery mildew fungi. Both

visits were financed by grants from the National Science Foundation, and we are very grateful to our American friends for providing the Institute with these valuable opportunities.

At the invitation of the National Research Council, National Academy of Sciences, Dr. C. H. Cadman attended and read a paper at a symposium on the biological control of soil-borne pathogens, held at the University of California, Berkeley. A grant from the Agricultural Research Council enabled him subsequently to visit other research centres in the United States and Canada.

The Agricultural Research Council also financed a six-week visit to the U.S.A. and Canada by Mr. D. L. Jennings, to study progress in the breeding of cane fruits and strawberries. The main purposes of this visit were to exchange information with North American workers on the latest techniques and progress in *Rubus* breeding and to search for plant material of possible value to any of our own programmes. His tour, which covered all the leading centres of small fruit breeding, was very rewarding, and a range of breeding material interesting especially for the possible improvement of winter hardiness and of fruit texture has since been imported under licence. It was something of a surprise to discover the emphasis being placed in the U.S.A. on the development of mechanical harvesters for raspberries. The prevailing outlook there is that no crop has an assured economic future unless its production can be substantially mechanized, and this attitude is clearly influencing the work of plant breeders. It must be expected that similar developments will occur in this country.

In September Dr. G. M. L. Haskell, Dr. A. B. Wills and Miss P. B. Topham attended the 11th International Genetics Congress, held at The Hague, Dr. Wills's visit being assisted by a grant from the Genetical Society of Great Britain; and also in September, Dr. A. R. Wilson attended the 2nd Triennial Conference of the European Association for Potato Research, held at Pisa. Miss W. G. Priestley, with the aid of a Travel Bursary awarded by the Women's Farm and Garden Association, visited several centres in Holland in connexion with the breeding of French beans, and Mr H. J. V. Gledhill spent a week at the Institute of Horticultural Plant Breeding (I.V.T.) at Wageningen, Holland, to study the work there on carrots. Dr. C. G. Guttridge and Mr. P. A. Thompson visited horticultural research centres in Holland for nine days in late April. The visits of Dr. Haskell, Dr. Wilson, Dr. Guttridge, Mr. Thompson and Mr. Gledhill were supported by grants from the Agricultural Research Council.

VISITORS TO THE INSTITUTE

The Institute was very pleased indeed to receive during the year two visiting scientists who each came for a period of twelve months. They were Professor R. G. Hill, Jr., of the Department of Horticulture, Ohio State University, U.S.A., who spent a sabbatical year with our Physiology Department, and Dr. D. L. Craig, Head of the Small Fruits Section at the Canada Department of Agriculture Research Station, Kentville, Nova Scotia, who came to work with the raspberry breeding section of the Pomology Department. It was a pleasure to welcome both of them and their families to

Scotland, and their visits produced profitable co-operative work which holds promise for the future.

The number of passing visitors from overseas has now grown to the point where even a bare catalogue of names would occupy undue space. In 1963 we welcomed visitors from Australia, Belgium, Bulgaria, Canada, Finland, Germany, Holland, India, Italy, New Zealand, Norway, Poland, the United Arab Republic and the United States of America. Some are mentioned by name in the departmental sections of this Report.

On 15 August Mr. Denzil K. Freeth, M.P., then Parliamentary Secretary for Science, paid an official visit to the Institute.

On 16 and 23 July two parties of county horticultural advisory officers and provincial specialists from the Yorks./Lancs. and Northern Regions of the National Agricultural Advisory Service visited Mylnefield, and on 24 July we received members of the N.A.A.S. Fruit Group, accompanied by their Chairman, Dr. H. B. S. Montgomery.

At the conclusion of the 7th Symposium of the Society of European Nematologists, held in September at Ayr, a group consisting mainly of delegates from continental Europe visited the Institute.

The many other visitors during the year included a group of 30 horticultural students from Studley College, Warwickshire, who came in May, and parties of science students from the University of St. Andrews and of senior pupils from the Dundee secondary schools.

A very successful Open Day for fruit-growers was held on 20 July. The weather was ideal and there was an attendance of about 200.

ACKNOWLEDGEMENTS

In previous Reports we have recorded our appreciation of the generosity of Scottish Agricultural Industries Ltd., who have regularly gifted funds which have been used to purchase items to benefit the staff as a whole. This year we record with gratitude and pleasure the receipt from them of a larger gift than usual, which assisted materially in the purchase of furniture for the new canteen.

The scientific journal *Horticultural Research*, which, though not an official organ of the Institute, is edited principally at Mylnefield, now has a circulation widely international in scope but not yet adequate in total size. During the past year the Editorial Board has been grateful to receive four generous financial grants which will help to sustain the journal in 1964 while further efforts are made to increase the circulation. These gifts have been acknowledged individually in the journal. The position of *Horticultural Research* has recently been strengthened by the appointment of five honorary Associate Editors, in the United States of America, Canada and Sweden.

Many gifts of chemicals, seeds and plants, too numerous to mention individually, were again made to the Institute for experimental purposes, and we thank all who helped in this way. Among those who kindly provided land and other facilities for experimental work were Mr. G. R. Bruce, Kirriemuir; Mr. J. G. H. Fenton, Perth; Mr. M. D. Henderson, Aberfeldy; Mr. D. McLean, Coupar Angus; Mr. W. McLeish, Coupar Angus; Mr. Robert Niven, Essendy, and Mr. W. D. Soutar, Kirriemuir.

We are again indebted to the A.R.C. Unit of Statistics at Aberdeen University for much invaluable assistance; to Queen's College, Dundee, for the use of the Mathematics Department's electronic computer, and to the staff of other research and experimental stations at home and overseas for their collaboration. The staff of the Chief Surveyor of the Department of Agriculture and Fisheries for Scotland again kindly reproduced the year's cropping plan, printed on pages 44-45 of this Report.

FARM, PLANTATIONS AND GLASSHOUSES

L. S. GRAY

After the most prolonged period of wintry weather for several years, most sowing and planting work in spring 1963 was some weeks late. A late blizzard on 12 April still further delayed the sowing of sugar beet, carrots and cabbage. These difficult conditions were followed by a cool, wet summer, and harvest operations were beset by rain, particularly in August and November. Conditions thereafter improved considerably, and the progress possible in the mild, open winter of 1963-64 was in marked contrast to the situation a year previously.

A major change was made in farm policy with the decision no longer to keep winter-housed cattle. These have in the past provided farmyard manure for fruit experiments and farm root crops. The steady expansion of the area under horticultural field experiments, however, has reduced the amount of land available for farm crops, whether for cash or winter keep, and by 1963 it was felt, not without reluctance, that the time had come to change over to the purchase of our annual requirements of farmyard manure. This decision will enable the farm cropping programme to be simplified, since it is now unnecessary to grow oats, hay, straw and turnips for winter keep, and land released in this way will become available for research projects or for additional cash crops such as barley or carrots. At the same time a minor re-organization has made our farm staff—as distinct from the plantations staff—available for routine work in connexion with vegetable experiments.

Considering the weather difficulties, the cropping results for the year were fair. The grain harvest produced approximately 71 tons of barley and 17 tons of wheat. Sugar beet, at just over 11 tons per acre of clean roots and 16·39 per cent. sugar, was well below normal but compared favourably with the Scottish averages of 8·8 tons and 15·5 per cent. sugar. The yield of potatoes was low, due mainly to reduced tuber-size caused by lack of sunshine. Indoor bulk storage of potatoes in the former cattle courts gave very satisfactory results.

The soft fruit season was made difficult by wet weather and a high incidence of grey mould disease. Moderate reductions in the expected yields of raspberries and strawberries were balanced, however, by good prices. Sales to processors were: strawberries, 23¼ tons (26½ tons in 1962); raspberries, 27½ tons (25¼ tons); black currants, 5¼ tons (3 tons). Apples were disappointing: apart from rather poor colour and finish, there was a loss of several tons as windfalls during September. The plum crop too was poorer than usual.

In vegetables, a pilot trial of about an acre of carrots yielded 20 tons of roots of canning size, which gave the very satisfactory gross return of £240. It is now planned to increase our production of carrots for processing.

Brussels sprouts yielded approximately 3¾ tons for marketing. A cabbage crop grown for outdoor clamping was not considered good enough for storage and was marketed direct in November.

The new oil-fired steam boiler mentioned in the 1962-63 Report came into operation at the end of June, and after some initial difficulties in the summer it functioned very well during the critical winter period. A stand-by diesel-electric generator has been installed to insure against mains failure. The existing vertical boiler, previously used to supply steam for soil sterilizing, was connected to the new system. In the event of boiler breakdown, therefore, a reasonable amount of steam can be generated until repairs are effected. The new boiler heats the existing hot water pipe system through a calorifier, but future glasshouses and other new buildings will be directly steam-heated. A start was made in January on the construction of two new glasshouses, each 124 ft. by 12 ft. and divided into four compartments.

At Carselea glasshouses a small commercial crop of tomatoes was grown. In No. 1 house a series of raised concrete beds, equipped with soil-warming cable and controlled watering, was constructed for potato experiments.

During the winter a large new general-purpose building was erected on a site north of the older farm buildings. This two-span structure has overall dimensions of 90 ft. × 70 ft. and is built of portal-frames with cladding of asbestos sheets. A part of it will be used for the seasonal handling of fruit, grain and other produce, including the washing and grading of vegetables. Provision is also being made for the installation of growth cabinets and controlled environment chambers for the Crop Physiology and Mycology departments. A loading ramp will greatly facilitate the handling of many heavy or bulky materials. The design and siting of the building provide for its extension at a later date.

The main yard and parking area adjacent to the laboratories and service buildings was tarred and resurfaced. Fences along some of the service roads were renewed, and the opportunity was taken to provide wider field gates. Resurfacing of farm tracks with ashes was done where necessary. The mixed deciduous and coniferous windbreak planted to the west of Quarry and West Loan Fields in 1954 underwent a first stage of thinning and trimming similar to that applied to an older planting a year previously (see 1962-63 Report), and some of the older lines of protective poplars were pruned severely to reduce their size. A short windbreak of *Chamaecyparis Lawsoniana* was planted along the north side of the glasshouse area. The permanent boundary fence was extended by some 400 yards, and several tubular steel gates were erected at selected points ready to be incorporated into the fence in the next phase of this work.

POMOLOGY

C. A. Wood

The year was an average one for soft fruit crops, with less wind damage than in 1961 and 1962 but many interruptions during the picking season from rain, especially in August. Ripening dates differed little from those of 1962. Strawberries were picked from 2 July to 9 August, raspberries from 17 July to 28 August and black currants from 15 July onwards. Most of the black currant crop again came from breeding material.

A feature of the strawberry season was that the fruits of many varieties and selections were difficult to remove from the husk, although a marked improvement in this respect occurred after one particular weekend of fine weather. The fruiting canes of raspberries, while still showing some amount of cane death due apparently to winter injury, were generally better furnished with laterals than in 1962.

Apples and pears again ripened poorly and lacked good colour. These features were fairly general in the United Kingdom, probably because of wet, dull weather during the later part of the summer.

In June and July Mr. D. L. Jennings made an extensive tour of cane fruit and strawberry experimental centres in the United States and Canada, mainly to see the breeding work in progress with these crops. Besides making very profitable contacts with other fruit breeders, he was able to see something of recent American progress in the machine-picking of cane fruits, a subject of some interest now to Scottish growers.

Mr. Jennings's tour was financed by the Agricultural Research Council. Following closely upon it, but as a result of arrangements made earlier, we were delighted to welcome Dr. D. L. Craig, Head of the Small Fruits Section at the Canada Department of Agriculture Research Station, Kentville, Nova Scotia and one of Mr. Jennings's hosts in Canada, who came in August under a grant from the Canada Department of Agriculture to work for a year with the raspberry breeding group at Mylnefield. Dr. Craig's visit—at the time of writing drawing to a close—subsequently became one of the highlights of a stimulating year.

Mr. M. McK. K. Willock was appointed in June as a Scientific Assistant and attached to the work on weed control. There were no departures from the staff during the year.

RASPBERRY BREEDING

The most important material fruiting for the first time in 1963 consisted of (i) S_2 families obtained by inbreeding selections from the cross Malling Jewel x Burnetholm Seedling, and (ii) cross-bred families in which one parent was a firm-fruited F_1 selection derived from Malling Jewel x Burnetholm Seedling and the other a selection from different material, selected for earliness and good fruit size but possessing only moderately good fruit texture. In spite of a very wet summer a high proportion of the seedlings in the S_2

families maintained a good level of firmness, but in general the overall quality of this fruit was disappointing because of its dark and downy appearance. Some of the cross-bred families did give selections with good overall fruit quality, but the fruit texture in most of these did not remain firm throughout the season. Selections from the S_2 families were further inbred by selfing and sibbing, and crosses were made between some of these selections and selections from the cross-bred families mentioned.

Nine selections from the cross-bred families were propagated for further observation.

Resistance to Diseases and Pests

Further families were raised to incorporate the two major genes *H* (hairy canes) and *s* (spine-free canes) into lines selected for good fruit quality. These genes reduce the liability of canes to be attacked by certain fungal pathogens. Similar families were raised to incorporate the genes A_1 and either A_2 or A_3 for aphid resistance. It is hoped to use the latter families in 1964 to initiate a selection programme for aphid resistance based on glasshouse techniques. (D. L. Jennings, B. M. Tulloch, P. B. Topham.)

Although the experimental population of raspberry beetle (*Byturus tomentosus*) was still small, preliminary observations were made in the experiment (see 1961-62 Report, p. 15) in which possible resistance to the beetle is being investigated in the species *Rubus innominatus* and *R. phoenicolasius* and in F_1 and backcross hybrids involving the raspberry and either of these two species or *R. kunzeanus*. No resistance was detected in any of the hybrids, but *R. phoenicolasius* itself seemed a completely unacceptable host to the insects. No observations were possible on *R. innominatus*. These observations will be repeated in 1964, when it is also hoped to investigate the possibilities that resistance is a recessive character and that it may be associated with certain recessive features of plant morphology. (C. E. Taylor, D. L. Jennings.)

Fertility Studies

In studies of factors which affect fertility in *Rubus*, attention has again been concentrated on diploid and tetraploid stocks of the raspberries Malling Jewel and East Malling Seedling 69/139. In a diallel set of crosses between these four stocks, it was found that the kind of pollen used had the largest influence on seed-set and that the four kinds of pollen differed considerably in effectiveness in this respect. Pollen of the diploid form of Seedling 69/139, for example, was inferior to that of diploid Malling Jewel in all the crosses, but the pollen of tetraploid Malling Jewel was slightly inferior to that of tetraploid Seeding 69/139. Tetraploid pollen was in each case inferior to the corresponding diploid pollen, even when used on tetraploid mother plants. Crosses which gave a high seed-set were not always the ones which gave high proportions of well-formed embryos, however, since in this respect the maternal parent appeared to exert most influence, Seedling 69/139 being superior to Malling Jewel at both ploidy levels. When the four kinds of pollen were used in crosses with the tetraploid blackberry *Rubus laciniatus*, it was found that seed-set was highest when diploid pollen was used, the

mean numbers of seeds obtained per pollinated flower being 3·97 and 1·08 respectively for pollination by diploid Seedling 69/139 and diploid Malling Jewel, and 0·28 and 0·05 respectively for pollination with the corresponding tetraploids. (More than 60 flowers were pollinated in each case.) It appears that the four kinds of pollen differ in their capacity to effect seed-set, and that in this respect the capacity of diploid Seedling 69/139 is below that of diploid Malling Jewel when used in crosses with the other three raspberry parents but greater than that of the others when used in crosses with *R. laciniatus*. The object of making the four crosses with *R. laciniatus* was to determine the proportions of sexual and apomictic seedlings obtained and to see if these proportions differed for the four kinds of pollen. The seedling progenies will therefore be classified from this point of view when they germinate.

The effect on seed-set of applying auxins (25 p.p.m. 2-naphthoxyacetic acid + 25 p.p.m. para-chlorophenoxylacetic acid) to young fruits 10 days after fertilization was also investigated. For the self of diploid Seedling 69/139, the cross of tetraploid 69/139 x diploid 69/139 and especially the cross of diploid 69/139 x tetraploid 69/139, the application of these auxins improved seed-set, although the drupelets and seeds obtained included a proportion which were smaller than normal and proved to be inviable. However, the same treatment reduced seed-set for the self of diploid Malling Jewel and the cross of diploid Malling Jewel x tetraploid Malling Jewel. Inconclusive results were obtained for three other pollinations studied. The difference in response between 69/139 and Malling Jewel suggests that these raspberries differ in their natural hormone production. Since seed-set in *R. laciniatus* is known to be improved by the hormone treatment used in these tests, it is proposed to repeat the four crosses with this species mentioned above and to compare seed-set with and without the application of auxins. This should also show whether the array of genotypes which survive can be increased or altered by auxin treatment. (D. L. Craig, P. B. Topham, D. L. Jennings, B. M. Tulloch.)

Out-of-Season Fruits

Physiological studies were continued to discover the best means of handling raspberry material out-of-season, so that progress with breeding and genetical work may be expedited. Satisfactory procedures have now been devised for avoiding or breaking cane dormancy and also for breaking seed dormancy. Papers on both these aspects of the problem were prepared for publication and synopses of them appear below (p. 30). (D. L. Jennings, B. M. Tulloch.)

BLACK CURRANT BREEDING

Germination of the seed derived from the crosses made in 1962 involving selections from 21 families (see 1962-63 Report) was slow and erratic. This was not confined to any one cross or associated with any particular parent, but occurred over a wide range of families. In the diallel crosses involving selections from Brödtorp x Silvergieter's Black and Brödtorp x Janslunda, germination was also erratic, particularly in the sib-crosses, where in one

case the seed failed to germinate and in the other five the required numbers of seedlings were not attained. Seed of one of the selfed families also failed to germinate and the seedling numbers fell short of requirement in one of the outcrosses. A second but small flush of seedlings occurred after the seed had been subjected to a second period of low temperature. The young seedlings obtained in all this work were planted directly into permanent fruiting positions in May and June and made good growth during the year. They should bear their first crop in 1965.

Five hundred and seventy seedlings were obtained from seven of nine crosses involving selections of *Ribes dikuscha* parentage chosen for high resistance or immunity to leaf spot (*Pseudopeziza Ribis*), but attempts to inoculate the young seedlings with spore suspensions of the fungus were unsuccessful. Nearly half the seedlings, however, were discarded for susceptibility to the disease while still in nursery rows in late summer and autumn.

The crosses which failed in 1962 were repeated in 1963. Two seedlings from the cross Amos Black x Brödtorp were backcrossed to Amos Black, and single selections from each of the crosses Brödtorp x Magnus, Magnus x Baldwin and Baldwin x Laxton's Giant were backcrossed to both parents. In addition, two crosses were made between seedlings selected from the backcross progenies of Brödtorp x Silvergieter's Black and Baldwin x Brödtorp. Several crosses were made with a highly vigorous Baldwin x Brödtorp selection in an attempt to obtain a seedling suitable for mechanical harvesting. Three crosses were made with *Ribes hudsonianum*, five with *R. bracteosum* and six between the black and the red currant. Thirteen foreign varieties of black currant, six seedlings and two *Ribes* species were self-pollinated. The foreign varieties included Sztahanovka, Juharlevelü, Gornoaltajszkaja, Gerby, Golubka and Pamjat Michurina.

THE CULTIVATION OF RASPBERRIES

The raspberry cultural experiments planted in 1957 and 1958 were all continued in 1963 and generally cropped better than in 1962. This was certainly due mainly to the lower incidence of cane death and fruiting-lateral damage among second-year canes.

In the main nutritional experiment on levels of application of nitrogen, phosphorus, potash and farmyard manure, the yields of Malling Exploit and Lloyd George again *declined* as the levels of inorganic nitrogen rose from nil to 40 lb. and further to 80 lb. per acre per year. This effect was the greater in Malling Exploit. The third variety, Norfolk Giant, showed an increase of yield with the first increase of nitrogen level only. The effect of these results in combination with the similar ones of 1962 has been very nearly to balance in Malling Exploit and Lloyd George the increases of yield accumulated under the higher nitrogen treatments in the period 1957-1960; but in Norfolk Giant—clearly the most responsive of the three varieties to nitrogen—the high nitrogen plots are still easily the best in total productivity since 1957. The effect of the farmyard manure treatments (0, 15 and 30 tons of F.Y.M. per acre biennially) was again to reduce yields, virtually at all three inorganic nitrogen levels but less drastically than in 1962. With these treatments, too, the adverse effects recorded in 1962 and 1963 are in

contrast with those of earlier years, when F.Y.M. produced little measurable effect. In 1962 and to some extent also in 1963 the quality of raspberry fruiting canes at Mylnefield was poor, and it will be instructive to see the behaviour of this experiment if it can be continued until another good year for cane quality occurs. This may happen in 1964. In any case, it is clear that the nitrogenous and organic manuring of the three varieties in this trial is a complex matter even on a single site favoured with a well-drained medium-loam soil, and also that very interesting facts can come to light when a manurial experiment is maintained for a period of years varying considerably in weather conditions. These results are discussed further in the fourth publication listed below (p. 30).

In the experiment in which four arable systems of raspberry cultivation are being compared with each other and with a straw mulch and a grass/clover cover crop, the straw-mulch treatment again gave the best yield and the cover crop treatment shared the lowest place. Cropping was again better under the two systems of shallow cultivation (which avoid routine ploughing and draw-hoeing) than under the two more traditional arable systems, but as in other cases, the final evaluation of all these treatments must await the completion of the experiment.

Past Reports have referred to an experiment to compare the performance of initially virus-free stocks of Malling Jewel and Lloyd George with that of the mildly virus-infected material of these varieties which was issued as nuclear stock prior to 1958. Virus infection, some of it quite severe in Lloyd George, is now general throughout this experiment, but all the stocks have remained fairly good in vigour and yield and there has been a continued interest in three planting-distance treatments which are combined factorially with the comparisons of stocks. In almost every year since 1957 (all except 1960 for Lloyd George and 1962 for Malling Jewel) the initially virus-free stocks have given the higher yields. If the planting-distance treatments are averaged, the increases in total yield to date of these stocks over the older stocks are 7·9 per cent. in Malling Jewel and 4·1 per cent. in Lloyd George, but larger differences than these occurred in the first three years after planting.

Among other experiments of this series, the one on the defoliation of first-year canes on three dates in autumn did not support the previous year's suggestion that such treatment may increase fruit yield in the following season. In another experiment the removal of the previous year's spent fruiting canes soon after picking (instead of in winter) may have been of slight advantage to subsequent cropping in Malling Exploit but was of none in Lloyd George; and the same experiment again showed no differences of yield associated with picking at three different frequencies—1, 3 and 5 days. Experiments to compare the normal winter 'tipping' of canes with the alternative of bending the tops over and retying them to the top wire showed once again the advantage of the latter method for Norfolk Giant, but no clear effect appeared in Malling Exploit or Lloyd George. Over a period of years, however, bending-over has usefully increased the yields of all varieties on which it has been tried. (C. A. Wood, M. M. Anderson.)

WEED CONTROL[1]

Raspberries

This year's results from the long term experiments on soil-acting herbicides described in earlier Reports confirmed previous findings that annual overall applications in spring of simazine (1·5 or 2·5 lb.[2]), diuron (3·0 lb.) or mixtures of 2,4-DES (4·6 lb.) with either propham (4·0 lb.) or fenuron (0·5 lb.) did not reduce either cane vigour or fruit yields. In plots of Lloyd George treated annually with monuron at 3·5 lb. since 1959, however, there is now a suggestion that vigour and yield have been reduced. The simazine, monuron and diuron treatments have all given adequate control of annual weeds for several seasons, but none of the treatments has prevented couch grass, coltsfoot or sheep's sorrel from spreading slowly along some of the rows. In the older experiment which was sprayed in spring 1962 with high rates of simazine (15 and 30 lb.) and atrazine (15 lb.), the raspberries (Norfolk Giant) continued to grow apparently normally, despite demonstrations by bio-assay and test-cropping of considerable herbicide residues in the soil. Sufficient simazine and atrazine remained to kill test crops of potatoes and peas. All three treatments killed the couch grass growing along the raspberry rows.

Soil samples were taken from the top 3 in. of soil which had received annual applications of simazine (2·5 lb.) for four years. Counts of the weed seedlings which subsequently appeared revealed a reduction of more than 95 per cent. in comparison with soil from control plots.

The experiment planted in spring 1963 to compare new systems of plantation management involving the use of herbicides (see 1962-63 Report, p. 23) has not yet shown any major differences in growth between the treatments. A second experiment, also with the variety Malling Jewel, was planted in spring 1964 to assess a number of recently developed soil-acting herbicides.

Strawberries

The experiment was continued in which total annual applications of either 2·0 lb. simazine, 10·0 lb. neburon or 12·0 lb. DAC 893 are made in two equal spring and autumn doses to fruiting Talisman strawberries. Simazine and neburon both provided good control of annual weeds, but at the expense of some reduction in fruit yield.

In May a new experiment was planted with the varieties Redgauntlet, Talisman, Cambridge Vigour and Merton Princess, to compare weed control by traditional methods (hand-hoeing within the rows and rotary cultivation between the rows) with the use of herbicides. The herbicide chloroxuron will be used in the herbicide plots until the first picking in 1964, after which weed control will be attempted by an autumn application of simazine supplemented by spot-spraying with paraquat. A further experiment is planned for spring 1964 to evaluate the advantages of dipping runners into activated charcoal before planting, and also to assess some other recently developed herbicides. This will be planted with the varieties Templar, Cambridge Favourite and Talisman.

[1]Work on weed control in vegetable crops (excluding potatoes) is reported on pp. 35 and 37.

[2]Rates are given in pounds of active ingredient per acre.

Potatoes

A second trial was conducted to measure the tolerance of potatoes to soil-acting herbicides, this forming a part of the series co-ordinated by the A.R.C. Weed Research Organisation. The herbicides linuron, trietazine, prometryne and desmetryne, each at 1·0, 2·0 and 4·0 lb., and EPTC at 1·5, 3·0 and 6·0 lb., were applied and mixed into the soil by rotary-cultivation before planting, and subsequently all the plots were given normal commercial tractor cultivations. The potato variety used was King Edward VII. The highest rates of linuron, trietazine, prometryne and desmetryne all reduced the yield of ware potatoes and caused foliar chlorosis, but the highest rate of EPTC had no effect on yield. Seed tubers from the treated plots were kept to be grown for observation in 1964. It should be emphasized, however, that the results from this trial cannot be compared directly with the farm use of herbicides, since the usual practice in Britain is to spray the soil surface after planting. In another experiment the same herbicides were applied at the same rates to the soil surface, the object in this case being to assess their herbicidal properties. Weed counts taken at one and two months after spraying indicated that EPTC at all three rates, and the other three materials at the lowest rate, all failed to control weeds adequately under the conditions of the experiment.

Another trial compared the effect upon the crop and weeds of (a) a number of possible commercial herbicides and (b) two levels of cultivation, using the varieties Duke of York, Home Guard and Redskin. In the herbicide-treated plots there were no post-planting cultivations and the herbicides were applied just as the first potatoes were emerging. The materials used were (i) dinoseb-amine (6·0 lb.), (ii) paraquat (0·5 lb.) + linuron (1·0 lb.), (iii) paraquat (0·5 lb.) + prometryne (1·0 lb.), (iv) prometryne (1·3 lb.) + simazine (0·7 lb.), (v) linuron (2·0 lb.), and (vi) MCPA (1·0 lb.) + linuron (1·0 lb.). The two cultivation treatments were (i) the normal sequence of breaking-down the ridges followed by inter-row cultivation and building-up again of ridges, and (ii) a single, light saddle-back harrowing just prior to emergence, followed by a light moulding with ridging bodies. Weed control was good throughout the experiment and there were no significant differences of yield.

A replicated screening trial was also conducted with the varieties Home Guard and Redskin. Sprays were applied at four stages of growth ranging from pre-emergence to complete emergence, and the chemicals used included several recently developed materials. However, weed growth on all the plots, including those neither sprayed nor cultivated, was so poor that no proper assessment of herbicidal efficiency could be made: but yields were reduced by some of the treatments applied to the emerged potato foliage.

Experiments with Newer Herbicides

One replicate of the experiment to assess the soil residual properties of dichlobenil (see the past two Reports) was retained so that several vegetable crops, including potatoes, could be drilled into the ground to test for the presence of toxic residues. Carrots failed to emerge on any of the plots which had been treated, regardless of the rate of application, and the

emergence of peas and broad beans was severely reduced on the plots which had received 4·0 and 8·0 lb. of the active ingredient. On the plots which had received 8·0 lb. of dichlobenil or 8·0 lb. of 2, 6-dichlorothiobenzamide (a closely related substance) weed growth was still inhibited two years after application of the chemicals.

A screening trial to compare the herbicidal activity of various residual (soil-acting) herbicides was carried out on bare ground which had recently been cultivated. Half of the plots were sprayed before weed emergence and the remainder a few days after the appearance of the first weeds. The most potent material tested was bromacil, which was more effective than simazine at equal rates per acre. The addition to low-rate applications of linuron and diuron of a proprietory wetter, based on a polyethylene glycol derivative, considerably enhanced the action of these herbicides on emerged weeds. (R. J. Stephens, D. W. L. Scott, M. McK. K. Willock.)

AUCHINCRUIVE STRAWBERRY SELECTIONS

The outstanding feature of the strawberry seedling trials was the cropping of Templar and of two other advanced seedling selections (A.41 and A.45) in a replicated trial, in which Talisman and Cambridge Favourite were also included for comparison. Although the season favoured grey mould, yields were exceptionally high. Templar cropped at the equivalent of 7¾ tons per acre, and A.45, Talisman and A.41 at equivalents of 8½, 6½ and 5¼ tons respectively. The relatively low yield of Cambridge Favourite—4¾ tons—was due to a killing of the crowns in the previous winter. Single observational plots of Templar (1/10 ac.) and A.41 (1/29 ac.) and a set of replicates of Talisman, all equal in age to the above trial and situated nearby, cropped at 6¾, 4¾ and 6¼ tons per acre respectively.

The picking of both Templar and Talisman began on 7 July, and their seasons thereafter were very similar; but this was probably not a typical result for Templar, which in past experience at Auchincruive has been similar in season to Redgauntlet. A.41 ripened at the same time as Cambridge Vigour—four or five days earlier than Templar—and A.45 three days earlier than Templar. The season of Cambridge Favourite, which was also atypical, coincided with that of Templar.

Losses due to grey mould averaged 9 per cent. in Templar, Talisman and the two unnamed seedlings and 4½ per cent. in Cambridge Favourite. A troublesome feature was that all varieties and seedlings were unusually difficult to husk until the third week of July. (M. M. Anderson.)

APPLE VARIETY-ROOTSTOCK TRIALS

A fairly detailed account of these long term trials was given in the 1962-63 Report (pp. 24-26). Progress continued in 1963, and the growth and leaf-colour of the trees showed a general improvement following extra applications of nitrogen and with the increased period of time since grassing-down.

Crop weights were mostly below expectation, and dessert varieties were less well coloured and ripened than in some past years. However, these were fairly general features of the 1963 apple season in Britain. The three

excellent apple years of 1958-1960 at Mylnefield have now been followed by three poorer years, of which two—1961 and 1962—were notable in most parts of the United Kingdom for the prevalence of high winds. The main adverse factor in 1963 was wet, dull weather during much of the summer.

The picking dates of dessert varieties in these trials were generally up to two weeks later than in 1962, but this was not true of the Worcester group of second-earlies. Tydeman's Early Worcester, Worcester Pearmain and Merton Worcester, ripening in that order, were harvested 2, 3 and 6 days earlier respectively than in 1962. Unfortunately there are not yet comparable results available for the variety Exeter Cross (Worcester Pearmain x Beauty of Bath), an apple which promises well for this area. Among culinary varieties, Grenadier, Edward VII and Royal Jubilee were picked 9, 12 and 26 days later respectively than in 1962, but Bramley's Seedling was ready 11 days earlier.

The new trial of promising North American varieties on Malling-Merton rootstocks, reported last year as having been planted in December 1962, made satisfactory progress, as did also the final section of trial 2A which was planted with Exeter Cross. (W. Fordyce.)

OTHER VARIETY TRIALS

Apples, Pears and Cherries

The established collections of these fruits received routine maintenance, and the apples and pears were as usual a source of much interest to visitors and staff. The pear collection has now become more interesting with the increasing size and cropping of the trees. (W. Fordyce.)

Red Currants

In the smaller of the two red currant trials planted in 1955 the highest-yielding varieties were Ayrshire Queen and Jonkheer van Tets, followed by Earliest of Fourlands, Red Lake and Laxton's No. 1. In the trial of fifteen varieties the highest yields were from Victoria and New Red Dutch.

Both of these trials were discontinued in the autumn, having become badly damaged by wind. Over the 8-year period the varieties in the smaller trial cropped in the descending order: Ayrshire Queen, Earliest of Fourlands, Laxton's No. 1, Jonkheer van Tets, Red Lake. In the larger trial the five highest-yielding varieties were New Red Dutch, Red Dutch, London Market, Victoria and Earliest of Fourlands, whilst very low yields were recorded from Pearson's Seedling, Cascade, Wilder and two Minnesota seedlings. The yields in both trials were generally low, however, only Ayrshire Queen giving an average yearly crop of more than ten pounds per bush. Wind damage seriously reduced the cropping of Jonkheer van Tets and Red Lake and, to a lesser degree, of Laxton's No. 1. Varieties which showed considerable ability to withstand wind were Ayrshire Queen, New Red Dutch, Red Dutch, Earliest of Fourlands and Victoria.

In fruit size and quality the best varieties were Jonkheer van Tets, Red Lake, Earliest of Fourlands and Ayrshire Queen. The earliest and latest varieties to ripen were Jonkheer van Tets and Ayrshire Queen. Three new red currants not included in these trials but grown alongside them for

observation deserve special mention: these were a variety under the name Minnesota (productive, with large berries), the variety Rondom (with long, very compact and productive strigs), and a very late-ripening variety, Heinemanns Rote Spätlese. (M. M. Anderson.)

Scottish Regional Fruit Trials

In the co-operative experiment now in progress on the post-harvest defoliation of strawberries (see 1961-62 Report, p. 25, and 1962-63 Report, p. 26), the defoliations applied in 1962 to the pair of blocks of Cambridge Vigour planted in spring 1961 apparently reduced the numbers of inflorescences borne in 1963, and consequently none of the defoliated plots outyielded the control (intact) plots. In Talisman, however, defoliation on the earliest date (30 July) led to more than a doubling of the number of inflorescences, and substantial but progressively smaller increases in inflorescence numbers occurred on the plots which were mown later. All the defoliated plots of Talisman gave increased yields, the increases from the earliest- and latest-mown plots amounting to slightly more than $4\frac{1}{2}$ and $2\frac{3}{4}$ tons per acre respectively. Mowing-off the foliage as early as 30 July, however, usually involves the loss of a certain amount of the current season's crop still unripe by that date; but this experiment is so designed that any such loss each year is measured, and when the results are complete it should be possible to consider on a more factual basis than exists at present whether a plantation should be defoliated once, twice, or more than twice during its lifetime.

In both varieties the defoliated plants of the 1961-planted blocks were smaller in 1963 than the intact control plants. In the second pairs of blocks of this experiment planted in 1962, both varieties cropped in 1963 at more than $6\frac{1}{4}$ tons per acre. Defoliations in 1963 were applied to plots in the first and second pairs of blocks on 1 August and subsequently at weekly intervals for four weeks. The third and final pairs of blocks were planted in early April 1963.

Although in 1963 grey mould was less serious at Mylnefield than in some other localities, the losses were higher than usual. In second-year plantations the weight of unmarketable fruit averaged 12 per cent. in Cambridge Vigour and 19 per cent. in Talisman. However, in the earliest-defoliated plots of Talisman in the above experiment, carrying a yield of fruit twice that of the unmown plots, only 15 per cent. of the crop was unmarketable.

In the raspberry variety trial planted in 1960, Norfolk Giant led in yield with a crop of more than $4\frac{1}{2}$ tons per acre, and Malling Promise and Malling Seedling 69/139—the two lowest-yielding varieties in 1962—both cropped at more than 4 tons. The three leading varieties in 1962—Lloyd George, Malling Jewel and Malling Exploit—all gave between 3 and 4 tons. In the 'health demonstration plot' of different grades of certified stocks, also planted in 1960, the originally virus-free stocks of Lloyd George and Malling Jewel outyielded the two stocks of lower grade of these varieties, but the 'standard' stock of Malling Promise cropped slightly better than the virus-free and 'special stock-cane' stocks. The performance of Lloyd George in both these plantings was severely restricted by death of the fruiting canes.

Cane death in the 1952 raspberry trial was mostly confined to Lloyd George. The varieties Malling Jewel, Malling Exploit and Malling Promise maintained their past high levels of yield with $4\frac{3}{4}$, 4 and $3\frac{3}{4}$ tons per acre respectively, whilst Norfolk Giant cropped at 4 tons and Lloyd George and Malling Enterprise each at nearly $3\frac{1}{2}$ tons. Only in Malling Jewel and Malling Enterprise were the yields higher in the sub-plots receiving the higher level of nitrogen.

In the 1962 trial of cold-stored runners of Redgauntlet strawberry, the April-planted plots gave the highest yield in 1963. The yields from the plantings made in April, May and July 1962 were equal to 8·7, 6·1 and 2·9 tons per acre respectively. The July-planted plots were the earliest to ripen and the April-planted plots the latest, the largest difference between their picking times (6 days) occurring at the beginning of the season. The largest berries were obtained from the July-planted plots, but the wastage on these plots was twice that on the April-planted plots. This experiment was repeated at all four trial centres (see 1962 - 63 Report) in 1963, when the planting dates at Mylnefield were 11 April, 28 May and 2 July. The first-year yields from the two earlier plantings did not exceed 1 oz. per plant, and the July-planted runners yielded less than $\frac{1}{2}$ oz. per plant.

Flowering and ripening dates in the 1954 trial of bush plums were among the latest on record. In comparison with 1961, an early season, flowering on both rootstocks began five weeks later and the fruit ripened on average about three weeks later. Thirty varieties fruited on Common Plum rootstock and 22 on Myrobalan B, but except for Thames Cross and Denniston's Superb on Common Plum and Cox's Emperor and Thames Cross on Myrobalan B, yields were low. The fruit of Thames Cross was of good size and appearance but was damaged by frost in October. Denniston's Superb and Cox's Emperor, however, and also the earlier varieties Early Rivers and Black Prince, were of good quality despite the adverse season. (M. M. Anderson.)

PUBLICATIONS

Research Papers

JENNINGS, D. L. (1964). Some evidence of population differentiation in *Rubus idaeus* L. *New Phytol.*, **63**, 153-7.

(Plants of *Rubus idaeus* were collected from habitats of contrasting altitudes in Scotland and grown at Invergowrie. Subsequent observations suggested the presence of population differentiation in respect of plant height and time of bud-burst, plants from more exposed situations being later to start growth in the spring and producing shorter canes with shorter internodes. The results are discussed in relation to the breeding system and physiological responses of the plants.)

JENNINGS, D. L. (1964). Studies on the inheritance in the red raspberry of immunities from three nematode-borne viruses. *Genetica*, **34**, 152-64.

(The inheritance of immunities to the viruses raspberry ringspot, arabis mosaic and tomato black ring was studied by means of graft tests on families of raspberry seedlings. Immunity from each virus was found to be dominant to susceptibility, but there was evidence that at least two genes were involved in each case. It was not possible to decide whether the second gene was a dominant complementary or a linked recessive affecting the viability of the immune segregates, but the latter explanation was thought to be the more probable. There was also evidence

of linkage between the genes for the three immunities. The experiment confirmed the practicability of breeding to incorporate genes for immunities from these three viruses into new raspberry varieties.)

JENNINGS, D. L. (1964). Two further experiments on flower-bud initiation and cane dormancy in the red raspberry (var. ' Malling Jewel '). *Hort. Res.*, **4**, 14-21.
(In one experiment, maintenance of fully grown canes of the raspberry variety Malling Jewel for six weeks at 45°F. and with a 9 hr. daylength resulted in the initiation of flower buds without the onset of dormancy. In the other experiment, treatment of dormant canes of the same variety for 30 hrs. with ethylene chlorhydrin vapour resulted in loss of their dormancy. Both of these alternative treatments were considered to be superior to some known methods of producing out-of-season fruits for experimental purposes.)

JENNINGS, D. L., ANDERSON, M. M., and WOOD, C. A. (1964). Observations on a severe occurrence of raspberry cane death in Scotland. *Hort. Res.*, **4**. (In press.)
(Observations on the incidence of cane death in raspberry experiments in 1962 are reported. Varieties differed considerably in the amount of damage which they suffered, and observations in cultural trials indicated that the damage was usually greatest where plants were given a wide spacing or where high rates of manuring were used. The manures which had the most influence were ammonium sulphate and farmyard manure. It is suggested that wide spacing and the use of the organic manure produced these effects because they augmented the plants' water supply. Some possible implications of the observations for cultural practice and plant breeding policy are discussed.)

JENNINGS, D. L., and TULLOCH, B. M. M. Studies on factors which promote germination of raspberry seeds. *J. Exp. Bot.* (In press.)
(Germination of raspberry seeds was favoured by applying certain combinations of chemical pretreatment prior to giving up to 6 wk. of moist-chilling before sowing, by adding 500 p.p.m. gibberellic acid immediately before sowing, and by providing supplementary light after sowing. These treatments were all effective individually and their benefits were additive when they were applied in combination. Of the chemical pretreatments, treatment for 20 min. with concentrated sulphuric acid followed by 6 days of treatment with 1·0 per cent. calcium hypochlorite containing an excess of calcium hydroxide was particularly successful, eliminating in some seed samples the need for a subsequent period of moist-chilling. Pretreatment with higher concentrations than 1·0 per cent. of calcium hypochlorite, 0·5 per cent. of sodium hypochlorite or 1·0 per cent. of thiourea, combined with calcium hydroxide, or pretreatment with these chemicals at the concentrations stated but in each case without the addition of calcium hydroxide, frequently delayed or prevented germination. The results are discussed in relation to an hypothesis that the germination capacity of raspberry seeds is determined by interactions between growth inhibitors and promoters.)

OTHER PUBLICATIONS

JENNINGS, D. L. (1963). Breeding new kinds of raspberry. *The Scotsman.* (11 November.)

WOOD, C. A. (1964). The Raspberry Industry of Scotland. *American Fruitgrower.* (March.)

VEGETABLE CROPS

C. NORTH

In a field experiment carried out jointly with the Virology Department it was shown that carrot varieties differ considerably in their susceptibility to motley dwarf, a virus disease which caused widespread damage in Scotland in 1961. This information has given an important lead to the carrot breeding programme, in which an attempt will now be made to develop varieties resistant to or tolerant of the disease.

A second item of special interest is the result of the brussels sprout variety trial in which F_1 hybrids bred at Mylnefield were compared with standard varieties. One of the Mylnefield hybrids gave promising results, and seed of it will be produced for tests on a more extensive scale in 1965.

Miss Priestley was awarded a travel bursary by the Women's Farm and Garden Association, with the aid of which she visited ten government and commercial establishments in Holland to discuss the breeding of French beans. Mr. Gledhill spent a week at the Institute of Horticultural Plant Breeding (I.V.T.) at Wageningen, Holland, to study the work there on carrots. His visit was supported by a grant from the Agricultural Research Council.

Mrs. M. J. Taylor resigned in December after five years' work in the Department. Three new Scientific Assistants, Miss S. C. Fergusson, Miss I. Duncan and Mr. C. D. Mason, were appointed.

FRENCH BEANS

New Varieties Bred at Mylnefield

The two unnamed varieties mentioned in previous Reports again gave good results both at Mylnefield and at the National Institute of Agricultural Botany's trial grounds at Cambridge. They will now be registered, and at least one will be released within the next few years. Both are very early-maturing snap-pod types with a growth habit suited to mechanical harvesting. One has fairly dark-green pods of the type acceptable for quick-freezing and for dehydration, whilst the other, with paler-green pods, is probably suitable for canning.

Seed crops of these two varieties were grown at Mylnefield. However, the 1963 season was the worst for French beans since the breeding programme was started here, and multiplication was barely five-fold. The crop had to be harvested while the pods were still green, but after careful post-harvest treatment the resultant seed showed a germination of 93 per cent. Most of this seed was sent to the United States to undergo the next stage of multiplication under more favourable climatic conditions, and it is hoped that there will be moderate quantities available for trial more extensively in 1965.

Other French Bean Crosses

Because of poor growing conditions during the summer, only a few of the 200 single-plant progenies tested were sufficiently mature by the end of August for further plant selections to be made. These selections were chosen mainly from (i) the F_4 generation of Record x Slavia, (ii) material derived from crosses between Record, Early Blue Lake and Prelude, and (iii) the F_2 generation from crosses between the two unnamed Mylnefield varieties. Despite the poor season, each of these populations produced some early-maturing plants, and a further 160 single-plant selections were made in addition to bulked selections.

Resistance to Anthracnose

A programme of breeding for resistance to anthracnose disease was started in 1962, using the variety Cornell 49-242 as a source of resistance (see 1962-63 Report). Cultures of the four pathogenic races (alpha, beta, gamma and delta) of the casual organism, *Colletotrichum lindemuthianum*, were supplied by the Instituut voor Plantenziektenkunding Onderzoek, Holland. The four races were cultured separately and spores from each were mixed to form a single inoculum. Inoculations of the seedlings were made in co-operation with the Mycology Department.

The particular stock of Cornell 49-242 originally used at Mylnefield was segregating for resistance, and only 5 out of the 46 F_1 seedlings obtained by crossing it with other varieties were completely resistant to all four strains of anthracnose. The resistant F_1 plants were backcrossed to the non-resistant parents, and the resultant seedlings will be screened for resistance in 1964.

A stock of Cornell 49-242 which is breeding true for resistance to all four strains of anthracnose has been selected for further crosses.

Breeding with Phaseolus coccineus

The segregating F_2 generation from the cross made in 1962 between Hammond's Dwarf Scarlet and a white-flowered selection from the variety Tschermak Multigaris was grown in the field. The potential red-flowered plants were eliminated by removing the seedlings which had anthocyanin-coloured hypocotyls, and later all climbing plants were destroyed. Seed was saved individually from the remaining 145 white-flowered dwarf plants left from the 1,653 seedlings raised.

The F_1 generation from the cross made in 1962 between Hammond's Dwarf Scarlet and *Phaseolus coccineus* var. *albonanus* Bailey was grown in the field and produced plants which all had an indeterminate habit and scarlet flowers. Seed was saved in bulk.

A large F_2 generation from the cross made in 1961 between Czar and a white-flowered selection of Tschermak Multigaris was direct-sown in the field, but the plants matured too late to produce ripe seed. (W. G. Priestley, M. J. Taylor.)

BRUSSELS SPROUTS

Cultural Experiments

For the third successive year the topping of spring-sown plants of the variety Irish Elegance led to an increase in yield of marketable sprouts of

between 15 and 25 per cent. These results suggest that topping in early September should be more widely adopted in Scotland.

In another experiment a comparison was made between direct-sown and transplanted plants of two varieties. Some plants were raised *in situ* by sowing the seed on 28 March and singling the seedlings to stand 2½ ft. × 2½ ft. apart, while others were established by sowing in a seedbed on the same date and transplanting later (28 May) to the same spacing. Direct-sown plants of Cambridge Special and Irish Elegance gave increases in yield of 33 and 62 per cent. respectively over transplanted plants. The plants grown *in situ* were taller and had larger, paler sprouts than the transplanted ones. Sprout firmness and the percentages of brown sprouts were unaffected by the treatments. (C. North, H. Taylor.)

Variety Trial

A trial series was introduced to compare new varieties and promising Mylnefield-bred stocks with the two popular commercial varieties Cambridge Special and Irish Elegance. The new varieties included Sherrardian and the F_1 hybrid varieties Jade Cross, Thor and 62251. There were six Mylnefield stocks in the trial.

The F_1 hybrid varieties Thor (from the Institute of Horticultural Plant Breeding in Holland), 62251 (from the National Vegetable Research Station) and Mylnefield No. 9 gave the best yields of marketable sprouts. Both Thor and 62251 were tall-growing and produced medium- to large-sized sprouts, but Thor was rather the more susceptible of the two to frost and also gave the paler-coloured sprouts. Mylnefield No. 9 is of medium height, with very straight stems bearing small- to medium-sized sprouts. It somewhat resembles Jade Cross and seems to be of a type suitable for quick-freezing or dehydration. At Mylnefield it produced fewer 'blowers' than Jade Cross and was much easier to pick. Seed of this variety will be produced for testing on a more extensive scale in 1965. It was derived by crossing two partially self-incompatible lines but does not carry the 'glossy foliage' gene for the detection of inbreds.

The new conventional variety Sherrardian yielded at least as well in this trial as either Cambridge Special or Irish Elegance and gave darker-green sprouts than these varieties. (C. North, H. Taylor.)

White Blister Rust

White Blister Rust (*Albugo candida* (Hook.) O. Kuntze) appeared in the breeding material and spread to other parts of the trial ground. It attacked both glossy-leaved and normal plants, though it was more prevalent on the former. In co-operation with the Mycology Department a trial was carried out to test various fungicidal sprays against this disease, but the assessment of any control obtained was prevented by the natural decline in symptoms which occurred during the autumn months. (W. G. Priestley, D. A. Perry.)

Breeding Parent Lines for F_1 Hybrids

Work on the development of suitable inbred lines for the production of F_1 hybrids was continued. Twenty normal 'waxy' lines were grown, and

some of these which produced exceptionally dark-green sprouts were selected for further breeding work. Progress was also made in the improvement of 'glossy' parent lines. A wide range of F_1 hybrids between 'glossy' and good inbred normal types were self-pollinated, and when the segregating F_2 generations are grown in 1964 only the 'glossy' seedlings will be planted for field selection.

Work on the incorporation of the dominant 'white petal' character into 'glossy' parent lines was also continued. The glossy seedlings alone from a segregating F_2 population were grown-on to flower in 1963, and 104 of them were white-flowered, 31 yellow-flowered and 25 without flowers. Some of the white-flowered plants were self-pollinated to isolate the homozygous white-flowered material. So far, this work has involved plants grown as annuals, and a mixture of forms of *Brassica oleracea* has been used. Several generations of backcrossing will now be required to develop good brussels sprout parent types breeding true for white-flower and glossy-foliage.

Plants from some of the more promising parent lines were screened for their capacity to produce shoots from root cuttings. Clones were built up from the plants which were most readily propagated by this technique. (W. G. Priestley, M. J. Taylor.)

Production of F_1 Hybrids

From a range of test-crosses made by hand in 1961, one particular 'glossy' x normal 'waxy' combination gave progeny which seemed specially promising. This hybrid was uniform and productive, with sprouts of good quality. In 1963 the same cross was repeated on a slightly larger scale, using inbred progeny from each of the original parent plants as the new parent lines and honey-bees as pollinators. This material, the first 'glossy' x 'normal' hybrid produced in this way, will be tested against standard varieties in 1964. (W. G. Priestley, M. J. Taylor.)

It was unknown whether an F_1 hybrid between white- and yellow-flowered parent lines could be produced in the field, because it had been suggested that insect pollinators might only visit flowers of one colour and thus fail to cross-pollinate between the two lines. To study the behaviour of honey-bees —the most numerous pollinators of this crop—four each of yellow-flowered and white-flowered plants were placed in an insect-proof compartment containing a small hive of bees. During a relatively short time the behaviour of individual bees on twelve foraging flights was carefully observed. On each of these flights the individual insects visited both white and yellow flowers, changing from white to yellow or vice versa on the average at every 4-5 flower-visits. They visited yellow flowers more frequently than white but stayed longer on the latter. These observations suggest that it may well be possible to produce F_1 hybrids between white- and yellow-flowered parent lines by utilizing honey-bees as pollinators. (C. North.)

Genetic Markers

In addition to work with the 'glossy' and 'white petal' characters, the inheritance of other possible genetic markers was examined.

During the 1960/61 season, a flower abnormality in brussels sprout was observed in an inbred line, the petals failing to unfold normally and remain-

ing creased or folded transversely across the centre. This abnormality could be observed in the flower-bud, which had a characteristically inflated appearance. The condition—designated 'crinkly petal'—was shown to be inherited as a simple recessive character.

A variety of collard (*Brassica oleracea* L. var. *acephala* D.C.) obtained from the U.S.A. was grown in 1961 for observation of its glossy-leaf character, which is phenotypically similar to that of the 'glossy' brussels sprout selected from the variety The Cluseed. Seedlings raised from test-crosses made at Mylnefield in 1962 showed that the 'glossy' condition in this collard is inherited as an incomplete dominant, whereas the 'glossy' form of The Cluseed is fully recessive. It is highly probable that 'glossy' in collard and the similar phenotypic condition in The Cluseed are caused by different genes. Test-crosses with two glossy-leaved plants of the brussels sprout variety Irish Elegance found in 1962 strongly suggest that the glossy condition of these is also inherited differently from that of The Cluseed. (W. G. Priestley, M. J. Taylor.)

CABBAGE

The F_4 generation material from the crosses January King x Slow Bolting I.M.2 and Christmas Drumhead x Blåtopp was very uniform and may provide useful autumn-maturing varieties. The most promising lines were maintained by sib-crossing selected plants.

Some material derived by inbreeding plants obtained originally from a cross between January King and Ormskirk Savoy had such a high degree of sib-incompatibility that it did not readily produce seed. It was decided, therefore, to see whether it could be used as a parent for an F_1 hybrid variety. Sixty plants of a stock of this material were grown with twenty of a late-maturing inbred line of the Danish Keeping type in an insect-proof compartment, with honey-bees as pollinators. The self-incompatible line gave a good crop of seed which will be examined in 1964 as a possible F_1 hybrid variety.

After transference of the 'white petal' character from winter cauliflower to cabbage by four backcross generations, the material, previously grown on an annual basis, was tested in the field. Some of the lines produced a high proportion of cabbage heads, and selection for a cabbage type which is homozygous for white flower colour has now begun. (W. G. Priestley, M. J. Taylor.)

Weed Control

Desmetryne was applied in a screening trial to a total of 32 varieties of cabbage, brussels sprout, kale, cauliflower, swede and turnip to assess its action on these crops. Applications at rates of 0·125, 0·25, 0·5, 1·0 and 2·0 lb. per acre were made before, at, and after the suggested stage of growth. The growth of many varieties was severely checked by early treatment or by dosages exceeding 0·5 lb. Another trial was conducted in the autumn with a smaller number of varieties and using plants raised from seed in boxes under glass. Both trials indicated that cauliflower, turnip and swede are more susceptible to desmetryne than cabbage, brussels sprout or kale.

Past trials at Mylnefield had shown 2,6-dichlorothiobenzamide to be a promising herbicide for weed control in transplanted summer cabbage. In a screening trial in 1963, granules of this material at rates of 1·0, 2·0, 4·0, 6·0 and 8·0 lb. per acre of active ingredient were lightly mixed into the ground by rotary cultivation before transplanting into the site five varieties each of cabbage, brussels sprout and cauliflower. At rates exceeding 1·0 lb. all the varieties were damaged, but 1·0 lb. proved insufficient for complete weed control and the plots were soon overgrown with fumitory. Other annual weeds were well controlled. In yield trials of cabbage and brussels sprout, 2,6-dichlorothiobenzamide granules, used in the same way as in the screening trial but at rates of 4·0 and 6·0 lb. only, provided good control of annual weeds but again damaged the crops. This compound now appears to show less selectivity between transplanted *Brassica* crops and annual weeds than the earlier work suggested. (R. J. Stephens, D. W. L. Scott, M. McK. K. Willock.)

CARROTS

Optimum Sowing Rate

The series of experiments to determine the optimum sowing rates for producing carrots of canning size ($\frac{3}{4}$ - $1\frac{1}{2}$ in. diameter) was concluded, and the results will be published in due course. The optimum rate in 1963 for sowing and harvesting at the usual times (i.e., sowing from April to early May and lifting after the end of October) was approximately 12 lb. per acre of seedbed. When sowing was delayed until the end of May and the crop harvested in early September, sowing at 9 lb. per acre of seedbed gave the highest yield. Delaying sowing until mid-May resulted in a reduction in total yield of 15-30 per cent., and a similar reduction occurred when the crop was sown at the usual time but harvested in mid-September. The optimum sowing rates given here refer only to crops sown in 6 in. rows, such as are used for the 'bed system', and do not necessarily apply when a wider spacing is used, as when crops are grown on 'ridges'.

Topping

Another experiment was conducted to assess the effectiveness of defoliation as a means of preventing roots from growing too large for canning. The results confirmed those of previous experiments in showing that removal of the tops one month before harvesting prevented further root growth without affecting root quality. In practice, however, defoliation is only likely to prevent the reduction in yield of canning-size carrots if the crop has been sown at abnormally low rates or if the germination or seedling establishment has been poor. At the sowing rates recommended above (9-12 lb. per acre of seedbed) the variation in root size is so great that when growth is allowed to continue, those roots which become too large are replaced by others which were previously too small, so that the yield of canning-size roots remains relatively constant.

Comparison between the 'Ridge' and 'Bed' Sowing Systems

There are two main systems used in Scotland for the production of carrots for processing. The typical 'ridge' system consists of double rows

6 or 8 in. apart and at 28 in. centres, with the seed drilled on ridges. The 'bed' system is a more recent innovation, although it has been used in Scotland since at least as far back as 1953. The beds consist usually of six rows 6 in. apart, at 56 in. centres.

A field scale experiment of about 1¼ acres was carried out to compare three possible sowing systems, namely (i) 'ridges', (ii) 'beds' sown on two levelled-down potato ridges (a common method of preparation) and (iii) 'beds' sown on the flat. Three sowing rates (corresponding to 6-8 lb. per complete acre, i.e., 9 - 12 lb. per acre of seedbed) were used for each of these treatments.

None of the differences in total yield recorded between the three sowing systems or between the three sowing rates were statistically significant, but there was a 5-10 per cent. greater weight of canning-size roots from the 'beds' than from the 'ridges'. Beds sown on the flat gave as good results as those prepared from potato ridges. The sowing rate equivalent to 12 lb. per acre of seedbed gave about 20 per cent. more canning carrots than the rate equivalent to 9 lb.

Causes of Variation in Individual Root Size

The variation in individual plant weight within a crop of carrots is higher than in most other crops. By sowing and thinning to various square spacings it was found that the coefficient of variation increased as plant densities fell below or rose above about one per square foot. This variation can be attributed to inter-plant competition at the higher densities and possibly to the lack of inter-plant protection at the lower densities.

Seedlings emerging relatively late in a population have a much reduced average weight, and it was thought that date of emergence might be closely related to 'seed' size. Size-graded seed was sown therefore, and it was found that the smallest seed gave only 30 per cent. establishment compared with more than 50 per cent. with the larger seeds.

Breeding

The breeding programme suffered a serious setback when all the initial breeding material was lost through frost damage, occasioned by a fault in the glasshouse heating system during the winter of 1962/63.

Several lines from controlled pollinations made in 1962 were grown in the field. Some of the selfed lines gave much reduced yields, indicative of inbreeding depression, whereas others showed very little reduction in vigour. (H. J. V. Gledhill.)

Weed Control

Two replicated field trials of carrots (var. Chantenay Red Cored), one on a medium loam and the other on a light blowing sand, were again carried out to evaluate a number of herbicides (see 1962 - 63 Report, p. 38). Chlorpropham, prometryne and linuron were each applied at 2·0 lb. per acre immediately after drilling, and prometryne and linuron (each at 1·0 and 2·0 lb. per acre) and an approved mineral oil (at 80 gal. per acre) were supplied to other plots some five weeks later. Ten weeks after drilling, further

applications of linuron and prometryne at half the original rates were made to the plots previously treated with these materials. There was some evidence that the prometryne and linuron applied five weeks after drilling reduced the yield of the crop. The highest yields were from the plots treated with chlorpropham and mineral oil, and these two materials and the pre-emergence applications of linuron and prometryne provided the best weed control. (R. J. Stephens, D. W. L. Scott, M. McK. K. Willock, H. Taylor.)

Motley Dwarf Disease

To investigate whether it might be possible to breed carrot varieties resistant to or tolerant of motley dwarf virus disease, twelve varieties were compared in the field for their reaction to the disease. Aphids (*Cavariella aegopodii*) previously fed on infected plants were used to transmit the disease to carrot plants in the trial. Non-colonized control plots were sprayed periodically with demeton-methyl to reduce the risk of natural infection.

The results clearly demonstrated varietal differences in susceptibility. By the time the crop was lifted in November, the disease had caused a reduction of between 10 and 50 per cent. in the yield of roots. In general, the varieties Flakee and Autumn King were less susceptible than Chantenay types, but there was considerable variation between different stocks of Chantenay. There was a well-defined correlation between foliage symptoms, as assessed subjectively by leaf coloration, and the percentage reduction in root yield. No correlation was found between the vigour of the top, as measured by its height, and varietal susceptibility. (H. J. V. Gledhill, A. F. Murant.)

CELERY

For the second year in succession, a trial of celery was conducted to discover if any varieties could be grown in this area without 'earthing-up' and be acceptable for canning as 'celery hearts'. Six of the most promising varieties from a trial of sixteen grown in 1962 were included in a replicated yield trial in 1963. Plants raised from seed sown in a glasshouse on 25 March were transplanted to open ground, 12 in. × 12 in. apart, on 24 May. The crop was harvested on 16 September.

Slow Bolting Green, which has long, rather dark-green petioles, gave a significantly higher yield than any of the other varieties. Cluseed Lathom Blanching, another green-stalked variety, also yielded well; its petioles were shorter and paler-coloured than those of Slow Bolting Green. The white and golden self-blanching types gave considerably lower yields than these two varieties and, except for Cluseed New Dwarf White, had distinctly stringy petioles.

Canning tests indicated that all the varieties grown in the trial might be acceptable for canning as celery hearts. Further tests will be made in 1964, and the yield trial will be extended in co-operation with the National Institute of Agricultural Botany to include new stocks from the National Vegetable Research Station and some other early-maturing varieties.

ONION

Sixteen onion varieties were compared *inter se* and with four varieties of shallot. One of the onion varieties was grown from sets and the others from

seed sown at three different rates (1 oz. per 200, 600 and 1,800 ft. of row). Seed was sown outside on 2 April and the seedlings were not singled. The shallots were planted 12 in. apart and onion sets 1, 2 and 4 in. apart. Weeds were controlled with paraquat and sulphuric acid, used as pre- and post-emergence herbicides respectively.

Onion sets of the variety Stuttgarter Riesen gave the highest yields, but some varieties of the seed-raised onions were nearly as productive. The best shallots gave yields which were almost as high as some of the most productive onions, but they produced much smaller bulbs. The one stock of shallots which was raised from seed gave very low yields.

Of the seed-raised onions the F_1 hybrid variety Early Harvest gave the highest yields of marketable bulbs, but these did not store well. The F_1 hybrid Premier gave high yields of bulbs which stored fairly well in comparison with others. Some conventional varieties which were fairly productive and stored relatively well were Up to Date, A 1, Leicester Globe, Maincrop and Rousham Park Hero. Of the shallots, Exhibition gave the best yield and Aristocrat ripened very early but gave a very small yield.

The heaviest crops of marketable-sized onions were obtained from the 1 oz. per 200 ft. rate of sowing, and the best crops of bulbs above 2 in. diameter from sowings of 1 oz. per 200 - 600 ft. of row.

None of the stocks of bulbs—not even the shallots or the onions grown from sets—kept well without post-harvest treatments. Bulbs of all varieties stored better when dried artificially in a current of warm air (approx. 30°C.) shortly after lifting. For example, the five conventional varieties when dried in this way lost only 30-35 per cent. in weight during storage from mid-September to mid-January, compared with the complete loss by rotting which occurred in most varieties when the bulbs had not been dried artificially.

SWEET CORN

Eleven varieties of sweet corn were compared in a replicated trial. Seed was sown in a glasshouse on 1 May and the seedlings were transplanted outdoors on 27 May. The plants were watered with a dieldrin suspension at transplanting time as a precaution against frit fly.

In spite of the exceptionally cold summer weather conditions some varieties produced quite good crops of ears, mostly of fairly good quality. Spring Gold was the most productive and gave ears of good quality, 5 in. long and with 14 rows of corn. Prima ripened earliest and gave a fair quantity of ears with 12 rows of corn. Spancross matured slightly later than the above two varieties but might be expected to give as good results as Spring Gold in an average summer.

LEEK

Twenty-five varieties were compared in yield trials at Mylnefield and at two centres in Lanarkshire. A similar trial of the same varieties was also conducted at Stockbridge House, the N.A.A.S. Experimental Horticulture Station at Cawood, Yorkshire. At one of the Lanarkshire centres the crop was grown as early leeks for harvesting in November, whilst at all other centres the crops were overwintered and spring harvested. The varieties

Winterreuzen and Siegfried gave consistently high yields in all the trials, both as early leeks and when overwintered. At Cawood the varieties Westland, Giant Dark Selection, Monument and Musselburgh also gave high yields. In the Lanarkshire trial harvested in November, Cullen's Giant and a stock of Walton Mammoth were the most productive. In all the trials Monument had the darkest-coloured foliage. This series of leek variety trials will be concluded in spring 1964.

RHUBARB

The rhubarb variety trial planted in 1961 is now in its second cropping season. As in 1962, Timperley Early was by far the earliest of the twelve varieties tested, but its 'stalks' had an unattractive green colour and tended to be more acid than those of others. Prince Albert gave the best yield and its stalks were attractive when bunched. The maincrop varieties The Sutton, Ruby, Valentine and Victoria also gave high yields, and the first two had stalks of good appearance.

JERUSALEM ARTICHOKE

Eleven clones of Jerusalem Artichoke were compared in a replicated yield trial. The most productive varieties, Bianke and Dayneutral—which appear to be synonymous—produced crops equivalent to 14 tons of tubers per acre, as compared with a yield of about 6½ tons from the Common Artichoke. However, both these varieties produced large conglomerations of branched tubers which were difficult to clean. Tubers of the variety Spindel—which also gave a fair yield—were mostly unbranched, relatively smooth, and easily cleaned. The variety Fuseau, often grown in market gardens around London because it has tubers relatively free from knobbles, was no better than Spindel in this respect and gave a much lower yield. (H. Taylor.)

PUBLICATIONS

Research Papers

Gledhill, H. J. V. (1963). A small grading machine for carrots. *Hort. Res.*, **3**, 62-63. (A small size-grading machine is described for use in experimental work. It is based on the principle of two moving, diverging V-belts, giving a gap of gradually increasing size between them, through which the produce falls.)

North, C., Taylor, H., and Frith, L. H. Some cultural techniques used with brussels sprouts. *Exp. Hort.* (In press.)

[Seedlings of bolting-resistant varieties raised outside in late summer and overwintered in the seedbed gave 1½ - 4 times the yield of marketable sprouts produced by seedlings of the same varieties raised in the open during the spring and transplanted. Seedlings transplanted into firm soil gave neither higher yields of marketable sprouts nor sprouts of better quality than seedlings transplanted into loose soil. Top-dressings of 2 or 6 cwt. of nitrate of lime (21 per cent. N), per acre gave improvements in the yield of marketable sprouts compared with controls receiving no top-dressing. Applications exceeding 6 cwt. per acre gave no further increase in yield. The percentage of 'blown' sprouts increased, and the firmness of marketable sprouts decreased, with increasing amounts of nitrogenous top-dressing, but these deleterious effects were less apparent in Irish Elegance than in Cambridge Special.]

TAYLOR, H., FRITH, L. H., and NORTH, C. (1964). Variety trials of vegetables in Scotland. XI. Leeks, 1958-1960. *Hort. Res.*, **3**, 107-14.

(Twenty-three strains of leek were tested at various centres in Scotland during 1958, 1959 and 1960. Strains of the popular Scottish variety Musselburgh gave high yields and were hardy, but their appearance was not as good as that of some other varieties. Cullen's Giant, Acquisition and Elefant were usually more productive than Musselburgh but of no better appearance. The varieties which combined good appearance with high productivity were Skt. Jørgen and Titan Original for autumn harvesting and Erda and Winterreuzen for overwintering.)

OTHER PUBLICATIONS

NORTH, C. (1963). Unusual vegetables. *The Scotsman*. (31 August.)

PHYSIOLOGY

C. G. GUTTRIDGE

The main interest of the Department continued to be the physiology of the growth and development of the strawberry plant and its fruit.

In field trials with strawberry, the growth retardant chemical Cycocel or CCC failed to suppress runner formation at levels of application which were effective in the glasshouse. Further trials are planned and another chemical, B-995, is being tested. Several years of experiments with post-harvest defoliation suggest that in this area the variety Cambridge Favourite is much less likely to suffer from deficiencies in numbers of flower trusses than Redgauntlet or Talisman, and is thus less likely to benefit from mowing-off. No real success has yet been achieved with chemical defoliants.

A study of strawberry runners cold-stored for us at Rosewarne Experimental Horticulture Station, Cornwall, indicated that 30°F. was a much better storage temperature than either 28°F. or 32°F. An investigation of the deterioration of plants during storage has been started jointly with the Mycology Department.

We have been very pleased to welcome Professor R. G. Hill, Jr., of the Department of Horticulture, Ohio State University, U.S.A., who came in July to spend a sabbatical year working in this department. Professor Hill has been working mainly with Mr. Thompson on the bio-assay of gibberellins, but has also studied some aspects of strawberry developmental physiology in the growth cabinets. He has shown that in the variety Cambridge Favourite the inhibitory effects of long daylengths on flower initiation are transmissible from plant to plant along the stolon.

Early in the year Mr. W. Scott Stewart was appointed as a Scientific Assistant to help with the field work. Mrs. Ruth N. Smith resigned during the year after five years in the Department as Scientific Assistant. Her place was taken by Mr. Harry Anderson.

PHYSIOLOGICAL INVESTIGATIONS ON THE STRAWBERRY

Effects of Environment and Gibberellins on Development of the Flower-Truss and Fruit

In an experiment designed to investigate the effect of photoperiod and gibberellic acid on flower truss development, plants of the variety Redgauntlet were grown in inductive daylengths for three weeks and then transferred to daylengths of either 8, 12, 18 or 24 hours for four weeks until just before the emergence of the flower trusses, when they were moved to a glasshouse to flower. During the post-inductive daylength treatments half the plants in each environment were treated with weekly sprays of gibberellic acid at 5 p.p.m. The time of anthesis of the primary flower varied with daylength, flowers opening approximately a week earlier on the plants which had been growing in daylengths of 18 to 24 hours. Contrary to results obtained earlier, gibberellic acid had no effect on the time of anthesis,

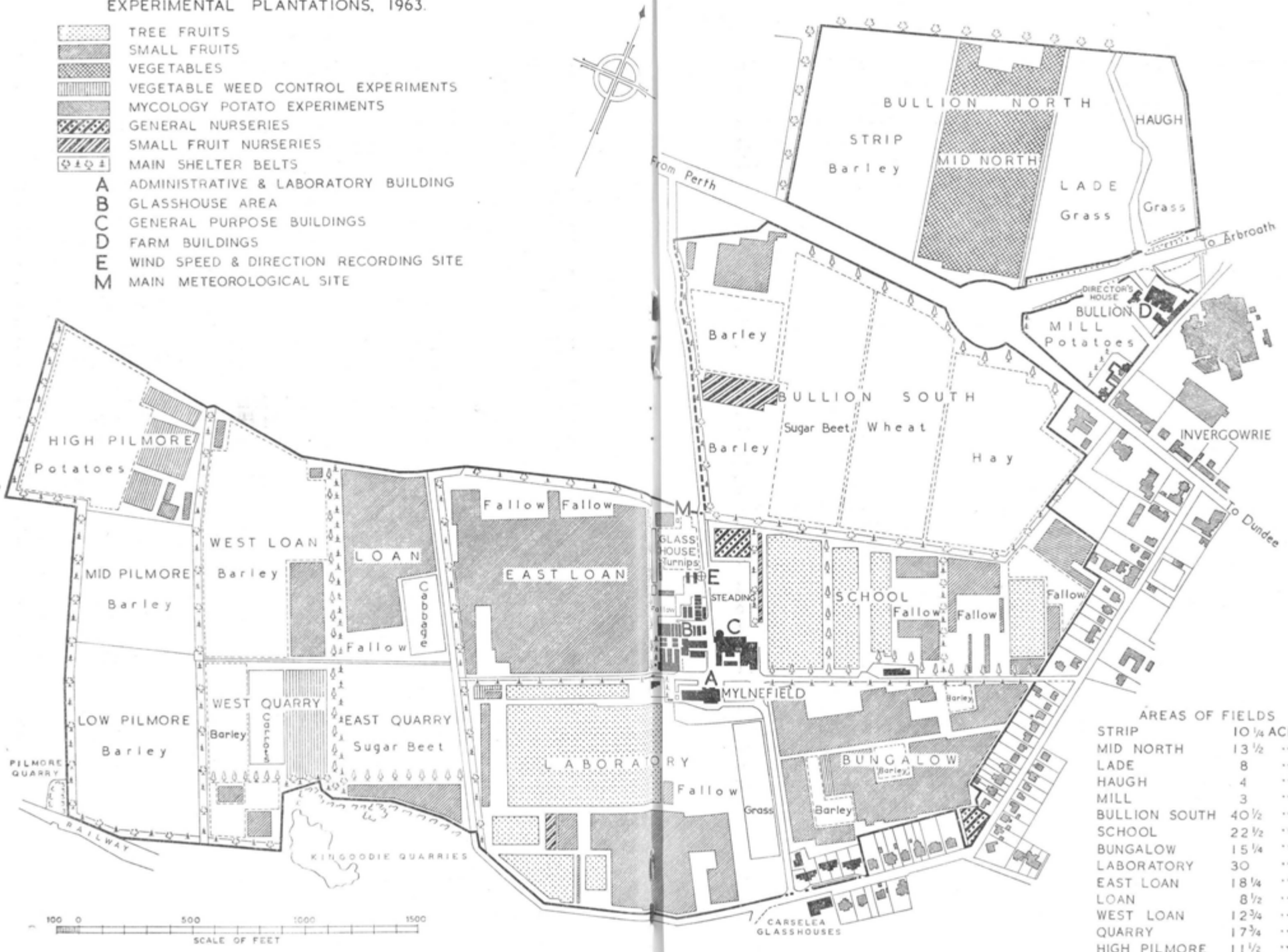
but this may have been due to the relatively low concentration used. Pollen production was slightly better in long days than in short, and in the short-day treatments anther development was better and pollen more freely produced when gibberellic acid was applied. Long days and treatment with gibberellic acid both promoted extension of the flower truss.

Redgauntlet was also used in a growth cabinet experiment to examine the effects of temperature and photoperiod on pollination and subsequent fruit development, and the results showed that these factors had a considerable influence on the final size of the fruit and on its period of development. Low temperature (10°C.) reduced pollen formation, and even when treated plants were pollinated with good pollen from field-grown plants the percentage of fertilizations was reduced: at low temperature there was also evidence of an increase in the frequency of embryo abortion during development. The period of development was increased at low temperature, fruits taking about twelve weeks to ripen at 10°C. compared with five weeks at 15°C. Fruit size, on the other hand, varied inversely with temperature, and, unless very poorly pollinated, the fruits grown at low temperature greatly exceeded in size those grown at high. This large size may have been due to the greater total quantity of incident light energy received by the plants at the lower temperature during the long developmental period of the fruits.

Daylength had very much less effect on fruit development, and most of the effects obtained were probably due to differences in the quantity of light received rather than to differences in photoperiod *per se*. However, daylength did affect the duration of development, which, in well-pollinated fruits, was shorter in long daylengths by about four days at 15°C. and by about 14 days at 10°C., as compared with short days. Moreover, the rather low quantity of total light energy received by the plants in short days had a deleterious effect on anther development, and, unless pollinated with good pollen obtained from outdoors, flowers developing in these conditions set badly and produced misshapen fruits. A combination of low temperature and short photoperiod decreased fruit-set still further. (P. A. Thompson.)

Growth Retardant Chemicals

Further trials on runner suppression were carried out on strawberry plants in pots in the glasshouse, using (2-chloroethyl) trimethylammonium chloride (Cycocel or CCC) and proprietary compounds known as B-995, ACP-61-265 and Phosfon-S. CCC again depressed top growth, shortening petioles and runners and, in high concentrations, entirely inhibiting the elongation of runners. B-995 was applied once by spray at concentrations of 10 per cent. and 2 per cent. At the higher rate, runner elongation was suppressed and petioles reduced substantially in length with little reduction in the rate of leaf emergence. Flower formation was not induced. This chemical thus caused a type of growth suppression similar to that produced by CCC. Phosfon-S was applied at rates of 0·2 per cent. and 0·05 per cent. in single applications, and no appreciable effect was observed. It may be active at higher rates of application. ACP-61-265 acted as a general inhibitor of growth rather than by specifically suppressing elongation of runner and petiole tissues as did CCC and B-995. Applied once as a 4 per cent. spray,



AREAS OF FIELDS

STRIP	10 ¼ ACRES
MID NORTH	13 ½ "
LADE	8 "
HAUGH	4 "
MILL	3 "
BULLION SOUTH	40 ½ "
SCHOOL	22 ½ "
BUNGALOW	15 ¼ "
LABORATORY	30 "
EAST LOAN	18 ¼ "
LOAN	8 ½ "
WEST LOAN	12 ¾ "
QUARRY	17 ¾ "
HIGH PILMORE	11 ½ "
MID PILMORE	7 "
LOW PILMORE	10 ¾ "

SCOTTISH HORTICULTURAL RESEARCH INSTITUTE
MYLNEFIELD AND BULLION
INVERGOWRIE

DEPARTMENT OF AGRICULTURE & FISHERIES FOR SCOTLAND
ST ANDREW'S HOUSE, EDINBURGH, 1

its effect was severe, the plants producing hardly any new leaf tissue for a period of about ten weeks. During this time the existing leaves gradually aged and died. The treated plants later recovered and produced new leaves from various sites on the old crowns, eventually growing into bushy plants with many crowns. Lower concentrations of spray were less effective, and at 0·2 per cent. the growth was only slowed down, new leaves being distorted. A 0·05 per cent. spray had little effect. (C. G. Guttridge.)

Mineral Nutrition

It has frequently been noticed that flower formation occurs more freely when pot-grown strawberry plants are checked in growth by mineral starvation than when they are growing vigorously. A small trial was made to see if root restriction in itself played any part in this. In February, runners of the variety Templar were set in (a) 5 in. clay pots filled with J.I. Potting Compost No. 1, (b) the same compost in bitumen-coated metal cans holding a volume three times that of the pots, and (c) a mixture of $\frac{1}{3}$ compost and $\frac{2}{3}$ sand in the cans. Thus each can in (c) contained the same quantity of compost as each pot in (a). The plants were grown in the glasshouse and received no supplementary feeding until later in the year. Initially—for two or three weeks—growth was better in the pots and the sand/compost mixture than in the large cans of undiluted compost, probably because of better drainage. Three months later, however, in May, growth was severely depressed in both the pots and the sand/compost mixture, and the fact that there was no appreciable difference between the two indicated that the nutritional state was a much more important factor than soil volume. Vigorous growth of the plants in the cans containing undiluted compost continued for about two months longer. The negative correlation between vigour of top growth and initiation of flower trusses showed up later, in July, when the trusses initiated under the deficiency conditions in April and May had emerged and come into flowering. In the pots 21 out of 24, and in the cans with the sand/compost mixture all 24, plants were flowering, whereas in the cans with undiluted compost and therefore the better nutrient supply only 3 out of 31 plants were flowering.

The major nutrient elements were then applied both separately and in different combinations to the plants suffering mineral deficiency. Applications of N and P were the most beneficial, indicating that the deficiency of these elements was greater than that of K or Mg. Improvements in vegetative growth were correlated with delay in the formation of a second flush of flower trusses. (C. G. Guttridge.)

Seed Germination

Investigations into factors influencing strawberry seed germination were continued. Most of the work was done with seed of *Fragaria vesca semperflorens* (Ehr.), which has an absolute requirement for light but none for chilling, and with three of the large-fruited cultivated varieties, each of which requires for maximum germination both light and chilling after imbibition.

The light-promoted germination of *F. vesca semperflorens* was inhibited by coumarin, which acted competitively against light, so that at low levels the inhibitory effects could be removed by increasing the quantity of red

light supplied. On the other hand thiourea was a very inefficient promoter of the germination of dark-grown seed, being less effective than even a very short period of red light exposure.

Several experiments were done to investigate the activity of gibberellins as germination promoters, either alone or in combination with chilling treatments. It was found that after a chilling treatment a large proportion of the seeds of all the varieties used still required light for successful germination, and that gibberellic acid (A_3) was not effective as a substitute for this light requirement. A range of gibberellins was tested at several concentrations, and the results showed that the most active was A_4, followed by A_7 and A_9. It was clear that A_8 and A_5 were almost entirely inactive, but the results for A_1 and A_3 were equivocal; on some occasions these last two showed some promotion, but at other times they appeared to have fairly strong inhibitory effects. This situation is being further examined.

Seed taken from three varieties of large-fruited strawberries and stored dry in a refrigerator after harvest had a very low percentage germination when sown at 25°C. It was found, however, that a rapid germination of more than 90 per cent. could regularly be obtained if the seed was sown and left to imbibe in the dark at 2°C. for a period of at least three weeks before transference to warm conditions. None of the gibberellins so far tested has proved to be an effective substitute for this chilling requirement, but experiments in which sulphuric acid has been used to scarify the pericarp of the seeds have suggested that the activity of gibberellins upon intact seeds may be complicated by permeability problems. (P. A. Thompson.)

PHYSIOLOGICAL INVESTIGATIONS WITH OTHER PLANT SPECIES

Flowering in Fuchsias

Work by Sachs and Bretz in California has shown that the flowering of fuchsias is controlled by the length of day, short days inhibiting or delaying flower initiation and long days promoting it. In addition, gibberellic acid prevented flowering in long days and did not promote it in short days. These observations are of practical interest as they open up the possibility of regulating flowering and the production of vegetative shoots for propagation, and also of physiological interest because the suppression of flowering by gibberellic acid in long-day plants is an unusual response. Horticultural fuchsias (predominantly hybrids between *F. fulgens* and *F. magellanica*) produce their flowers singly (or occasionally in pairs) in the leaf axils, the apex remaining vegetative irrespective of daylength. Hybrid fuchsias from *F. triphylla* form terminal inflorescences, and continuation growth is by vegetative axillary shoots.

Varieties of both types were grown either in short daylengths (9 hours) or in night-break conditions (a basic 9-hour day with four hours of light from tungsten filament lamps in the middle of the dark period). All the ten varieties of the *fulgens* x *magellanica* group flowered with the night break and remained vegetative with the short daylengths. The two *triphylla* hybrids that were tested flowered in both conditions.

Gibberellic acid sprays of 5 and 25 p.p.m. applied twice weekly to *fulgens* x *magellanica* hybrids increased the height of the plants in both the

above daylength conditions. Flowering was inhibited in night-break conditions and all the plants in short daylengths remained vegetative. The two *triphylla* hybrids, although increased in height with gibberellic acid, continued to flower under both daylength conditions. Their inflorescences were elongated, and at 25 p.p.m. GA some of the flowers aborted.

It seems possible that as well as flowering in both long and short daylengths, the *triphylla* hybrids have a flowering mechanism which is insensitive to gibberellic acid.

Plants of the variety Howlett's Hardy (a *fulgens* x *magellanica* hybrid) were examined to see whether the suppression of flowering was caused by the failure of flower initiation or followed from the abortion of buds or the suppression of their development. The leaf axils were found normally to contain three meristems. In night-break conditions the lowermost (abaxile) meristem produced a flower, the central meristem developed into a vegetative shoot, whilst the uppermost (adaxile) meristem remained small and usually failed to develop. In short daylengths the lowermost meristem grew out as a vegetative shoot and the others remained small and vegetative, although the uppermost one developed more than the central one. Microscopic examination showed that gibberellic acid checked the actual initiation of a flower in the lowermost position, causing the formation of a vegetative shoot similar to that on plants growing in short daylengths.

Two growth retardants, Phosfon-D and B-995, which have the opposite effect from gibberellic acid on internode elongation, were applied to plants of the variety Howlett's Hardy to see if flowering was affected. The plants were grown in 5 in. pots, and two applications of Phosfon-D (each of 1·6 gm. of 1·5 per cent. powder) and three applications of B-995 (each of 25 ml. of 0·4 per cent. solution) were applied to the soil. There was no effect on flowering, but internode length was reduced by B-995 in both long and short daylengths and by Phosfon-D in long daylengths. Recovery was rapid, suggesting that both chemicals act on the elongation phase of internode growth.

In another experiment, sprays of 0·2 per cent. ACP-61-265 reduced apical dominance and also appeared to remove any inhibitory effect of one meristem on its neighbour, as adjacent buds in each axil grew out with equal vigour. (D. T. Mason.)

Induction of Parthenocarpy in Fuchsias

Past Reports have described experiments made to determine the effects of various growth regulating substances on parthenocarpic development of the strawberry fruit. This work has now been extended to fuchsia fruits. The fuchsia is easily managed under glasshouse conditions and flowers over a long period in summer. The fruit is a true berry, and therefore more representative of fruits in general than the strawberry receptacle. Ten varieties of fuchsia were examined for fruit development in response to growth substances as well as to normal pollination. Several growth substances, including chlorinated phenoxy acids, indole and naphthalene ring compounds and gibberellic acid, were applied at 50, 250 or 1,000 p.p.m. in lanolin emulsions to the carpels of flowers emasculated four days prior to anthesis.

None of the varieties produced any fruit growth in response to treatment with gibberellic acid, but all responded to one or more of the auxin-like growth substances at some concentration. There were very wide variations in the responses of particular varieties, however, some being relatively specific whereas others responded to a number of different growth substances over a range of concentrations. The most consistently successful of the growth substances was 4-(indole-3-yl)-butyric acid, which promoted growth in most varieties over the concentration range examined. Other chemicals with a wide range of activity were indole-3-acetic acid, 1-naphthaleneacetic acid and 2-napthoxyacetic acid. Some varieties responded well to 1-naphthaleneacetic acid but not at all to 2-naphthoxyacetic acid, whereas with others the position was reversed. In general the concentrations used for the chlorinated phenoxy acids appeared to be too high, and in most varieties successful stimulation of carpel development was obtained only at the lowest concentration used.

In a second experiment, carpels of emasculated flowers were treated with either 4-(indole-3-yl)-butyric acid or indole-3-acetic acid at 50, 150 or 450 p.p.m. in lanolin emulsions, with or without added gibberellic acid at 1,000 p.p.m. The more active of the first two chemicals was 4-(indole-3-yl)-butyric acid, but it was clear that combining gibberellic acid with indole-3-acetic acid greatly increased the activity of the latter and in a few examples raised it to a level comparable with that of the butyric acid.

In the pollination tests, flowers of each variety were either pollinated separately with pollen collected from each of the other nine varieties, pollinated with a mixture of pollen, or self-pollinated. None of the flowers treated produced any seeded fruits, and very few seedless fruits were produced except in one variety with a natural tendency towards parthenocarpy. This sterility was unexpected, and very severely limited the scope of the experiments.

In attempts to extend these results, a series of tissue culture experiments was set up. Carpels of fuchsias collected either before or three days after pollination were surface-sterilized and then placed on agar in tubes containing White's nutrient with or without additions of growth substances. Most of the experiments were planned to examine the activity of gibberellic acid and 4-(indole-3-yl)-butyric acid, individually and in combination. The results were variable and difficult to interpret, but some effects were found fairly consistently with all or most of the varieties examined. For example, fruits which were pollinated and retained on the plants for three days after anthesis grew to a greater size than fruits removed before pollination. This may have been an effect of pollination or may have resulted from the greater maturity of the carpel at the start of the experiment. Gibberellic acid usually promoted growth at one at least of the concentrations used, and also greatly prolonged the period of survival of the carpel in culture, even in conditions where it failed to induce growth. On the other hand 4-(indole-3-yl)-butyric acid was variable as a growth promoter, and instances were found where it reduced the growth-promoting effect of gibberellic acid. It appears, therefore, in spite of the negative result obtained with whole plants, that gibberellins can play a part in the promotion of fruit growth in the fuchsia. (P. A. Thompson.)

EXTRACTION OF AUXINS AND GIBBERELLINS FROM STRAWBERRY

Several experiments were done on the extraction and bio-assay of naturally-occurring auxins and gibberellins, using a modification of the oat coleoptile test for the former and the lettuce hypocotyl test for the latter.

Comparisons were made of auxin levels in fruit tissues of different varieties and at various intervals during fruit development. These indicated that the achenes were consistently a richer source of auxins than the receptacle, but confirmed the presence of auxins in the latter tissue too: they also suggested that the quantity of auxins present increased considerably during the first fortnight after anthesis, rising very rapidly between the ninth and fifteenth days.

Comparisons of gibberellins in the receptacles and intact achenes showed a rather similar relationship to that found for auxins, and suggested that the achene pericarp was at least as rich a source of these compounds as the inner tissues of the achene, including the endosperm, nucellus and embryo.

Recent results have shown that the methods of extraction and bio-assay used here previously, based on paper chromatography, paid insufficient attention to problems arising from the presence of inhibitors, so that quantitative estimations obtained from them would probably be inaccurate even when used only to assess comparative levels in different tissues. It has also been found that those gibberellins which are of low or negligible activity in the lettuce test may nevertheless modify the response of the test plant to more active compounds, which means that chromatographic techniques which result in the separation of different gibberellins may produce considerable errors when used in the estimation of total activities.

Modifications to the present methods of extraction and bio-assay are being developed to overcome these problems. These are based on the preparation of a water extract, which is freeze-dried and made up as a dilution series before being assayed by the lettuce hypocotyl test. This method has the advantage of eliminating the use of all organic chemicals as well as the delays and hazards of paper chromatography. It has been found possible to produce flat-topped curves, free from interference by inhibitors, from which the relative levels of gibberellin-like substances can be read off. Comparisons of activity in different strawberry tissues have confirmed that immature leaves and runner tips are active tissues relative to mature leaves (in ratio approximately 9 : 7 : 1), and that achenes are much more active than receptacles (ratio approximately 12 : 1). (P. A. Thompson.)

MYCORRHIZAL INVESTIGATIONS

The examination of soils under various crops to determine the number of spores of *Endogone* spp. present was continued in 1963. As in 1962, the highest population of spores in the soil of a raspberry plantation occurred in July and August, with 400 spores per litre of soil, whereas from October to June the population remained at a low level of about 50 spores per litre. In a soil under barley the number of spores was low in May and June, rose to about 350 spores per litre in July, showed a fall in autumn (less in 1963 than in 1962), and rose again to about 450 spores per litre in the winter. In the 1963 samples of strawberry soil, taken only from a limited area in a single

field, the counts were low in July, amounting to about 250 spores per litre, but rose to 450 per litre in the winter. In this soil a small number of single spore sporocarps was found, although none were observed in the raspberry or barley soil. Because of the different seasonal patterns of spore numbers found under different crops, an investigation is being made into the possible relationship between phases of root growth and the numbers of spores present.

Attempts to infect pot-grown plants with spores washed from soil were not always successful. Nevertheless, spores from barley soil infected plants of *Fragaria vesca*, red clover and apple. Spores from raspberry soil infected *F. vesca*, and spores from soil in which *F. vesca* was growing infected raspberry plants. In each case a large number of new spores was produced in the rooting medium. (D. T. Mason.)

FIELD INVESTIGATIONS WITH STRAWBERRIES

Temperature in relation to Flower Initiation

It is well established from results in controlled environments at Mylnefield and elsewhere that temperature is an important factor in regulating flower truss formation in the strawberry. Although these results have come mostly from experiments at rather higher temperatures than occur outdoors in Scotland in the autumn, the possibility that temperature is a critical factor in the field seemed worth investigating. Comparisons between temperature and flower formation at Mylnefield for eight years have confirmed this. A detailed study suggests that the critical period in this area is from mid-August to the end of September. When the accumulated temperature for Shaw weeks 43 and 44 (26 August-8 September) is above average, initiation is decreased, and conversely it is increased when this figure is below average. A reverse relationship holds for weeks 45 and 46 (9-22 September), when temperatures above normal increase initiation and temperatures below normal decrease it. These observations go some way to explain the conflicting results of experiments in which cloches have been used to raise the temperature during parts of the initiation period.

When, as in 1960 and 1961, the favourable alternative situation occurred in each of these periods (i.e., cool conditions in weeks 43 and 44 and warm in weeks 45 and 46), initiation was at a high level. When both periods were unfavourable, as in 1955 and 1962, a proportion of crowns were barren. Other combinations—the whole initiation period being either cooler than normal (1963) or warmer than normal (1958)—led to moderate levels of inflorescence initiation.

Records collected at Mylnefield were alone used to formulate these conclusions, and the influence of temperature on inflorescence initiation in the south of England requires to be separately determined. (D. T. Mason.)

Defoliation

The study of post-harvest defoliation has now reached the stage at which a consideration of individual experiments in isolation is no longer satisfactory, and a review of the work to date is being undertaken.

In the earlier experiments, defoliation was found to promote flower truss formation and increase yields in Talisman and Redgauntlet when truss numbers were otherwise deficient. When the work was extended to other varieties and to a site less favourable for strawberries, however, the treatment was found to be less frequently beneficial. These results demonstrate the importance of confining defoliation—even in the two varieties named—to vigorously growing plantations, where deficiencies in numbers of trusses are most likely to arise.

Cambridge Favourite has always initiated a satisfactory number of trusses in our experiments at Mylnefield, and consequently substantial increases of yield have not been obtained by defoliation in this variety. In fact, under the less favourable conditions in one of our fields (Bullion South) the number of trusses and the yield have sometimes been reduced by defoliation.

Some recent experiments have pointed to the importance of avoiding damage to the actual crowns by too close mowing. Where there is little chance of a large increase in the number of trusses, the loss of crowns by damage can cause a reduction in cropping. Some experimental evidence suggests that crowns can be killed by infection with pathogens. Delaying defoliation after mid-August has not only reduced the chance of promoting flower initiation but also increased the tendency for damaged crowns to die. (D. T. Mason, C. G. Guttridge.)

Chemical Defoliation

The possibility of defoliating strawberries chemically was tested in the autumn of 1962 (see 1962-63 Report, p. 23). Of the three varieties tested, only Talisman was deficient in flower initiation and therefore offered scope for a large beneficial response. All the chemicals used did in fact increase inflorescence initiation in this variety, but not as effectively as did mechanical defoliation, which doubled it. The total yield of fruit was increased by mechanical defoliation and to a lesser extent by treatments with magnesium chlorate and sodium monochloroacetate. Dinoseb and sulphuric acid treatments resulted in lower yields than were given by the intact control plots, despite the increased levels of inflorescence initiation which they induced. Calculations based on numbers of trusses initiated and numbers emerging in the following spring showed that damage was done to the plants by all the treatments, although mechanical defoliation was least damaging. It seems that the low yields which follow certain chemical treatments are attributable to spray damage which reduces the numbers of crowns per plant.

In Redgauntlet and Cambridge Favourite, where there was no deficiency in truss numbers in control plants and therefore less likelihood of a response to defoliation, the number of crowns per plant was reduced by all treatments and caused decreases in yield.

It is suggested that growth is checked after these chemical treatments by some of the spray material either being translocated to the crowns or running down the outsides of the petioles and accumulating on the crowns. Modifications of spraying technique, particularly the use of a lower volume of spray (i.e., less than 45 gal./ac.) may reduce such damage. (D. T. Mason, R. J. Stephens.)

Advancement of Flowering with Gibberellic Acid

Gibberellic acid was sprayed on to field plots of strawberries in spring, as has been done elsewhere, in an attempt to advance cropping or increase the yields from the earlier picks. Aqueous solutions of 25, 50 or 75 p.p.m. GA were applied to one set of plots on 16 May and to a second set on 27 May. On the later date the first flowers were open on the earliest trusses.

Fruit-set was strongly checked by these applications, especially the second. The earlier application mainly affected the set of the primary flowers, but the later one tended to affect the whole truss. Unopened as well as open flowers were damaged, indicating that the effect was systemic and not just due to a physical 'scorching' of open flowers. (Systemic action was also deduced from the results of experiments described in the 1961-62 Report.) However, the observation that damage from the first application was mainly to primary flowers suggests that flowers had to be open or at least near to open in order to suffer damage. The higher rates of GA were the more damaging: 75 p.p.m. on 27 May reduced the total crop (averaged for the two varieties) by about 40 per cent. Earliness was not affected.

These results point clearly to the disastrous consequences of applying gibberellic acid at this stage of truss growth. The possibility remains that earlier applications of gibberellic acid may advance fruiting. (C. G. Guttridge.)

Control of Runner Formation in the Field

In some earlier glasshouse experiments a suppression of runner formation was obtained by applications of (2-chloroethyl) trimethylammonium chloride (Cycocel, or CCC), either to the soil or by spray to the leaves. Poured onto the soil, CCC solutions reduced top growth by shortening petioles and also inhibited runner formation, without damage to the leaves. Spray applications caused some chlorosis of the foliage, but petioles were reduced and runners checked at concentrations of spray which were not seriously damaging to the foliage.

In 1963 some attempts were made to check runner formation in the field on April-planted maidens, but with disappointing results. Plants of Cambridge Favourite and Redgauntlet were sprayed with 0·5, 1·0 or 2·0 per cent. CCC (active) on 30 May (when early flowers were open). The highest concentration caused severe damage to the next leaf to emerge on each plant; but later leaves were healthy, so that effectively only one leaf was lost on each plant. Even at the highest concentration, however, only occasional runners were checked completely, although others were shortened. Trusses flowering at the time of the first application failed to set. No prolonged check to growth was suffered and the plants fully recovered. A repeat spray in June also failed to check runnering. From these results it is concluded that the vigorous and active runner formation found in early summer in newly-planted stock is not readily checked, and that higher concentrations of spray or else more frequent applications are required. This work is continuing with CCC and other chemicals. (C. G. Guttridge.)

Chemical Deblossoming of Maiden Plants

Two contact herbicides, Dimexan and Solan, were applied as sprays at rates between 0·25 and 1·5 per cent. to the open flowers of maiden strawberries. Fruit-set was in every case reduced, but not without considerable damage to the foliage. There was a slightly selective killing of trusses, due probably to the retention of greater amounts of spray in the open flowers than on the foliage, but not a sufficient margin of safety for practical application. (C. G. Guttridge, R. J. Stephens.)

Cold Storage of Runners

Cold storage of runner plants is becoming increasingly important in Britain. Recent experience has shown a need for further study of the technique of storage.

Talisman plants were again cold-stored for us at Rosewarne E.H.S. at three different temperatures, 28°, 30° and 32°F., as in 1962. They were lifted and sent to Rosewarne in mid-March 1963 and stored until the end of August in 200-gauge polythene bags.

On their return the plants showed clear differences associated with the three storage treatments, although they had survived at all three temperatures. Those stored at 30°F. were in the best condition. At 28°F. some of the developing leaves and flower trusses in the buds (examined by microscopic dissection) had died. The extent of damage varied from slight necrosis of the tips to complete death of the leaf or truss. When planted, many of this batch suffered death of the main crown, and lateral buds grew out. No necrosis of bud tissue was seen in the plants stored at 30° or 32°, although old leaves which had expanded before storage survived less well at 32° than at 30° or 28°.

When sample plants were planted in boxes and grown outside until harvested on 10 October, those previously stored at 30°F. grew better and produced more healthy flower trusses than those stored at the other temperatures. Although the storage continued until later in the year than is usual in this country, it is reasonable to suppose that 30°F. will generally be better than either 28° or 32° even for shorter periods, although the harm done at the latter temperatures might be less.

Some plants were retained in our own store at 30°F. until December, thus completing a full year's storage. By this time a large number were found to be rotting. Selected plants were potted and grown in the glasshouse, but many of these became severely infected by *Botrytis cinerea.*

The varieties Talisman, Templar, Redgauntlet and Cambridge Rearguard survived better than Cambridge Vigour and Cambridge Favourite, but the condition of the plants at lifting (which may have varied with variety) could have influenced this result. Rotting in storage, and the apparently high susceptibility of long-stored plants to infection with *B. cinerea* (also observed in other circumstances) is now being investigated in co-operation with the Mycology Department.

Yields from cold-stored runners planted in 1962 and cropping for the first time in 1963 were very disappointing. This was due partly to the long spell of cold weather which prevented the plants from making as much

growth as usual in the autumn, and partly to the prolonged freezing conditions in winter, which damaged some of the plants, especially of Cambridge Favourite. It seems unlikely that cold-stored plants will be used for extensive field planting in Scotland. On a small scale, however, they may be useful if grown under cloches to provide an early crop of fruit. (C. G. Guttridge.)

PUBLICATIONS

GUTTRIDGE, C. G., and MASON, D. T. (1963). The growth and cropping of cold-stored strawberry runners in Scotland. *Hort. Res.*, **3**, 34-44.

[The cropping of cold-stored strawberry runner plants at various times was compared with that of (a) fresh runners planted in April (the normal planting time in Scotland) and (b) new-season runners, which first became available for planting in July. Four varieties were tested. Delay in the planting of cold-stored runners from April to September, and of new-season runners from July to September, reduced yields in the following year. New-season runners outyielded cold-stored runners when both were planted at the same time. This is attributed to the fact that chilling causes stored plants first to produce vigorous vegetative growth. Probably not until this phase is passed do they initiate trusses and build up food reserves for the following year's crop.]

GUTTRIDGE, C. G. (1964). The effect of (2-chloroethyl) trimethylammonium chloride on the growth and runnering of strawberry plants. *Hort. Res.*, **3**, 79-83.

[Application of (2-chloroethyl) trimethylammonium chloride to strawberry plants growing in pots decreased petiole length and suppressed the elongation of developing runners and the initiation of new ones, but did not induce the formation of flower trusses in long photoperiods. After an initial phase in which these responses were observed, the treated plants recovered and grew more strongly.]

GUTTRIDGE, C. G., MASON, D. T., and ING, E. G.[1] (1965). Cold storage of strawberry runner plants at different temperatures. *Exp. Hort.*, **12**. (In press.)

(The work reported in this paper is summarized on page 54 of this Report.)

[1]Rosewarne Experimental Horticulture Station, Cornwall.

GENETICS

G. HASKELL

The genetical problems of adaptation of horticultural plants were further studied. Blackberry segregants carrying the thornless gene introduced from Merton Thornless have proved unsuited to local conditions, and this has led to the start of a programme to see whether thornlessness can be induced in native Scottish brambles by chemical mutagenic treatments. Two of our tomato selections derived from Ware Cross were again economically superior to most of the better-known varieties grown in Scotland. One selection is now undergoing preliminary trials in Lanarkshire.

Dr. G. Haskell and Dr. A. B. Wills attended the 11th International Genetics Congress held in September at The Hague. Dr. Haskell read a paper on variation in virus-free clones of strawberry and Dr. Wills demonstrated the ideograms of horticultural plants grown in Scotland. Genetics departments of research stations were visited at Wageningen. The Genetical Society of Great Britain is thanked for a grant towards Dr. Wills's expenses.

Visitors to the Department during the year included Dr. A. W. S. Hunter (Director, Genetics and Plant Breeding Institute, Ottawa, Canada), Dr. E. P. Baker (Botany Department, University of Sydney, Australia), and Mr. T. P. Palmer (Crop Research Division, Christchurch, New Zealand).

At the invitation of the Scottish Education Department we provided two practical courses in cytology and genetics for graduate teachers. These were held in the Botany Department of Glasgow University and at Dundee College of Education.

The technical side of the Department was strengthened by the appointment in June of Mr. J. B. Garrie, who will assist particularly in work with chromatography and electrophoresis.

GENETICS AND CYTOLOGY OF TREE FRUITS

Survey of Tree Fruit Genetics and Breeding

The survey of recent cytogenetical researches on tree fruits (see 1962-63 Report, p. 56) has been completed, and certain general conclusions can now be stated. It is clear that the amount of investigation on any given fruit genus in a particular region is determined much more by the economic value there of the crop or crops than by the intrinsic merits of the scientific problems posed. Thus, apples have been the most widely studied fruit crop in Europe and North America.

The survey has also shown that even in some of the major fruit growing areas of the world, such as some South American countries, South Africa, Australia and New Zealand, very little cytogenetical research has been undertaken on fundamental problems. Results obtained in Britain, Sweden, Canada and the U.S.A. are widely applied elsewhere.

A feature of the survey has been the opportunity it has given for preparing tables of pedigrees and lists of the varieties considered most useful to

practical fruit-breeders for specific breeding purposes. These tables serve to emphasize that improved new varieties of the future are very likely to stem from a limited number of possible parents.

Somatic Changes in Aneuploid Apples

Earlier findings that blackberry plants with unstable aneuploid chromosome numbers may shift towards a higher and balanced euploid level suggested that the same principle might apply in apple genetics. Apples are either diploid ($2n=34$) or triploid ($2n=51$): the latter class may produce fruits of desirable commercial merit but are poor as breeding parents. A long-term experiment has been initiated, therefore, using open-pollinated seeds (kindly supplied by the Pomology Department) of triploid varieties, whose seedling populations are expected to carry a wide range of aneuploid chromosome numbers. During the next few years it should be possible to see whether shifts in chromosome numbers occur towards the triploid or diploid values, and to determine the fertility and the types of fruit produced by these seedlings.

Many of the seedlings of this material died during the early stages of germination, probably from genetical causes, so that the initial variability of the population has already been reduced. The stomatal index, which is often a good guide to polyploidy, is highly constant in all the progenies so far investigated, even though the seedlings vary widely in growth and vigour. (G. Haskell.)

RUBUS **INVESTIGATIONS**

Genetics of Apomixis

In some genera there are genes which influence breeding behaviour by affecting the cytological mechanism—for example, by causing asynapsis or by inducing abortion at a particular stage in the pollen cycle. Little is known, however, of the genetical control of the apomictic mechanism in *Rubus*. Previous crosses of the sexual Merton Thornless ($4x$) by apomictic thorny Himalayan Giant ($4x$) have given F_1 plants which have reproduced sexually and segregated for thornlessness in accordance with the theoretical expectation for a tetraploid.

A cross of Merton Thornless (female) with $4x$ Merton Early (a cultivar of *R. nitidioides*) gave a uniform F_1 family characterized by being more like the male parent than the female in habit and leaf shape. It also had the prickle type of Merton Early, not that of the John Innes blackberry from which Merton Thornless was derived. The influence of the female parent was further seen in the purple coloration of the stems and petioles. A very large number of seeds was sown from the F_1 plants and these gave no germination in the first year but a prolific germination in the second. The several thousand plants comprising the F_2 generation were uniform, entirely thorned, and identical with the F_1 parents. There is clearly a dominant genetic control of apomixis in *R. nitidioides*, since the absence of any form of segregation for leaf shape, prickle shape or stem anthocyanin would rule out the possibility of linkage with a lethal gene. It would seem that in the large genus *Rubus*, with its many apomictic forms, the genetic control of

apomixis has arisen independently in different species. The apomictic mechanism is inherited sometimes as a dominant character and often as a recessive. Possibly the dominance mechanism is modified according to the genetic background in which it acts.

Breeding Thornless Tetraploid Blackberries

Further selection was made from the thornless segregants of a Merton Thornless x Himalayan Giant cross (see 1962-63 Report), and the best plants were transferred to a new plot for further examination. Although these plants are hardy enough for local conditions, they are far too late in flowering and fruiting to be a commercial proposition. Their fertility also is less satisfactory than one could wish, a characteristic which is general of progenies derived from Merton Thornless. In view of this situation it has been decided to enlarge our stock of thornless blackberry material by introducing various forms of thornless *Rubus* from North America, and to widen our breeding programme with these. At the same time a programme of applied chemical mutagenesis has been started in the hope that the thornless character can be mutated in the germplasm of some of our local Scottish varieties. (G. Haskell.)

RIBES **INVESTIGATIONS**

Experimental Apomixis

Previous instances of the occurrence of true black currant seedlings in progenies from interspecific crosses in which black currant was the seed parent suggested the possibility of apomixis in this species (see 1958 - 59 Report, p. 35). This idea recently received support from some results of Zatyko, in Hungary, who induced apomictic seed production by the combined application of gibberellic acid and indoleacetic acid. Since it might be expected that true apomicts in *Ribes* would be genotypically similar to or identical with the maternal variety, and virus free, they would be of great genetical interest and also valuable in a polyploid breeding programme.

An experiment to test these possibilities was begun in May 1963, when flowers of two varieties each of black currant, red currant and gooseberry were emasculated and sprayed on single occasions up to 7 days later with a mixture of equal volumes of 100 p.p.m. gibberellic acid and 100 p.p.m. indole-butyric acid. Controls were included to determine seed production following emasculation and hand pollination and following natural pollination without prior emasculation.

The results indicate that only a low proportion—less than 1 per cent.—of berries become set in emasculated, non-pollinated plants. The majority of these berries in 1963 had very few seeds—usually one per berry—and the cause of seed-set could not be ascribed definitely either to accidental pollination or to natural apomixis. However, in a much smaller proportion of these berries the seed number approached that found in hand-pollinated fruits: it must be assumed that such cases were the result of accidental self-pollination during the emasculation procedure, despite the stringent precautions taken.

Less than 0·5 per cent. of the emasculated and sprayed black currant flowers produced fruit. In red currants this proportion was increased to

5 per cent., and in gooseberries to 10 per cent. The majority of such fruits contained no seeds, and in most of the remainder there was only one seed per berry.

Five sterile hybrid plants derived from red currant x black currant crosses did not respond to spraying, and four unemasculated hybrid control plants set no fruit. However, following spraying, 187 fruits (*c.* 15 per cent.) were set on two hybrid plants from a cross between an unidentified *Ribesia* species and black currant, hybrids which had been observed to set no fruit in the two previous seasons when either open-pollinated or hand-pollinated. Although these parthenocarpic fruits remained very small, they ripened to give red, juicy berries. The first four berries to ripen each contained one malformed seed, whilst the later berries had none.

It is hoped that by repeating this experiment with a modified solution it will be possible to induce the formation of enough apomictic seed to enable certain genetical tests to be made on them.

From the outset of these experiments, samples from all the treatments and controls were taken at frequent intervals for subsequent cytological examination. The study of sections prepared from these samples is still in progress and has shown that the embryo-sac in black currant and red currant is a normally-formed 8-nucleus type, but samples in which natural or induced apomictic development was taking place have not yet been detected.

Ribes *Ideograms*

Measurements have revealed that well grown young black currant plants do not show the varietal constancy of ideogram pattern expected in older plants, even when such measurements are made from terminal growth of the oldest stems. More caution must be exercised therefore in the selection and interpretation of ideograms of woody perennials, especially from a recent plantation, than is necessary with herbaceous annuals.

Chemical Analysis of Ribes *Species*

Aqueous extracts of freeze-dried leaves of *Ribes* species and of black currant varieties and seedlings have been hydrolysed and chromatographed. No consistent differences were detected in the constituents of varieties within a species, and the differences so far detected between species show little relationship to the genus classification. (A. B. Wills.)

TOMATO INVESTIGATIONS

Selection for an Early, High-Quality Variety Adapted to Scottish Conditions

Six of the best Mylnefield tomato strains, derived originally from Ware Cross, were again tested against commercial varieties popular in Scotland. As in the trial in 1962, the varieties were assessed on the basis of income produced, a method which takes into account not only the actual yields but also the market prices at the times of picking. Table I reveals that in terms of income from the first eight trusses harvested, Ailsa Craig, Mylnefield No. 1 and Eurocross were the three most profitable varieties in 1963.

Lanarkshire growers have expressed interest in two of the Mylnefield strains, but particularly in No. 5 because of its larger fruit size and attractive

shape. In view, however, of the higher market return obtained here in 1963 from No. 1, we have arranged for this strain to undergo provisional testing in 1964 in the Carluke district. Nevertheless, as growers in that area usually produce up to thirteen trusses, it may yet be the case that the larger-fruited strain No. 5 will give them the better return. A provisional test of this strain in Lanarkshire will be made in 1965.

Breeding for the 'Non-Greenback' Character

Moneymaker and Eurocross are examples of varieties grown in Scotland which are homozygous for the uniform ripening or 'non-greenback' gene (*u*), which means that their fruits are uniformly pale-green prior to turning red. This is a desirable feature, because such types do not reflect poor growing conditions or soil mineral deficiencies as do the 'greenback' types.

TABLE I

Tomato selection trial at Mylnefield, 1963: Crop yields and estimated financial returns from six F_5 selections from Ware Cross, selected for earliness and high quality, and also from five commercial strains. (Data for the first 8 trusses only, on 100 plants of each type.)

Variety	Number of Grade A fruits	Number of Grade B fruits	Estimated total income*
			£
Ailsa Craig	2,898	1,873	75·19
Mylnefield No. 1	3,226	2,100	72·64
Eurocross	2,533	2,310	71·38
Moneymaker × Mylnefield No. 5 (F_1)	3,318	2,142	70·67
Mylnefield No. 5	2,759	2,428	69·28
E.S.1	2,948	2,289	67·36
Mylnefield No. 3	2,948	1,911	65·15
Mylnefield No. 4	2,986	1,840	65·13
Moneymaker	2,995	1,781	64·94
Mylnefield No. 8	2,507	1,827	60·32
Ware Cross	2,717	1,563	59·01
Mylnefield No. 7	2,797	1,562	58·37

*Estimated income per 100 plants, calculated for 12 lb. chips of grades A and B on the basis of typical prices offered at Glasgow market on each picking date.

which may develop either blotchiness or else a yellow band around the base of the ripe fruit, associated with internal pithiness. A cross was made between Moneymaker (*uu*) and Mylnefield No. 4 (*UU*), and an F_2 population is being raised in 1964. Selection will be made within this for non-greenback types, the earliest and highest-yielding of which will be used as future breeding material.

It is impossible to recognize homozygous *uu* seedlings prior to fruit-setting and development, even by close examination of hypocotyl colour or by looking for colour differences with u.v. light. Selection for the non-greenback condition can therefore be undertaken only after the fruits are well formed. This involves much waste of glasshouse space, as three-quarters of an F_2 population segregating for this character will not be retained. An experiment has therefore been started which involves the use

of discriminant functions of the biometrical characteristics of young seedlings, to see whether a means can be found of screening for non-greenback before the stage of planting-out into the glasshouse. This approach will be extended also to the general problem of separating pure-line varieties in tomato.

Genetical Detection of Outcrossing in Glasshouse Tomatoes in Scotland

The progenies of four 'tomato-leaf' seedlings derived from Fortuna (see 1962-63 Report, p. 65) were examined to see whether each segregated in a 3:1 ratio for 'potato-leaf'. As no segregation occurred, it was concluded that the presence of these tomato-leaf types in the original test samples was due to a mechanical error during handling.

It is clear that in Scotland the flowers of tomato, even when varieties are mixed in the same glasshouse, may well not be subject to cross-pollination. This means that pedigree stocks of the best varieties can probably be grown safely for seed without risk of contamination, even when several varieties are present together. Self-pollination is of course absolutely guaranteed when only one variety occupies a house. The production of pure-line tomato seed on a commercial scale might be looked into as an economic possibility for Scottish growers. (G. Haskell, E. B. Paterson.)

CHROMOTOGRAPHIC AND ELECTROPHORETIC STUDIES ON HORTICULTURAL PLANT MATERIAL

These studies investigate techniques which may be of aid in interpreting the evolution and genetical relationships of plant species. An examination of the anthocyanin pigments of raspberry and bramble fruits by one-way paper chromatography showed that except for *Rubus parviflorus* all the species and varieties tested in these two groups probably contained the same pigment. In *R. parviflorus*, which is of North American origin (in contrast to the European origin of the other species tested), the pigment was different. Forestal solvent gave the best chromatographic separations.

We have modified the Wanscher Flower Colour Chart for classifying the pigments obtained on Whatman No. 1 paper, and have found that the raspberry varieties Malling Jewel, Malling Enterprise and Malling Promise all apparently have an anthocyanin pigment in common, as anticipated; but a yellow-fruited raspberry lacked this pigment, although a whitish-blue luminous area was produced under u.v. light at the same R_F position.

Two-way chromatography for the separation of flavonoid components was used to compare the two regions of a sectorial colour chimera in an orange fruit received from Mozambique. It was found that the mutation from orange to yellow was more complex in terms of pigments than might have been supposed. The results of this investigation will shortly be published.

Electrophoretic studies of the proteins of *Rubus* have also been initiated, mainly to see whether this technique might be useful for taxonomic separation, particularly with regard to apomictic forms. Experiments using the Cohn's Universal Tank, with paper or cellulose acetate strips, have been found too insensitive for either seed or leaf tissues. Preliminary trials by

Dr. A. Berrie (Botany Department, University of Glasgow), however, applying disc electrophoresis with polyacrylimide to the seeds of certain raspberry varieties, have indicated that this method may be more successful. A disc electrophoresis apparatus is now being constructed here. (G. Haskell.)

CYTOLOGICAL INVESTIGATIONS

Routine cytology was continued. The investigations mainly concerned interspecific hybrids of *Ribes*, hybrids between *Fragaria* and *Potentilla*, and the confirmation of chromosome numbers in *Ribes* polyploids and *Rubus* progenies.

During recent years we have tested several methods of applying the cytological techniques most often used by plant breeders and others in research stations like Mylnefield. The aim has been to select for general use those rapid and cheap methods which give a high frequency of successful squash and smear preparations. Some of the older standard methods of examining chromosomes can now be improved upon, or even replaced by, equally satisfactory but faster techniques. These modern and rapid cytological methods have now been collected together as part of a book which it is hoped will find a gap in contemporary technical literature.[1] (G. Haskell, A. B. Wills.)

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(Paper read at the XIth International Congress of Genetics, at The Hague.)

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(Paper read to Systematics Association, at Leicester University.)

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(Demonstration given at the XIth International Congress of Genetics, at The Hague.)

[1]Haskell, G., and Wills, A. B. *A Primer of Practical Cytology*. (To be published shortly.)

VIROLOGY

C. H. CADMAN

Transatlantic crossings were fashionable in the Institute this year, and the Virology Department was no exception. In April Dr. C. E. Taylor returned from Davis, California, after spending a year there in the Nematology Department at the University of California. At about the same time, Mr. R. M. Lister left to spend a year working in the Department of Botany and Plant Pathology, Purdue University, Indiana, in co-operation with Dr. J. B. Bancroft and Dr. J. R. Shay on virus diseases of apple, this being part of a project financed by the National Science Foundation. Later, a three-month extension of his stay was officially sanctioned to enable him to complete some of his researches. Also in April, Dr. C. H. Cadman went at the invitation of the National Research Council, National Academy of Sciences, to a symposium on the biological control of soil-borne pathogens, held in the University of California, Berkeley, and afterwards visited research centres and university departments in the U.S.A. and Canada.

It was therefore a special pleasure to receive three American visitors during the year, all of them members of the staff of the University of California: Professor D. J. Raski, Davis, in transit from India; Dr. S. J. van Gundy, Riverside, who attended the 7th Symposium of the Society of European Nematologists at Ayr in September, and Dr. R. N. Campbell, Davis, who joined the A.R.C. meeting of plant virus workers held this year at Rothamsted Experimental Station, also in September. Members of staff also took part in each of these meetings, and after the Nematology Symposium entertained a group of European delegates at Mylnefield. Dr. G. Martelli of the University of Bari, Italy, spent two weeks here prior to the Rothamsted meeting.

In October Mr. R. M. Lister was awarded the degree of Ph.D. *in absentia* by the University of St. Andrews for a thesis based on his research on strawberry viruses and virus diseases.

In other respects the year was a frustrating one. Weather conditions usually figure in other departmental reports though not in ours, but the problems posed by work on certain viruses, notably those infecting carrot and fruit trees, this year made us acutely aware of the limitations imposed by summer conditions in the glasshouse on the sensitivity and susceptibility of test plants to virus infection. Productive work with some kinds of viruses is possible only during the winter and early spring, and there is need to know why this is so. In addition, we suffered a series of disasters which deprived us of test plants at a vital time of year. One of these, caused by the application of simazine to the ash floors of the glasshouses, deserves publicity because it does not seem generally known that this compound volatilizes when deposited on warm surfaces. Concentrations which are without effect when watered on to growing plants are rapidly toxic when absorbed

through the leaves. Toxic effects persisted for two months after the initial application until, on the advice of Dr. T. J. Sheets of the United States Department of Agriculture, Beltsville, the houses were drenched with a suspension of activated charcoal. Persistent and heavy attacks on young plants by the larvae of fungus gnats (*Bradysia* sp.) have become increasingly troublesome but we seem to have achieved reasonable control by fortnightly fumigation of the glasshouses with nicotine and watering of pots with TEPP.

NEMATODE-BORNE VIRUSES

Ecology

The spread of viruses in crops usually reflects the activities of the organisms that transmit them, but this concept is probably misleading when applied to the spread of nematode-transmitted viruses. Closer acquaintance with outbreaks of diseases caused by viruses transmitted by *Longidorus elongatus* suggests that spread reflects the progress of the viruses through a relatively static population of nematodes and not the active movement of infective vectors from plant to plant. Healthy plants may become infected simply through their roots intermingling with those of infected plants and their attendant population of infective nematodes. Once infected, such plants in turn serve as sources of infection for nematodes and neighbouring plants. Thus, the apparent rate of spread of virus through the crop may bear little or no relation to the rate of movement of the nematodes themselves through the soil. In trying to understand and control the spread of nematode-borne viruses in the field, it is essential to know something of the factors affecting the inter-relationships between the nematodes, the plants they feed on and the viruses they transmit. With *L. elongatus* some progress has been made in unravelling these associations.

The likelihood of crops becoming infected by viruses increases with the size of the vector population, and hence the rate at which *L. elongatus* multiplies on plants of different kinds is of some consequence. Strawberry and raspberry commonly become infected with raspberry ringspot and tomato black ring viruses but differ considerably as hosts for the nematode: in infected strawberry crops there may be as many as one *L. elongatus* per gram of soil, whereas in infected raspberry crops the populations of the nematode are commonly less than three per 100 gm. Pot tests with a range of species in the glasshouse have shown that sugar beet and turnip, commonly used as bait plants for detecting the presence of the viruses in soils, are indifferent hosts for the nematode, whereas chickweed (*Stellaria media*) and ryegrass (*Lolium perenne*) are good ones. On raspberry, *L. elongatus* feeds but reproduces at a very low rate, if at all. Thus, the extensive outbreaks of virus which occur in raspberry are a legacy from previously infected crops such as strawberry or a ryegrass ley. The wide host ranges of the viruses and the nematode preclude crop rotation as a control measure, but some effective manipulation may be possible because not all plants that are good hosts for *L. elongatus* are susceptible to the viruses. (C. E. Taylor, A. M. Yassin.)

Transmission

L. elongatus can survive for several months in moist soil even when denied access to plants, but infective populations lose their capacity to transmit virus within about 8 weeks. Experiments with raspberry ringspot virus have shown that nematodes which had fed on infected plants remained able to transmit the virus to healthy plants for periods as long as 5 weeks.

Preliminary work on the mechanics of transmission of raspberry ringspot and tomato black ring viruses has shown that the gut contents of larval and adult *L. elongatus* taken from virus-infected plants contain sufficient virus to be detectable by mechanical transmission to herbaceous test plants. Virus was detectable for longer in living nematodes than in dead ones when both were kept at 20°C., but has been detected for up to 6 weeks in dead nematodes kept frozen. It remains to be seen what role, if any, this virus plays in the transmission process. It is, however, interesting that *Xiphinema diversicaudatum* fed on raspberry ringspot-infected strawberry failed to transmit the virus and that no virus was detectable in the gut contents. As vector specificity is a feature of the transmission of antigenically distinct strains of raspberry ringspot and tomato black ring and, indeed, of other viruses of this group, it would be interesting to know whether *Longidorus* spp. ingest viruses and virus strains which they are unable to transmit.

Two other species of *Longidorus, L. goodeyi* and *L.* (near) *leptocephalus* (det. D. Hooper) have been found locally, but there is no evidence yet that either of these transmits raspberry ringspot or tomato black ring viruses. (C. E. Taylor.)

Control

There is much evidence to show that varieties of raspberry immune from infection by raspberry ringspot and tomato black ring viruses when inoculated by grafting are also immune from infection by these viruses in the field. Lloyd George is one such, and despite the fact that this variety has often been grown on land containing both these viruses, no evidence of breakdown of immunity has been known until last year. An outbreak of a ringspot-like disease in Lloyd George, found at a smallholding at Coupar Angus by Mr. D. H. Turner of the Edinburgh and East of Scotland College of Agriculture, proved to be caused by an unusual form of raspberry ringspot virus. The disease is almost certainly identical with one found in 1943 in this same area and which has not since recurred. (C. H. Cadman.)

In herbaceous hosts the virus causes exceptionally mild or no symptoms, but serologically it is indisguishable from other Scottish isolates of raspberry ringspot virus. Mild and severe forms of this virus commonly occur together in soils, and there is evidence that the Lloyd George isolate becomes more virulent after passage through certain hosts. It remains to be seen whether these differences in virulence are associated with pathogenicity towards the variety Lloyd George. This kind of variation in virulence and pathogenicity is not unexpected; the surprising thing is the apparent rarity and localization of a variant able to infect a variety of raspberry, normally immune, which has been widely grown in infected soils. Only *L. elongatus*

was found in soil from the Coupar Angus outbreak, and tests so far made indicate that it is probably a vector of the Lloyd George virus. (A. F. Murant, C. E. Taylor.)

Chemical treatment of soil to control *L. elongatus* and the viruses it transmits has proved eminently successful. In the experiment at Coupar Angus, where various treatments were applied in autumn 1960, plots of Talisman strawberry planted in spring 1961 on land treated with DD (400 lb./acre) or with PCNB (1,200 lb./acre) are still virtually free from virus infection and have only small populations (20 per 500 gm. soil) of *L. elongatus*. Those planted on untreated soil are now almost entirely virus-infected and have nematode populations approaching one *L. elongatus* per gram of soil. A striking feature of this experiment is the evident slowness with which nematodes and viruses have moved into the treated plots from adjacent untreated ones. The dosage of PCNB used—that normally recommended for fungicidal purposes—is hopelessly uneconomic, but the method of application—rotavation of a granular material into the top-soil—is simple, and tests to determine the minimum efficient rate of application are being made. Work being done to investigate the mode of action of PCNB as a nematicide has shown that a residual toxic effect persists for at least 8 weeks in soil, and that toxicity is inhibited at low temperatures. Other field experiments have been started to test the effects of herbicides as means of decreasing the population of virus-infected weed seeds in soils. (C. E. Taylor, A. F. Murant.)

CHYTRID-BORNE VIRUSES

In all cases where the experiment has been made, air-drying abolishes the infectivity of soil containing nematode-borne viruses because it kills the nematodes themselves. By contrast, soils containing lettuce big vein or tobacco stunt, viruses which are transmitted by the chytrid fungus *Olpidium brassicae*, retain infectivity for long periods when dried. With lettuce big vein, there is evidence that this is because the virus survives within the resting sporangia of the fungus. It has been suggested that tobacco necrosis virus, the transmission of which is also associated with *O. brassicae*, might persist in soils in a similar fashion. However, this idea finds no support from the results of tests made with lettuce roots, infected with both *O. brassicae* and tobacco necrosis virus, which were air-dried for 9 weeks. An extract of these roots containing resting sporangia of the fungus was added to pots of lettuce seedlings. Tests on these bait plants three weeks later showed that *O. brassicae* was present in pots to which the root extract had been added, but tobacco necrosis virus was not detected in any.

Tests with two isolates of *O. brassicae* (isolates 1 and 2), which differ slightly in host range, confirmed those reported last year in showing that isolate 2 transmits tobacco necrosis virus to cress, lettuce and other bait plants, whereas isolate 1 does not. There is some evidence to suggest that zoospores of the two isolates carry net opposite charges under comparable experimental conditions, and attempts are being made to determine their electrophoretic mobilities.

In the light of what is now known about tobacco necrosis virus and its transmission, it seemed worth while to re-investigate the nature of Augusta disease, outbreaks of which cause heavy losses in some varieties of forced tulips. Whether the disease develops only in bulbs which are infected with tobacco necrosis virus when planted, or results from a current-year infection, has never been established, and the events which lead to disease outbreaks are still unknown. Observations so far are confusing. Only in one of four outbreaks examined during the past season was tobacco necrosis virus isolated from the soil and *O. brassicae* also isolated both from the soil and from tulip roots. Of 10 different varieties grown in this soil only one, Princess Beatrix, became diseased, although virus was present in low concentrations in some bulbils and leaves from disease-free varieties and also in leaves from symptomless plants of Princess Beatrix. By contrast, repeated attempts at two other nurseries failed to detect *O. brassicae* or tobacco necrosis virus either in soil from boxes in which tulips had become necrotic or in plants or soil from the field site whence the boxes had been filled. At one of these nurseries virtually the entire stock of the variety Korniforos became diseased in 1962/63, yet neither the disease nor virus infection occurred in the subsequent season's planting of the same variety into soil from the same source. (W. P. Mowat.)

APHID-BORNE VIRUSES

Raspberry

Following public concern at the diminution of supplies of virus-free raspberry stocks, the propagation programme has again been reviewed and a revised plan agreed to in consultation with the Department of Agriculture and Fisheries. The Institute has been commissioned to find a suitable site, free from sources of virus infection, where a proportion of the virus-free plants now produced in limited quantity under glass at Mylnefield may be field propagated for ultimate distribution to fruit-growers. This should materially improve the present position, but the first harvest of cane will not be available until autumn 1965. (J. Chambers.)

Carrot and other Umbellifers

Very little motley dwarf disease was seen in carrots in Angus in 1963, and at Mylnefield the populations of *Cavariella aegopodii* did not exceed 10 aphids per plant in mid-July, after which they declined rapidly following heavy rain (which washed the aphids off the plants) and attack by predators. In Morayshire, young carrots at the cotyledonary to second-rough-leaf stage became heavily infested and the crops were severely retarded until systemic insecticides had been applied.

At Mylnefield, batches of 100 potted carrots were exposed in a carrot crop at fortnightly intervals during the growing season, but none became infected with virus. A few colonies of the aphid were found on willow: winged nymphs appeared in early June and winged adults by mid-June, and the first aphids were found on carrot on 19 June. Field observations suggest that, on carrot, all generations of *C. aegopodii* except the first produce an appreciable proportion of winged forms. This feature, and the tendency

for the apterous adults to move readily from plant to plant within the crop, seem likely to result in a rapid spread of virus within the crop once infection has been introduced.

Following a successful pilot experiment in 1962, twelve carrot varieties were compared for tolerance to the effects of motley dwarf disease in a field trial in collaboration with the Vegetable Crops Department. In mid-July, infective *C. aegopodii* were released on plots of each variety, under muslin cages, and killed 7 days later by spraying the plants with demeton-methyl. Comparison of the yields of roots from infested and untreated plots revealed decreases in yield varying from 8 per cent. in a Flakee type to 47 per cent. in a Chantenay type of carrot. Although, in general, Chantenay types were less tolerant of infection than Flakee types, one Chantenay type—Clucas New Stump Rooted—was more tolerant than some Flakee types. This is of interest locally, because Chantenay types are almost exclusively grown for the canning industry. There was good correlation between foliage symptoms, assessed by leaf coloration, and the percentage reduction in yield, but none between the vigour of the haulms, assessed by height, and the susceptibility of a variety. Further trials are planned in connexion with the carrot breeding programme of the Vegetable Crops Department.

Carrots with motley dwarf disease contain two viruses, one of which, red-leaf virus, is not sap-transmissible and whose presence seems necessary before aphids can efficiently transmit the second, sap-transmissible component of the disease, carrot mottle virus. From November to February in the glasshouse, infected plants become virtually symptomless, and during this period aphids are unable to transmit either virus from plants known to contain them. Symptoms rapidly re-appear, and the ability of aphids to acquire the viruses is restored, if the plants are given supplementary light. Judging from infectivity tests, the concentration of carrot mottle virus in infected carrot plants is not affected by light, and it is presumed that the effect of inadequate light is to decrease the concentration of carrot red-leaf virus and thereby interfere with the transmission of carrot mottle virus.

Progress in the purification of carrot mottle virus has been hampered by difficulties in assaying the virus during the summer months, when *Chenopodium quinoa* plants fail to produce countable local lesions. Infective fractions are recoverable from density-gradient columns, but so far no specific virus-like particles have been detected in these, possibly because of the presence of excessive amounts of non-viral host plant material.

Carrot mottle virus has not been found in any wild umbellifers in Scotland, but a virus which may be red-leaf virus has been transmitted by *C. aegopodii* from *Anthriscus sylvestris*. Two sap-transmissible viruses have also been isolated from this plant. One of these infects *C. quinoa*, and occasionally *C. amaranticolor*, systemically. Of other herbaceous plants tried, only parsnip and chervil became infected. The virus has filamentous particles and is serologically related to, but distinct from, raspberry bushy dwarf virus (see below). Attempts to transmit this virus by means of *C. aegopodii*, *Myzus persicae* and *M. ascalonicus* all failed.

The second sap-transmissible virus from *Anthriscus* causes local lesions in *C. quinoa* and *C. amaranticolor*, infects spinach, chervil, parsnip

and *Claytonia perfoliata* systemically, and sometimes infects *Nicotiana clevelandii* and tomato. It is transmitted as a persistent virus by *C. aegopodii* and in many respects resembles a virus isolated from parsnip. The properties and relationships of these viruses are being studied. The parsnip virus has isometric particles and does not protect plants from infection by carrot mottle virus. (A. F. Murant, R. A. Goold.)

OTHER VIRUSES

Raspberry Bushy Dwarf

Sap-transmissible viruses with characteristic filamentous particles resembling those of sugar beet yellows virus have now been isolated from apple, pear, plum, cherry, raspberry, *Anthriscus sylvestris* (see above) and various ornamental Prunus species, including *P. amygdalus* and *P. pissardii*. We have also isolated viruses of this kind from apple material sent from Indiana, U.S.A., by Dr. J. B. Bancroft, and received others isolated from peach and cherry in Switzerland by Dr. F. Pelet, of Nyon, and from apple by Dr. O. de Sequera, of East Malling Research Station.

On symptomatology in herbaceous hosts and properties *in vitro*, all these isolates can be assigned to one of two groups. Isolates of the first group, typified by those from raspberry, are readily sap-transmissible to a variety of herbaceous plants, including *Chenopodium* spp., *Nicotiana clevelandii*, *N. tabacum*, cucumber, French bean, *Petunia hybrida* and *Claytonia perfoliata*. They retain infectivity in sap at 20°C. for about 48 hrs. and have thermal inactivation points around 60°C. Isolates of the second group, typified by the isolate from *P. pissardii*, have limited host ranges (virtually restricted to *Chenopodium* spp., sugar beet, spinach and *Claytonia perfoliata*), rapidly lose infectivity in sap at 20°C., and have thermal inactivation points near 50°C.

Tube precipitin tests with antisera prepared by injecting rabbits with virus preparations made from *C. quinoa* or *C. amaranticolor* have confirmed the results reported last year. These indicate varying degrees of antigenic relationship both within and between the two groups of isolates. Exceptions are the viruses from Switzerland and East Malling, which seem distinct, though in properties and symptomatology they resemble isolates of the raspberry type. The technical difficulties of producing specific antisera to these filamentous viruses are considerable, and much further work is needed to clarify the relationships which current results suggest.

This work, begun in an attempt to solve a problem in raspberry, has expanded in unforeseen directions, but the basic problem, the mode of spread of raspberry bushy dwarf virus in raspberry, is still unsolved. Such evidence as there is suggests that the virus spreads from some alternative host to raspberry, and that spread within susceptible raspberry varieties occurs fairly rapidly. For various reasons an insect vector is suspected, but attempts to find one have failed. The attempts made last season confirmed that neither of the two aphid species common on raspberry (*Aphis idaei* and *Amphorophora rubi*) transmit, though *A. rubi* proved itself an efficient vector of sugar beet yellows virus. Tests made with mites (*Eriophyes gracilis* and *Tetranychus telarius*) also failed. Field experiments have now been

started which are planned to yield information on the mode and time of spread of the virus. (C. H. Cadman.)

The results of collaborative work done at Purdue University, Indiana, U.S.A., are summarized below. (R. M. Lister.)

Using leaf material kindly sent from Gainsville, Florida, by Dr. W. C. Price, we have confirmed the observations of Brazilian workers that Tristeza disease of citrus, caused by an aphid-borne virus, is associated with the presence of long filamentous particles which in structure resemble closely those of sugar beet yellows and raspberry bushy dwarf viruses. The particles from citrus are commonly about 2 μ long, but as this virus has not been mechanically transmitted it is not known if this is the 'normal' infective length of the particle. Particles of all three viruses are 10 mμ wide and appear to be loose helices with a periodic structure which repeats at intervals of about 40 Å. (C. H. Cadman, J. Cathro.)

PUBLICATIONS

Research Papers

Cadman, C. H. (1964). Pathogenicity by soil-borne viruses. (In *Ecology of Soil-borne Plant Pathogens—Prelude to Biological Control.* University of California Press.) (In press.)

(This is a review article summarizing information on soil-borne viruses with special reference to their ecology and control by biological means.)

Holliday, P.,[1] and Mowat, W. P. (1963). Foot rot of *Piper nigrum* L. (*Phytophthora palmivora*). Phytopathological Paper No. 5, Commonwealth Mycological Institute, Kew, Surrey.

(This memoir reports work done on the foot rot disease of black pepper in Sarawak.)

Lister, R. M. (1964). Strawberry latent ringspot: a new nematode-borne virus. *Ann. appl. Biol.*, **54**, 167-76.

(Outbreaks of a previously undescribed virus occurred in raspberry in Northern Ireland and in strawberry in Hampshire in association with arabis mosaic virus, from which it was differentiated by serological means. This virus has been found infecting plum and also cherry, both in Britain and Switzerland. It causes characteristic symptoms only in cucumber and *Chenopodium* spp., and seems to cause none in other herbaceous hosts or in the crop plants in which it was found. Like arabis mosaic virus, strawberry latent ringspot virus is transmitted by *Xiphinema diversicaudatum*, and it shares many properties with, though is district from, other nematode-borne viruses.)

Lister, R. M., Bancroft, J. B.[2] and Nadakavukaren, M. J.[2] (1964). Characteristics of filamentous viruses isolated mechanically from apple. (Abs.) *Phytopathology*, **54**, p. 899.

[Viruses of two types were isolated in *Chenopodium quinoa* Willd. by inoculation of neutral buffered extracts from flowers and leaves of apple trees containing 'latent viruses' (entities characterized by the diseases produced on woody indicator plants infected by grafting). They were partially purified by ultracentrifugation from sap clarified by mixing with about one-sixth volume of a 1 per cent. suspension of crude bentonite in water. Such preparations contained mainly phytoferritin and fraction 1 protein together with virus, which was separated from these normal constituents by rate-zonal centrifugation. Infective particles sedimented (i) 0·523 ± ·023 times the rate of TMV for type 1 isolates, which were only

obtained from sources of chlorotic leaf spot disease (CLS) and which caused CLS when introduced into Russian apple R12740-7A, and (ii) 0·643 ± ·014 times the rate of TMV for type 2 isolates, which were from sources of stem-pitting disease of Virginia crab. Type 1 particles were flexous filaments generally 12 × 500-700 mμ and had a half-life at 45°C. of about 12 min. Type 2 particles were flexous filaments 12 × 619 ± 14 mμ and had a half-life at 45°C. of 1·67 hrs. These data and results of serological tests provide evidence that types 1 and 2 viruses are unrelated.]

LISTER, R.M., BANCROFT, J. B.,[2] and SHAY, J. R.[2] (1964). Chlorotic leaf spot from a mechanically transmissible virus from apple. *Phytopathology*, **54**, 1300-1.
[A sap-transmissible virus of type 1 (see above), isolated in *Chenopodium quinoa* from apple carrying chlorotic leaf spot disease of Russian apple R12740-7A, was successfully back-transmitted by grafting to a seedling apple, and from this to Russian apple R12740-7A, causing chlorotic leaf spot disease.]

TAYLOR, C. E., and RASKI, D. J.[3] (1964). On the transmission of grape fanleaf by *Xiphinema index*. *Nematologica*, **10**, 489-95.
[Grape fanleaf virus persists for long periods in the long-lived adult female life-stage of the vector, *Xiphinema index*, but the virus does not persist through the egg or through the moult. This is in common with other NEPO viruses (i.e., nematode-transmitted viruses with polyhedral particles) but there is evidence to suggest that the mechanism of virus transmission differs basically between *Xiphinema* and *Longidorus* vectors.]

OTHER PUBLICATIONS

CADMAN, C. H. (1964). Virus diseases of apples and pears. (Book review.) *Nature, Lond.*, **202**, p. 1257.

CADMAN, C. H. (1964). Ecological aspects of soil-borne viruses. *Trans. Brit. mycol. Soc.*, **47**, 461.

TAYLOR, C. E. (1963). Symptoms of virus diseases in plants. (Book review.) *Eur. Potato J.*, **7**, p. 74.

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[3]Nematology Department, University of California, Davis, Calif., U.S.A.

MYCOLOGY

A. R. Wilson

The number of the staff was reduced during the year by the absence of Dr. Jarvis, who left in June to spend six months working under Professor C. E. Yarwood in the Plant Pathology Department of the University of California at Berkeley. His work there on the physiology of powdery mildews was supported by a grant from the National Science Foundation. The Department has gained considerably from his experiences at Berkeley and from the information he obtained during private visits to numerous research centres in the United States and Canada.

Dr. Correia left in September to return to Portugal, and Miss I. G. Stockdale was appointed Scientific Assistant in his place. It was with the greatest regret that the Department parted after nearly six years with Miss H. B. Oswald, who left in March to be married.

During his visit to North America Dr. Jarvis led seminars at Berkeley and Davis in California, at Corvallis in Oregon and at London in Ontario, and attended the Western Small Fruit Pathologists' 1964 Conference at Portland, Oregon.

In February Dr. Wilson and Dr. Jarvis attended a symposium on *Botrytis cinerea* at East Malling Research Station, during which both read papers. In April Dr. Wilson attended a Council Meeting of the European Association for Potato Research at the Station de Recherches de l'Etat pour l'Amélioration de la Pomme de Terre, Libramont, Belgium, and afterwards visited Wageningen in connexion with his duties as joint editor of the *European Potato Journal*. In September Dr. Wilson and Miss Glendinning attended the Second Triennial Conference of the European Association for Potato Research, held at Pisa, Italy. During the winter Dr. Wilson gave a series of eight lectures on potato storage for the Potato Marketing Board at various places in Scotland from Berwickshire to Ross-shire.

Facilities were again provided as required for Mr. Dickens (Queen's College, Dundee) in connexion with his work on stamen blight of raspberries, and for Mr. Rubens (The Edinburgh and East of Scotland College of Agriculture) in connexion with his work on the etiology of raspberry die-back.

Among the many who assisted the Department during the year were: Dr. A. M. Paton, University of Aberdeen; Miss A. Adam, Queen's College, Dundee; Mr. I. G. Cumming and Mr. D. F. Leach, British Jute Trade Research Association, Dundee; Mr. M. D. Henderson, Aberfeldy; Mr. J. G. H. Fenton, Perth; Mr. Robert Niven, Essendy, and Mr. W. D. Soutar, Kirriemuir. Sincere thanks are due to Ciba Clayton Ltd. for samples of optical brighteners and to various firms for the supply of fungicides and other materials.

GREY MOULD OF TOMATO

Stem Infection by Botrytis cinerea

In continuation of work reported last year, plants growing in the glasshouse border were deleafed to a height of 4 ft. in mid-June and the scars inoculated with dry spores of *B. cinerea* or with a suspension of spores. There was no significant difference ($P < 0{\cdot}05$) between the numbers of plants infected by these methods (24/30 and 17/30 respectively), but they both differed significantly ($P < 0{\cdot}01$) from the number of infected plants in the uninoculated control (4/30), the latter figure indicating the background level of chance infection. The type of inoculum had no apparent effect on the amount or duration of latent infection.

The mechanism whereby spores applied dry to deleafing scars enter the xylem vessels was studied. Change in vascular pressure from negative to positive, induced by moving plants from a glasshouse environment into an almost saturated atmosphere, led to exudation of water from petiole stubs and to the passing into suspension of dry spores previously applied to their cut ends. Return of the plants to the original environment again reversed the vascular pressure and the exudate was resorbed. Examination at this time showed the presence of considerable numbers of spores in the xylem vessels below the inoculated surfaces. Sections through stubs from similarly inoculated plants in which the vascular pressure had remained negative showed only occasional spores in the vessels. Because of the dangers of introducing stray spores during processing of the material, it is uncertain whether the few spores found in the vessels of the latter group of plants had been drawn in from the inoculated wound surfaces prior to the removal of the stubs for fixation and sectioning.

The usual method of deleafing under commercial conditions is to break-off the petiole at its junction with the stem; a knife is less frequently used. The relative susceptibility to infection by *B. cinerea* of the two types of scar was examined, using a dry spore inoculum. No difference was found under the conditions of the experiment, which, however, involved the use of a much heavier inoculum than would be met with under natural conditions. The best method of deleafing is that which leaves fewest snags (fragments of tissue) attached to the scar, as these die and invariably lead to infection of the stem from the saprophytic base so provided.

In a preliminary experiment it was found that one-month-old plants in 5 in. pots, grown-on for a further two months in soil kept permanently moist, were highly susceptible to infection by *B. cinerea* when deleafed and inoculated; 5/10 plants showed lesions within one week and 10/10 within two weeks. Similar plants grown-on in soil maintained as dry as possible prior to deleafing and inoculation proved considerably more resistant; no plants showed lesions in the first week, only 3 in the second week and only 6 by the end of the fourth week, when the experiment was terminated.

Control

A 1 per cent. w/v water (+0·1 per cent. wetter) suspension of TMTD (98 per cent.), having a particle size roughly comparable to that of spores of *B. cinerea*, gave good control of infection in the glasshouse border when applied by brush to fresh deleafing scars prior to inoculation with dry

spores. Equally good control was obtained by applying the TMTD after inoculation with spore suspension. The addition of 30 per cent. v/v of a plastic transplanting spray concentrate to the TMTD suspension, for the purpose of sealing-off the cut ends of the xylem vessels, did not improve the level of control obtained. (A. R. Wilson.)

STAMEN BLIGHT OF RASPBERRY

This disease is now of considerable importance in raspberry plantations in the counties of Angus and Perth. Since the life-cycle of the causal fungus, *Hapalosphaeria deformans* Sydow, is little understood in any host, it is being investigated in detail in the raspberry preparatory to the devising of control measures.

The fungus overwinters on the young canes, probably in the axillary buds. Late in the following spring, before the flower buds open, it invades the stamens and to a certain extent the carpels.

Spore dispersal has been studied and the disease appears to be spread mainly by spores being washed from the diseased flowers on to the young canes below. There is no evidence that dissemination of the spores by wind, insects or pickers is important, and it is suggested that the planting of cane from affected fruiting plantations is the major factor in the spread of the disease.

Attempts to infect raspberry canes artificially have so far been unsuccessful, and the process of natural infection is not yet well understood. Spray trials have been carried out in collaboration with the local advisory officers to find a fungicidal control method, but the results are not yet available. The removal of fruiting canes before flowering has been demonstrated as an effective, if drastic, control measure. (J. S. W. Dickens[1].)

BACTERIAL CANKER OF PLUM

Studies continued on the vital staining of bacteria with fluorochromes and optical brighteners as a means of tracing their movement in plant tissues. Two isolates of *Pseudomonas mors-prunorum*, one of *Ps. syringae* and one of *Ps.* sp. (*fluorescens* group) took up acriflavine, primulin and uranin reversibly, and these dyes have now been discarded in favour of diaminostilbenes, substituted methylaminocoumarins and similar compounds[2]. All of these latter compounds were absorbed readily from media containing sublethal concentrations, and after repeated washings the bacteria fluoresced intensely in u.v. light. On subculturing, the stained organisms continued to divide and fluorescence was retained through several generations.

Leaf laminae were removed from both plum and French bean and the stained bacteria were applied to the cut ends of the petioles. When fresh sections were cut a few minutes later and examined by fluorescence microscopy, the organisms were found in the xylem vessels and surrounding tissues at least 5 cm. from the cut surface. The bacteria fluoresced an intense yellow-green against the red auto-fluorescence of the host tissue.

Parallel investigations are being made with *Botrytis cinerea* and other fungi. (H. M. Wilson.)

[1]Queen's College, Dundee. [2]Supplied by Ciba Clayton Ltd.

DISEASES OF POTATO CAUSED BY *RHIZOCTONIA SOLANI*

Black Scurf

Inoculation experiments with 45 isolates of *R. solani* from sclerotia on potato tubers confirmed that very few isolates from this source are more than very mildly pathogenic to wheat (see 1962-63 Report). Further attempts to develop a satisfactory method of inoculating potato sprouts were unsuccessful, but in a preliminary trial of a detached leaf inoculation method recently described by Hadley and Harvais [*Eur. Potato J.*, (1963), **7**, 72 - 73], results were obtained which support the suggestion that this test may prove valuable for assessing the pathogenicity of isolates of *R. solani* to potatoes. All of the nine isolates from sharp eyespot of wheat which were tested gave a negative reaction, three isolates from potato sprout lesions were all strongly positive, while the reaction produced by the 45 isolates from sclerotia on tubers varied from negative to strongly positive, a large majority being positive to some degree. (A. R. Wilson.)

Stolon Infection

The presence of stolon infection by *R. solani* in the field and its ability to sever the tuber from the parent plant was confirmed, although the incidence of this form of attack was low.

The cropping performance of seed tubers of the variety Majestic, substantially free from black scurf and dipped in methoxyethyl mercury chloride five weeks before planting, was compared with that of similar tubers inoculated shortly before planting with sterilized beet seed infested with *R. solani*. The inoculated tubers gave a significantly smaller crop: tuber number was reduced mainly in the seed and chat grades ($2\frac{1}{4}$ in. $\times$ $1\frac{1}{4}$ in. and $< 1\frac{1}{4}$ in. respectively) and tuber weight particularly in the chat grades.

Direct inoculation of stolons was unsuccessful. Attempts to link attack to the stage of growth of the potato plant by inoculation of the soil at intervals after planting gave no definite results.

Simulation of the results of attack by pruning stolons when the plants were just starting to flower led to a loss in yield but an increase in the number of tubers. There was a decrease in the number and weight of tubers in the seed grade and an increase in the number and weight of chats. (D. Glendinning.)

STORAGE OF POTATOES FOR PROCESSING

No progress was made during the year because of deterioration in the stored crop, which necessitated clearing the store early in the season. This deterioration was not connected with storage conditions but appeared to be linked with the extensive blackleg infection prevalent in this and many other crops in Scotland during the growing season. (A. R. Wilson[1].)

PRE-EMERGENCE FAILURE IN PEAS

Hollow Heart

Hollow heart in peas is a physiological disorder which affects the adaxial surface of the cotyledons and becomes apparent only after the seed has germinated. Although similar to marsh spot, it is distinguished by a normal

[1]In collaboration with the Agricultural Research Council's Ditton Laboratory.

manganese content in the seed and the absence of a brown discoloration before germination. In partially sterilized potting compost it does not prevent germination or the production of normal seedlings, although it may be one of the predisposing factors in pre-emergence failure in field soil.

In germinated seed, cells of the abnormal tissue were dead. When affected cotyledons were inoculated, *Botrytis cinerea* caused a general rot but *Ascochyta* spp. pathogenic to peas were restricted to the area of the hollow heart. Unidentified bacterial contaminants were invariably involved in the general breakdown of the cotyledons in unsterilized media. The number of seeds developing hollow heart varied according to the conditions of germination. For example, the average incidence in four samples was 12 per cent. in moist, partially sterilized potting compost and 38 per cent. after soaking in water for 24 hours at room temperature and germinating in a humid atmosphere. The incidence was reduced by soaking seeds in solutions of mannitol or removing them from water before they were fully turgid. These observations, together with the absence of visible abnormalities on the seeds before soaking, indicate that the cells die during or after water absorption. A high incidence of hollow heart was correlated with a large water uptake before germination, and it is suggested that cotyledon cells predisposed to the condition are killed by excess of water.

Young plants of the variety Thomas Laxton, grown from seed with hollow heart, were shorter and lighter in weight than those grown from normal seed. Four-day-old seedlings of the same variety with hollow heart developed more extensive cortical rot following inoculation with mycelial suspensions of *Ascochyta pinodella* and *Mycosphaerella pinodes* than did normal seedlings. Inoculation with *A. pisi* had no effect in either case. (D. A. Perry.)

MISCELLANEOUS

The Ascochyta *complex in Peas*

During the 1963 season, leaf and pod spot and foot rot, caused by *Ascochyta pisi, A. pinodella* and *Mycosphaerella pinodes*, were common on local pea crops following excessively wet weather. Although *A. pisi* caused extensive lesions on pods, very few seeds were discoloured when harvested for canning or freezing. Techniques for inoculating the fungi to the foliage, pods and foot region have been developed and will be used to determine the relation of the pathogenicity of the isolates to their taxonomy. Preliminary results of inoculation experiments showed that pea varieties differed in their reaction to each of the fungi. (D. A. Perry.)

Clayburn of Carrots

Clayburn, a physiological disorder which appears only after the roots have been boiled or peeled in 'carbonate lye', is being investigated in co-operation with the Vegetable Crops Department. Although, in the past, the condition has been attributed to anaerobiosis beneath adherent clay or to the action of toxic salts, recent experiments have shown that the lesions develop not beneath clay but at the site of cracked, scurfy areas. The appearance and position of these areas suggest that they may arise when two

roots grow closely together in the soil, but in some soils such scurfy areas are to be found on roots which do not develop clayburn. (D. A. Perry.)

PUBLICATIONS

Research Papers

JARVIS, W. R. (1964)[1]. Thermal and translocated induction of endophytic mycelium in two powdery mildews. *Nature, Lond.*, **203**, p. 895.

[The sub-lethal heat treatment of one of a pair of cucumber cotyledons, before or after inoculation with *Sphaerotheca fuliginea*, or of one of a pair of sunflower leaves before or after inoculation with *Erysiphe cichoracearum*, was followed by the appearance of endophytic mycelium, both in the heated leaf and in the opposite unheated leaf. Heat treatment also predisposed sunflower to infection by *S. fuliginea*, which became endophytic in this host as well, but while cucumber was similarly predisposed to infection by *E. cichoracearum*, there was no endophytic mycelium in this case. Heat treatment also predisposed rust-infected leaves of bean (*Phaseolus vulgaris*) to endophytic infection by *S. fuliginea*. In cucumber, crude sap extracts from both heated and opposite unheated cotyledons, when applied to single cotyledons of other seedlings, predisposed both these and the opposite untreated cotyledons to endophytic infection by *S. fuliginea*.]

PERRY, D. A. (1963)[2]. Interaction of root knot and *Fusarium* wilt of cotton. *Emp. Cott. Gr. Rev.*, **40**, 41-47.

(Fumigation trials and inoculation experiments proved that root-knot eelworm increased the susceptibility of cotton to *Fusarium* wilt. Infection of seedling roots by the eelworm did not result in extensive mechanical damage or necrosis, nor were fungal hyphae attracted to the points of entry of the larvae. The fungus did not colonize egg masses or mature gall tissue in preference to normal tissue. It is suggested that eelworms increase the susceptibility of cotton to wilt by affecting the physiology of the plant rather than by the physical damage done.)

[1]This paper reports work done at the University of California, Berkeley, Calif., U.S.A.
[2]This paper reports work done at the Cotton Research Station, Namulonge, Uganda.

WEST OF SCOTLAND UNIT (AUCHINCRUIVE)

R. D. REID

In 1963 the season was again later than average and suffered from much wet weather during the picking period. Nevertheless, satisfactory crops were harvested from a number of the newer selections.

Mr. R. D. Reid and Mr. A. M. Sutherland again took part in the fruit-growers' annual Open Day at Mylnefield, held this time on 20 July, when Auchincruive strawberry selections in advanced stages of trial were demonstrated to a large gathering of growers. Similar joint demonstrations were given on other dates in July on the occasions of visits to Mylnefield of the Fruit Group of the National Agricultural Advisory Service and of Advisory Officers from the Yorks./Lancs. and Northern Regions of the N.A.A.S.

Mr. Reid gave lectures at a meeting of the Nuclear Stock Association Ltd. in London in March, at a growers' Open Day at Efford Experimental Horticulture Station, Hampshire, in May, and at a growers' meeting in Lanarkshire.

STRAWBERRY BREEDING

General Objectives

The practical aim of all the strawberry breeding at Auchincruive during the past thirty years has been the production of varieties acceptable to the commercial grower and resistant to red core disease. It has been realized for many years that complete immunity from all races of the red core pathogen (*Phytophthora fragariae* Hickman) is a constantly receding objective, because of the disconcerting frequency with which new races of the organism appear. In the long-term sense the idea of ultimate immunity from all races has never been abandoned, but in the short term the practical consideration of producing varieties for early release has made it necessary to accept immunity from some races combined with a high overall resistance to the disease in the field.

In pursuit of the long-term objective much use has been made of octoploid *Fragaria* species, but these have introduced retrograde factors resulting in small and soft-textured fruit. Repeated attempts to break the linkage between the desired hardiness and the inferior fruit characters have been most disappointing. Some of the species hybrids are now in their sixth generation of outcrossing or backcrossing, but although they are approaching nearer to the desired type, none have yet been good enough to introduce as varieties. As parent material for shorter-term breeding we have relied mainly on outstanding seedlings selected here over the years, but occasionally we have drawn heavily on American sources of breeding material. As recorded in past Reports, our breeding programme suffered a serious setback when June Yellows ruined the variety Auchincruive Climax and proved to be present potentially in much of our breeding material. A fresh start had to be made, and our present stocks are based largely on the last ten

years' work. This has involved the handling of considerably more than 100,000 seedlings, and sometimes it takes seven or eight years to clear completely the productions of any single year.

Organization of Testing

It has been customary hitherto to report percentages of seedlings resistant to infection by red core and to give the numbers selected for further observation on the basis of fruiting and other characters. This year it is proposed to examine more generally some trends which have developed in the course of the breeding work. Methods of testing for 'survival' value have been discussed in several previous Reports: basically intended to test for resistance to red core disease, they include the growing of seedlings under glass in concrete benches containing naturally infective soil and the planting-out of seedlings into a field where red core infection has been present for many years. In earlier work all infected plants were discarded, but with the recognition of 'field resistance'—discussed in some detail in the last two Reports—plants found to be infected in the field have often been left *in situ* to fruit as single-plant units, and it is now known that many seedlings actually infected by the causal fungus can still continue to grow and crop satisfactorily. This enables other factors to be taken into consideration jointly with red core. 'Hardiness' may be interpreted as the possession of field resistance to red core combined with the ability to grow successfully on land which has carried strawberries for many successive rotations, and where it may be assumed that other pathogens are present. The latter description would apply to many commercial strawberry growing regions today.

The concentration of testing on land where conditions are highly exacting has, however, required as a necessary adjunct the parallel use of other centres where selections can be tested under less adverse conditions. Co-operation with the National Fruit Trials has existed for about 20 years. Formerly at Wisley, and for the past ten years on very good land at Brogdale in Kent, these trials have provided an opportunity to test advanced selections—sometimes as many as ten at a time—in comparison with existing varieties and with recent selections from breeders in Europe and elsewhere, quite impartially and without the restricting factors of red core or other diseases commonly present in 'old' strawberry land.

The extensive trials at Mylnefield start at a much earlier stage of selection, sometimes—in the case of seedlings of exceptional promise—immediately after the first fruiting of the original plant. About 90 selections were fruited there in 1963 and a further 30 have now been sent. This policy ensures that promising material receives an early and careful assessment on good land which is free from red core, and in a district of lower annual rainfall than Auchincruive.

Another part of the co-operative work at Mylnefield consists of larger-scale replicated trials of the more advanced selections, including, where possible, tests of the effects of post-harvest defoliation. Such trials now provide reliable performance data for use when the introduction of a new variety is under final consideration.

These developments in the testing programme show that whilst the original conception of resistance to red core disease is in no way being disregarded, an increasing recognition is being given to the need for varieties for areas where red core is no problem. In following this trend, effective co-operation has already been established with the Efford (Hampshire) and Rosewarne (Cornwall) Experimental Horticulture Stations of the N.A.A.S., and the way is being prepared for possible participation by other similar stations.

Under the arrangements here outlined, therefore, the seedlings raised in any given year are first subjected to a survival test, and those having a high degree of hardiness or disease resistance are retained for fruiting as single-plant units. The numbers reaching this stage are surprisingly consistent: usually some 4,000 to 5,000 seedlings are fruited each year for the first time. The same consistency does not apply, however, to the numbers selected next as showing sufficient merit to justify more extended trial, nor does the second and subsequent cropping of these selections follow a well-defined pattern. In some seasons we find very few with real promise of all-round merit, and selections are then retained in the knowledge that most of them will have little chance of doing well on their own account. Most of the selections made in such circumstances are chosen for a few special characters which may make them useful as parents in further crossings. Occasionally we have a year in which the proportion of seedlings showing excellent fruiting characters is greatly above normal. Such a year may yield 150 or even 200 selections, all of which require to be grown and observed for three, four or five years. Those which reveal weaknesses are discarded year by year until finally the few left are considered for development as varieties.

Recent Results

The progenies from crosses made in 1954, 1955 and 1956 yielded many selections which required long observation. None quite reached the necessary standard, but it was not until 1963 that a final decision could be made not to develop any of them.

The crosses made in 1957, whose progenies fruited for the first time in 1959, were in a different class and yielded many highly promising selections. From about 12,000 seedlings successfully raised to maturity, some 184 were later retained for their fruiting merits and received increasingly critical scrutiny from 1960 onwards. The first one to be developed was multiplied in 1963 and distributed to growers in March 1964 under the name 'Templar'. A second selection is now being multiplied at Mylnefield, and if the fruiting merits of this are substantiated in 1964 its release should follow within the next two years. Yet a third selection is under consideration as an early variety. In trials up to date this has yielded heavily, been reasonably early, and given fruit of attractive quality. The only problem has been that in some trials too high a proportion of the fruit has been small. The Efford and Rosewarne Experimental Horticulture Stations are co-operating in trials of this seedling, on which it is hoped that a decision will be possible fairly soon. Despite a substantial clearance in 1963, a fair number of selections of

considerable merit still remain from the 1957 crosses. Several more years' work may be required before the future of these can finally be decided.

The 1958 and 1959 crosses were less useful. The selections from them fruited for the second time in 1963 and gave little evidence of yielding successful introductions. Final decisions on these selections are expected in 1964.

From the crosses made in 1960 and 1961 some 4,500 seedlings were fruited as single plants in 1963, and these gave promise of being as useful a source of selections as the 1957 progenies. More than 100 selections were made, and in view of their apparent merit some of them are receiving special priority in multiplication so that their intensive testing at other centres can start as early as possible. These and the selections previously described should be capable of providing varieties for introduction for several years to come. The remaining seedlings from the 1961 crosses and many from the 1962 work will fruit for the first time in 1964.

The most recent crosses made have broken new ground. Following discussions with Dr. D. H. Scott of the United States Department of Agriculture during his visit in 1962, some fourteen selections of American origin were imported in time to use them for pollination in 1963. Some of these selections were sent because of their high disease resistance under North American conditions, others as sources of extra firmness in fruit. The results of this major introduction of new genes into our material are awaited with great interest. (R. D. Reid, A. M. Sutherland, K. C. McConnell.)

MYCOLOGICAL INVESTIGATIONS

Physiologic Races of Phytophthora fragariae

Seventeen strawberry varieties and Auchincruive selections, namely American Aberdeen, Auchincruive Climax, Cambridge Vigour, Huxley Giant, Juspa, Little Scarlet, Oberschlesien, Perle de Prague, Redgauntlet, Royal Sovereign, Siletz, Sparkle, Talisman, Auchincruive No. 6, Auchincruive No. 11 and Auchincruive selections 52AC18 and 53Q13, have been used here in recent years to determine the pathogenicity of isolates of *P. fragariae*. Considerable variation has been found between varieties in the proportion of pathogenicity tests in which any disease escape occurs. This has varied from nil when Huxley Giant and Royal Sovereign have been used to 64 per cent. of all tests in which 52AC18 has been the host (see Table I).

TABLE I

Percentages of pathogenicity tests in which some runners escaped infection

Variety	Percentage	Variety	Percentage
Huxley Giant	0	Oberschlesien	28
Royal Sovereign	0	Cambridge Vigour	31
Juspa	4	Little Scarlet	40
Sparkle	8	Aberdeen	42
Redgauntlet	8	Auchincruive No. 6	44
Siletz	10	Auchincruive No. 11	58
53Q13	11	Perle de Prague	61
Talisman	17	52AC18	64
A. Climax	28		

Huxley Giant and Royal Sovereign have proved very susceptible to all the isolates. Auchincruive No. 6 was previously considered a useful differential host, but, with improvements in the method of testing, it became clear that all the isolates in this collection were more or less pathogenic to it. Most of the isolates are pathogenic to Oberschlesien, Perle de Prague, Little Scarlet and 52AC18, but as a few have been consistently non-pathogenic to Perle de Prague and 52AC18, these two varieties have been of value as differential hosts. The isolates pathogenic to Auchincruive Climax have been found pathogenic also to Redgauntlet, Juspa and Sparkle, and those pathogenic to American Aberdeen have proved pathogenic also to Auchincruive No. 11, Talisman and 53Q13. Differences in pathogenicity between certain isolates previously regarded as identical have been demonstrated, however, by the reactions of Cambridge Vigour and Siletz.

Race classification has thus been based on the pathogenicity of isolates to different varieties and selections, an isolate being rated as pathogenic if it caused a red stele to develop and if it also formed oospores in the root, no

TABLE II

Pathogenicity of races of Phytophthora fragariae

Race	Huxley Giant	Perle de Prague	52AC18	Red-gauntlet	Talisman	Cambridge Vigour	Siletz
1	P	NP	NP	NP	NP	NP	NP
2	P	P	NP	NP	NP	NP	NP
3	P	P	P	NP	NP	NP	NP
4	P	NP	P	NP	NP	NP	NP
5	P	P	P	NP	NP	P	NP
6	P	NP	NP	P	NP	—	P
7	P	NP	P	P	P	P	—
8	P	P	P	P	P	P	NP
9	P	P	P	P	P	P	P

P=pathogenic NP=non-pathogenic —=no result

matter how slight the symptoms of disease. In this way, two years ago, nine pathogenic races were differentiated, and although additional varieties have since been tested, the number of races has remained at nine. The pathogenicity of these races to seven differential varieties is given in Table II. Talisman has never been found susceptible to races 1-6, Perle de Prague to race 7 or Siletz to race 8. Although Redgauntlet and Talisman are derived from the same cross (Climax x NJ1051) they behave differently when inoculated with race 6, which is pathogenic to Redgauntlet but non-pathogenic to Talisman.

Whereas Hickman [*Ann. appl. Biol.* (1962), **50,** 95-103] used Huxley Giant, Perle de Prague, Climax, Talisman, Aberdeen and Cambridge Vigour to differentiate twelve pathogenic races, results with these varieties and the isolates in the present collection have demonstrated only six races. Races 1, 2, 6, 7 and 9 are the same as Hickman's races 1, 2, 3, 11 and 12 respectively. Race 5 has no equivalent in Hickman's classification.

Cultures of six U.S.A. and six Canadian races were received from Dr. R. H. Converse, U.S. Department of Agriculture, Beltsville, Md., and tested

for pathogenicity to sixteen varieties. The full results of this study are not yet available, but those which can now be compared with the results of other workers are given in Table III (p. 84).

Only two of the results with the U.S.A. races show disagreement. In the Auchincruive tests A-2 and A-4 were pathogenic to Perle de Prague, whereas in the North American studies both were non-pathogenic to this variety. There is less agreement between the results with the Canadian races.

New Sources of Red Core Immunity

The only race which was pathogenic to all varieties and selections was race 9 (=isolate 74 of previous Reports) and sources of immunity from it were sought. Although tests detailed below were made with limited numbers of runners, the results suggested that some immunity to race 9 was possible.

Earlier results (see 1962-63 Report, p. 89) had indicated that both Cambridge Vigour and Auchincruive No. 11 might be sources of resistance to race 9, and both were therefore selfed in order to test their progeny. Seven plants from the S_1 and twenty-three from the S_2 generation from Cambridge Vigour did not become infected, while ten derivatives of Auchincruive No. 11 (six from the S_1 and four from the S_2) were also not infected by this race.

Seedlings derived from seed collections of *Fragaria* spp. were similarly tested for susceptibility to race 9, but only three species gave promising results. These were *F. ovalis* from Utah, U.S.A., *F. vesca* from Yugoslavia, and *F. virginiana* from Beltsville, Md., U.S.A. Of seedlings obtained from *F. ovalis* which had been open-pollinated in isolation, only one failed to become infected, but there are now two plants from the S_2 and eight from the S_3 which also reacted in this way. When thirteen of the *F. vesca* seedlings which were immune from race 3 were tested with race 9, two did not become infected. *F. virginiana* was used from three different sources. The first sample consisted of seedlings raised from a seed collection from the Sheldon clone of pistillate plants then growing at Beltsville, Md., and in this case the parent plants were susceptible to race 9, but two seedlings resulting from open pollination, eleven others from the S_2 and another from the S_3 failed to become infected. The second *F. virginiana* seed collection was obtained from pistillate plants of U.S.D.A. 3946 by open pollination. Again the parent plants were susceptible to race 9, but two plants from the S_2 and eight from the S_3 have so far not become infected. The third seed collection of this species was obtained by open pollination from pistillate plants of N3954: these themselves were susceptible, but two plants in the S_2 did not become infected. (I. G. Montgomerie.)

PUBLICATIONS

New strawberry cultivar—'Templar'. *Scot. Agric.*, **43**, 121-2. (January, 1964.)
[This official description of the new strawberry variety Templar was published in accordance with the provisions of the International Code of Nomenclature for Cultivated Plants (June, 1961). The variety was also registered with the appropriate Registration Authority.]

REID, R. D. (1963). Auchincruive strawberry work brings promising selections. *Grower*, **60** (13), 514-15. (28 September.)

TABLE III

Comparison of pathogenicity tests of U.S.A. and Canadian races of Phytophthora fragariae *to six differential varieties*

U.S.A. races	H	PP	C	T	A	CV	Authors	Canadian races	H	PP	C	T	A	CV	Authors
A–1	P	NP	P	NP	NP	NP	P & D	C–1			NP		NP		McKeen
		NP	P		NP		C & S			NP	NP		NP		C & S
	P	NP	P	NP	NP	NP	M		P	P		NP			M
A–2	P	NP	NP	NP	NP	NP	P & D	C–2		P	NP		P		McKeen
		NP	NP		NP		C & S			P	NP		NP		C & S
	P	P	NP	NP	NP		M		P	P	NP	NP	NP		M
A–3	P	P	P	P	P	NP	P & D	C–3		P	NP		P		McKeen
		P	P		P		C & S			NP	NP		NP		C & S
	P	P	P	P	P		M		P	P	NP	NP	NP		M
A–4	P	NP	NP	NP	NP	P	P & D	C–4		P	P		P		McKeen
		NP	NP		NP		C & S			NP	NP		P		C & S
	P	P	NP	NP	NP		M		P	NP	P	NP	NP		M
A–5	P	P	P	P	P	P	P & D	C–5		NP	NP		NP		McKeen
		P	P		P		C & S			P	NP		NP		C & S
	P	P	P	P	P		M		P	P	NP	NP	NP		M
A–6	P	P	P	P	P	NP	P & D	C–6		P	P		NP		McKeen
		P	P		P		C & S			NP	P		P		C & S
	P	P	P	P	P		M		P	NP	P	NP	NP		M

P=pathogenic; NP=non-pathogenic. H=Huxley Giant; PP=Perle de Prague; C=Climax; T=Talisman; A=Aberdeen; CV=Cambridge Vigour. P & D=H. S. Pepin and H. A. Daubney [*Phytopathology* (1964), **54**, p. 241]. C & S=R. H. Converse and D. H. Scott [*Phytopathology* (1962), **52**, 802-7]. McKeen=W. E. McKeen [*Plant Dis. Reptr.* (1958), **42**, 768-71]. M=I. G. Montgomerie.

METEOROLOGICAL RECORDS, 1963

J. SUNDERLAND

All the monthly means of maximum temperature at Mylnefield except that for October were below average. An almost unbroken period of frost and snow lasting from before New Year's Day until the second week of March was followed by cool, rather wet weather for much of the remainder of the year.

Meteorological records from Mylnefield and Auchincruive are summarized in the tables below, the figures for Auchincruive being taken from the Monthly Weather Reports issued by the Meteorological Office. Owing to an interruption in the recording of sunshine at Auchincruive, sunshine figures from Prestwick Airport are given for the months of October, November and December.

AUCHINCRUIVE, 1963

Month	Temperature (°C.)[1]		Rainfall (in.)	Sunshine[2] (hrs.)	Ground Frost (days)
	Mean of daily maxima	Mean of daily minima			
Jan.	2·7 (36·9)	— 2·7 (27·1)	0·49	86	30
Feb.	3·8 (38·8)	— 3·1 (26·4)	0·14	126	28
Mar.	8·9 (48·0)	2·6 (36·7)	3·20	111	16
Apr.	11·1 (52·0)	4·6 (40·3)	1·69	136	12
May	12·9 (55·2)	5·7 (42·3)	3·37	207	3
June	17·9 (64·2)	9·8 (49·6)	2·54	191	0
July	17·3 (63·1)	10·0 (50·0)	2·81	174	0
Aug.	16·1 (61·0)	9·7 (49·5)	3·55	109	0
Sept.	15·3 (59·5)	8·6 (47·5)	3·07	138	0
Oct.	13·0 (55·4)	7·4 (45·3)	4·43	78	4
Nov.	9·3 (48·7)	3·2 (37·8)	6·45	52	13
Dec.	6·1 (43·0)	0·3 (32·5)	0·85	45	23
Year	11·2 (52·2)	4·7 (40·5)	32·59	1,453	129

[1]Fahrenheit equivalents shown in brackets.
[2]October, November and December figures from Prestwick Airport.

SUMMARY OF WEATHER AT MYLNEFIELD

JANUARY

Persistently cold. Frequent slight snowfalls and hail showers in the first three weeks. Ground snow-covered for most of the month (max. depth 1 in.).

FEBRUARY

Very cold. Frequent snow showers during the first three weeks. Ground snow-covered for most of the month (max. depth 2 in.).

MARCH

Rather cold and wet. Slight snow showers on the 4th and hail showers on the 25th and 27th.

MYLNEFIELD, 1963

Month	Temperature (°C.)[1]													Rainfall		Sunshine		Run of Wind
	Mean of daily maxima		Deviation from average[2] (C.°)	Mean of daily minima		Deviation from average[2] (C.°)	Accumulated Temperature (C.°)		Highest Max.		Lowest Min.		Soil Temperature at 1 ft. depth		Ground Frost (days)	Inches	Deviation from average[3]	Hours	Deviation from average[2]	Miles
							Above 5·6°C.	Below 5·6°C.	Temp.	Date	Temp.	Date	Mean	Deviation from average[4]						
Jan.	2·3	(36·2)	−3·5	−2·8	(27·0)	−3·1	0	181	6	25	−9	12	0·3	−1·7	30	1·76	−0·17	51	+01	5,676
Feb.	2·7	(36·9)	−3·7	−3·4	(25·9)	−4·3	1	166	7	27	−8	26	0·0	−2·1	28	1·78	−0·07	95	+19	4,447
Mar.	8·0	(46·4)	−0·6	1·6	(34·8)	−0·2	29	53	12	23	−7	3	2·4	−1·9	19	3·39	+1·54	94	−11	5,615
Apr.	10·7	(51·2)	−0·3	3·6	(38·5)	+0·4	104	25	17	26	−1	13	6·6	−0·7	12	2·22	+0·61	148	+08	7,079
May	13·6	(56·5)	−0·4	4·8	(40·6)	−0·5	124	10	18	28	1	23	9·6	−0·6	9	1·13	−0·87	221	+55	5,986
June	16·9	(62·4)	−0·8	9·4	(48·9)	+1·2	229	0	22	8	6	20	13·9	+0·3	0	2·58	+0·89	168	−14	5,287
July	17·5	(63·5)	−1·9	9·6	(49·3)	−1·1	248	0	26	30	5	26	14·1	−1·2	0	2·66	+0·10	159	+05	4,371
Aug.	16·8	(62·2)	−1·9	9·0	(48·2)	−1·2	227	2	26	1	2	28	14·2	−0·6	1	5·18	+1·91	102	−39	3,988
Sept.	15·8	(60·5)	−0·6	7·9	(46·3)	−0·2	193	5	19	15	2	25	12·1	−0·8	3	2·14	+0·14	156	+34	5,152
Oct.	13·1	(55·6)	+0·5	5·8	(42·4)	+0·5	129	6	16	7	0	14	9·3	−0·4	10	1·34	−1·26	96	+01	5,716
Nov.	8·2	(46·7)	−0·3	3·5	(38·3)	+1·0	52	45	12	6	−4	17	6·4	+0·5	13	5·79	+3·47	53	−10	4,907
Dec.	5·4	(41·7)	−1·3	0·8	(33·5)	−0·4	13	88	11	30	−5	11	2·6	−1·1	24	0·68	−1·84	36	−05	5,556
Year	10·9	(51·6)	−1·2	4·1	(39·4)	−0·7	1,349	581	—	—	—	—	7·6	−0·9	149	30·65	+4·45	1,379	+44	63,780

[1] Fahrenheit equivalents shown in brackets.

[2, 3] Recorded at official Dundee meteorological station, 1921-1950 and 1881-1915 respectively.

[4] Recorded at Mylnefield, 1954-1961.

APRIL

Rather cold and wet. Snow (depth 6 in.) fell on the 12th but had melted by the following morning.

MAY

Continuing cold, but drier and sunny. Hail showers on the 1st and 21st.

JUNE

Mainly cool, but with several warm days. Rather wet and dull.

JULY

Warm, becoming very warm in the final week and dry in the final two weeks.

AUGUST

Very wet (1·1 in. of rain on the 4th). The first two days very warm but the remainder of the month cool. Thunderstorm with heavy rain on the 23rd. Slight ground frost on the 28th.

SEPTEMBER

Generally cool and dull. Gale on the 26th. Slight ground frost on the 12th, 25th and 28th.

OCTOBER

Fairly warm and dry. Thick fog on the 28th. Slight air frost on the 14th.

NOVEMBER

Cold and unusually wet (1·01 in. of rain on the 10th). Thick fog on the 15th. Frequent air frosts from the 15th onwards.

DECEMBER

Generally cold. Slight snow showers on the 13th and 18th and 1 in. of snow on the 25th.