The Scottish Horticultural Research Institute

Twelfth Annual Report for the years 1964 and 1965

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The Scottish Horticultural Research Institute
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West of Scotland Unit
Auchincruive, Ayr *Telephone* ANNBANK 293

1966

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Governing Body

Professor J. H. Burnett, M.A., D.Phil., F.R.S.E., *Chairman*

James Brown, Esq.

Professor R. Brown, D.SC., Ph.D., F.R.S.

George Bruce, Esq. *Appointed* April, 1965

Andrew T. Bryden, Esq., J.P.

James Gilchrist, Esq.

Professor D. S. Hendrie, B.SC., N.D.A., N.D.D.
Died June, 1965

Sir David Lowe, C.B.E., F.R.S.E.

Professor J. A. Macdonald, B.SC., Ph.D., D.SC., F.R.S.E.
Appointed April, 1965

Robert S. M. Milne, Esq.

Professor J. M. Robertson, C.B.E., M.A., D.SC., LL.D., F.R.S., F.R.S.E.
Retired March, 1965

Major Charles J. Shaw of Tordarroch, M.B.E., T.D., D.L., J.P.
Retired March, 1965

David L. L. Storrie, Esq., S.H.M.

M. A. H. Tincker, Esq., M.A., D.SC., F.L.S., F.R.S.E.

Professor S. J. Watson, C.B.E., M.SC., D.SC., F.R.I.C., F.R.S.E.

Professor P. E. Weatherley, M.A., D.Phil., F.R.S.E.

Staff

Directors

T. Swarbrick*, C.B.E., M.S.C., Ph.D., S.H.M.
Retired January, 1965

C. H. Cadman*, B.SC., P.hD., F.R.S.E., F.I. Biol.
Appointed February, 1965

Deputy Director

A. R. Wilson*, B.SC., M.S., Ph.D., M.I. Biol.
Appointed April, 1965

Secretaries

A. B. Ross, F.C.C.S., A.I.A.C. *Resigned* November, 1965
N. D. Anderson, *Appointed* December, 1965

POMOLOGY

C. A. Wood*, B.SC., Ph.D., M.I. Biol. *Resigned* January, 1965
P. D. Waister, B.SC., Ph.D. *Appointed* October, 1965
D. L. Jennings, B.SC., Ph.D.
R. J. Stephens, B.SC. *Resigned* September, 1965
M. M. Anderson, N.D.H., S.D.H., D.H.E.
M. R. Cormack
Miss E. A. Dickie, B.SC. *Appointed* March, 1965
W. Fordyce, N.D.H., S.D.H. *Resigned* October, 1964
Miss P. B. Topham, M.A., B.SC.
Miss B. M. M. Tulloch, S.D.H.
D. W. L. Scott, S.D.H. *Resigned* September, 1964

Assistants

Miss E. Carmichael. *Appointed* April, 1965
G. G. Hutchison
J. Stoa. *Appointed* September, 1965
M. McK. K. Willock. *Resigned* April, 1965

VEGETABLE CROPS

C. North*, B.SC., Hort., M.SC., Ph.D., N.D.H., M.I. Biol.
J. W. Dancer, B.SC., Ph.D. *Appointed* September, 1964
H. J. V. Gledhill, B.SC.
Miss W. G. Priestly, Dip. Hort.
H. Taylor, N.D.H.

Assistants

D. Bruce. *Appointed* November, 1964
Miss I. Duncan. *Resigned* December, 1965
Miss S. C. Ferguson. *Resigned* November, 1964
C. D. Mason

PHYSIOLOGY

C. G. Guttridge*, B.SC., Hort., Ph.D.
P. B. Goodwin, B.SC. Agr., M.SC., Ph.D. *Appointed* August, 1965
D. T. Mason, B.SC., Ph.D.
P. A. Thomson, B.SC.Hort., M.SC., Ph.D. *Resigned* November, 1964
A. Gordon, B.SC.

Assistants

H. McC. Anderson, S.D.H.
Miss C. A. Chambers. *Appointed* March, 1965
Miss M. Edward. *Appointed* October, 1964
Miss A. C. Lindsay. *Resigned* January, 1965
W. S. Stewart. *Resigned* February, 1965

GENETICS

G. M. L. Haskell*, Ph.D., D.Sc., F.L.S., M.I. Biol. *Resigned* August, 1965
A. B. Wills, B.Sc., M.S., Ph.D.
E. B. Paterson

Assistants

Miss R. S. Archer
J. B. Garrie

VIROLOGY

C. H. Cadman*, B.Sc., Ph.D., F.R.S.E., F.I. Biol.
Appointed Director February, 1965
C. E. Taylor, B.Sc., Ph.D.
Mrs S. Allen, B.Sc., Ph.D. *Appointed* March, 1966
R. M. Lister, B.Sc., Ph.D., Dip. Agr. Sci.
W. P. Mowat, B.Sc., Dip. Agr. Sci.
A. F. Murant, B.Sc., Ph.D.
P. R. Thomas, B.Sc., M.Sc., Ph.D. *Appointed* March, 1965
J. Cathro
J. Chambers, B.Sc.
R. A. Goold
Miss H. P. Holmes, B.Sc., M.Sc. *Appointed* October, 1965

Assistants

Miss S. M. Alexander. *Resigned* March, 1965
Miss M. J. Cameron. *Appointed* November, 1965
Miss D. McR. Dewar. *Resigned* May, 1964
I. M. Roberts. *Appointed* August, 1964
B. A. A. Robertson. *Appointed* March, 1965. *Resigned* August, 1965
Miss W. I. Pattullo
W. M. Robertson. *Appointed* September, 1965

MYCOLOGY

A. R. Wilson*, B.Sc., M.S., Ph.D., M.I. Biol.
R. A. Fox, B.Sc., B.Agr., M.I. Biol. *Appointed* October, 1965
W. R. Jarvis, B.Sc., Ph.D., D.I.C., M.I. Biol.
Miss I. G. Montgomerie, B.Sc., Ph.D.
D. A. Perry, B.Sc., Ph.D.
Mrs. D. Spencer, B.Sc., *Appointed* October, 1965
H. M. Wilson

Assistants

D. Bain. *Appointed* May, 1964
Miss P. J. Julian.
R. Lowe. *Appointed* November, 1964
Miss P. Majer. *Appointed* October, 1965
J. H. Stewart. *Appointed* May, 1964. *Resigned* November, 1964
Miss I. G. Stockdale

LABORATORY SERVICE

J. H. Couttie, *Head Technician*
J. R. Caithness. *Appointed* November, 1965
J. C. Lornie,† *Resigned* August, 1965
R. MacDonald
G. Merchant
W. Waterston
R. G. Watson

FARM, PLANTATIONS AND GLASSHOUSES

L. S. Gray, B.SC., N.D.A., *Manager*
W. R. S. Batchelor, *Mechanic*
R. W. Reid, *Plantations Foreman*
F. Ritchie, *Farm Foreman*
R. D. Taylor, *Glasshouse Foreman*

ADMINISTRATION

A. B. Ross, F.C.C.S., A.I.A.C., *Secretary. Resigned* November 1965
N. D. Anderson, *Secretary. Appointed* December, 1965
A. P. Thomson, *Assistant Secretary*
N. B. Hill. *Appointed* April, 1965. *Resigned* September, 1965
I. MacDiarmid. *Appointed* October, 1965
D. L. McIntosh
Miss B. M. Doughty, *Director's Secretary. Resigned* May, 1964
Miss R. B. L. McGill, *Director's Secretary. Appointed* May, 1964
Miss J. Doig. *Appointed* March, 1965
Miss M .Campbell. *Appointed* October, 1964
Miss M. Hay. *Resigned* October, 1964
Miss J. E. McLeish. *Resigned* March, 1965
Miss H. Moncrieff
W. Anderson, A.L.A., *Librarian*
Mrs. M. A. B. Mitchell
J. Sunderland, *Photographer and Met. Observer*
Mrs F. Langé. *Appointed* June, 1965. *Resigned* January, 1966
Miss M. I. McMaster. *Appointed* March, 1965

WEST OF SCOTLAND UNIT (Auchincruive)

R. D. Reid†, O.B.E., M.SC., S.H.M., *Officer-in-Charge*
A. M. Sutherland. *Died* March, 1965
K. C. McConnell, S.D.H.
W. I. A. Jack
Miss S. A. Dodd

* Honorary Lecturer in the University of St. Andrews.

† Honorary Lecturer in the University of Glasgow.

General Report

C. H. CADMAN

To the stresses and strains of adaptation to a new regime has been added sadness for which we were ill-prepared. The death of Dr Thomas Swarbrick, C.B.E., S.H.M., on 11 November 1965 came as a shock to us all. Although the shadow of ill-health marred his final twelve months of office as Director, characteristically he was more vexed by this interference with his ability to manage the Institute's affairs than disposed to take the warning as seriously as many of us would have wished. It is sad that he should have been deprived so soon of the well-earned retirement for which he had planned. Perhaps the only compensation is the fact that his health allowed him to participate in and enjoy the public recognition which was his due and that he knew he had created a viable organisation which would keep his memory green. This and our sympathy we hope will sustain Mrs Swarbrick in her loss.

Sadly too we record the tragically sudden death of Professor Donald S. Hendrie in July 1965. In the few months of association with him, I, like his colleagues in the West of Scotland Agricultural College, had found him an eminently helpful friend with a fund of commonsense, and I therefore felt his loss from the Governing Body keenly. With his wide grasp of, and interest in agricultural affairs, he will be a difficult man to replace.

On 6 March 1965, Mr A. M. Sutherland, C.D.H. of the West of Scotland Unit died at the untimely age of 46. Sandy Sutherland first joined Mr R. D. Reid in 1938 and, apart from a period of war service in the years 1939 to 1946, had been at Auchincruive ever since, where he became intimately associated with and knowledgeable about the whole of the strawberry breeding work. The loss of his services is a sore one.

Apart from these unfortunate events, the past eighteen months has been a period of change in many aspects of the Institute's affairs. On the Governing Body, Professor J. A. Macdonald, University of St. Andrews and Mr G. Bruce, Garlowbank, Kirriemuir, replaced Professor J. M. Robertson, University of Glasgow, and Major C. J. Shaw of Tordarroch, who resigned in March 1964. We thank these gentlemen for giving up their time to participate in our affairs and welcome their successors.

Partly to relieve pressure on the Chairman, Professor J. H. Burnett, and partly because of changes in the organisation of the Institute's domestic affairs, the committees of the Governing Body were amended in May 1965. The Lands Committee was dissolved because its main function–planning utilisation of the estate–had been virtually fulfilled, and its subsidiary functions had been assumed by a domestic Estate Committee. Instead, a new Buildings Committee was constituted for the purpose of considering and making recommendations on proposals for the design and use of buildings, roads and services at the Institute. The Chairman's Committee was enlarged and re-named the Finance and Executive Committee. The three committees of the Governing Body with their respective conveners are therefore now: *Finance and Executive:* Professor J. H. Burnett, *Staff and Research:* Professor P. E. Weatherley, and *Buildings:* Dr M. A. H. Tincker.

The Chairman's Committee met in March 1965 to consider my proposals for re-organising the Institute. These proposals have recently been accepted by the Agricultural Research Council and the Department of Agriculture and Fisheries for Scotland, following a discussion in which I was invited to take part, last September, with an A.R.C. Working Group, especially convened for the occasion under the chairmanship of Sir Alexander Robertson. Essentially the new organisation is designed to rationalise the division of work within the Institute by collecting together people with interests in common. In April 1966, therefore, the Institute's organisation will take on something of a new look. We have already abandoned the term 'department' in favour of 'section,' which seems more appropriate to the sub-divisions in an establishment of our size, and the Institute will consist of eight sections: Crops Research, Plant Breeding, Mycology, Plant Physiology, Virology, Zoology, Maintenance and Administration. Of these, the first two are new creations. The main function of the Crops Research section will be to investigate the effects of environment on growth of crops but it will also, meanwhile, have to co-ordinate much of the husbandry and field trial work previously done by the Vegetable Crops and Pomology departments. Formerly, plant breeding was a major interest of three different groups–Vegetable Crops, Pomology and Genetics. The research and the personnel concerned are now gathered under one head in the Plant Breeding section.

With my departure from the headship of the Virology department, it became expedient to make the two fields of work–research on viruses and virus diseases and research on the animals concerned in their spread–the provinces of separate sections, Virology and Zoology respectively. Minor changes include the substitution of 'Maintenance' as a more literal title for the activities of the Laboratory Service section, and the association of photographic services with the library.

The years 1964-66

Because of the unsettled state of affairs both before and after the late Dr Swarbrick's retirement, production of a Report for the year 1964-65 was impossible, and the present Report therefore covers the period 1 April 1964 to 31 March 1966. It follows the customary pattern in so far as research reports are assembled under the old department names, some of which are due to disappear in April 1966. In other respects it departs from convention–mainly with an eye to brevity–in the belief that only a small proportion of our domestic business can be of real interest to the world at large.

We have, for example, had so many changes in staff – no less than 17 – in the past eighteen months, that it would be quite impossible to mention them all individually. Most are reported by the appropriate heads of sections, but I must make mention of one or two. Dr C. A. Wood left in January 1965 to become head of the Department of Horticulture at the West of Scotland Agricultural College, Auchincruive, Ayr. As he and I had been colleagues since 1946, we had shared many of the experiences and problems of former days with the A.R.C. Scottish Raspberry Investigation and the period of initiation and growth of the Institute. His new post is a challenging one to which he brings his talents and experience and our good wishes for success. Dr G. M. L. Haskell left in August of the same year to become head of the Department of Biological Sciences at Portsmouth Technical College and to assume charge of an active school of teaching and research. We hope that his knowledge of the scope for research in applied biology will in time induce a flow of recruits in our direction. Finally, but by no means least, Mr A. B. Ross left in November to become Administrative Secretary to a new research laboratory being set up by the International Wool Secretariat at Bradford. After fourteen years' service as Secretary of the Institute, there was little about its affairs unknown to Allan Ross, and I count myself fortunate in having had him at my elbow for at least my first year of office as Director. Like our other senior members of staff who have left, he was of the age and experience which merit a more challenging task. The new laboratory's gain is certainly our loss.

Among the many new names appearing in the staff list are those of Mr N. D. Anderson, who replaced Mr Ross; Mr R. A. Fox (Mycology), Dr P. B. Goodwin (Plant Physiology), Dr Susan Allen and Dr P. R. Thomas (Virology), and Dr P. D. Waister, the head-designate of the new Crops Research section. Perhaps the Institute was in need of a blood transfusion of these dimensions. At all events, we welcome all the newcomers and hope they find the environment a genial and stimulating one.

In April 1964, Dr I. G. Montgomerie moved from the West of Scotland Unit to the Institute's headquarters, and Dr A. R. Wilson became the Institute's deputy director in April 1965.

Aided by grants from the Agricultural Research Council, several members of staff made study tours or attended conferences overseas, and the European Association for Potato Research again generously financed Dr Wilson's visits to Europe in connection with its Council's meetings. Mrs Dorothy Spencer's tenure of a Potato Marketing Board studentship terminated in September 1965 and the Board generously provided the Institute with a Research Grant which enabled her to be employed as a research assistant and to continue her work with black scurf disease of potato.

From many other sources, not all of which may have been acknowledged in the sectional reports which follow, we have received and are grateful for assistance in the shape of gifts of materials or the use of land for experimental purposes. The Staff Association benefited from the generosity of Scottish Agricultural Industries who provided the means of acquiring new table tennis equipment.

During 1965 I was invited to serve on the Advisory Committee of the National Fruit Trials, the N.F.U. Joint Working Group on Soft Fruit Breeding and the Seed Production Committee of the National Institute of Agricultural Botany. Because of the useful contacts with affairs and personalities which result, I was happy to accept these invitations. The Council of the Institute of Biology saw fit to nominate me as one of its Fellows.

One of the most welcome innovations last year resulted from Dr D. T. Mason's willingness to act as the Institute's receptionist for visitors and visiting parties. Some adequate organisation has long been needed, and all our visitors seemed appreciative of the attentions they received. It was a great relief to have this aspect of the organisation taken care of as 1965 was a particularly busy year. Among the many visitors and visiting parties, we were glad to welcome in May 1964, the members of the N.F.U. Joint Working Group on Soft Fruit Breeding, who also visited the West of Scotland Unit, many delegates to the 7th International Botanical Congress held in Edinburgh in 1964, and members of the British Mycological Society who attended the Plant Pathology Field Day, held jointly at Queen's College, Dundee, and the Institute, in July 1965. Sir Gordon Cox, Secretary of the Agricultural Research Council spent a day at the Institute in November 1965, and we were very pleased to have visits both by other members of the A.R.C's headquarters staff and by members of staff in St. Andrew's House who handle our affairs.

Inevitably, 1965 has been a year of re-organisation, introspection and planning for the future. If, as its promoters intended, the Institute is to serve the Scottish horticultural industry, it has an embarrassingly wide remit and our field of interest has recently been extended to include pathology problems in the potato crop. Clearly, priorities have to be decided and problems worthy of the investment of time and money defined before the potential contributions of the Institute to Scottish horticulture and to agricultural research in the U.K. can be planned. To this end, the efforts made during the year to establish closer links with the horticultural industry and with the Advisory Services promise well and have at least provided evidence of honest intent. The Horticultural Advisory Officers held their biennial conference in May at the Institute, and advisory staff and growers took part in meetings held later in the year which were designed to explore aspects of bulb-growing and the production of soft fruits and carrots.

The task of compiling an Annual Report inevitably prompts questions as to its function and the audience it is directed towards. Primarily it provides our masters with evidence that we have been gainfully employed. That much of the information it contains may appear abstruse or unintelligible to the layman is unfortunate, but the reporting of scientific work imposes certain conventions. The art of writing is difficult enough; that of distilling into simple language the results of significant advances in knowledge is doubly so. We understand that our Annual Report is widely read and enthusiastically received in many parts of the world. Whatever may be the shortcomings of this issue, we hope it may meet with as good a reception as its predecessors.

Farm, Plantations and Glasshouses

L. S. GRAY

Perhaps no industrialist has to face quite the type of risk inherent in the average farming year, where production has to be planned in a spirit of optimism, and the outcome is at the mercy of an inclement season. Poor summers have been the pattern of recent years, and those of 1964 and 1965 were no exception. In both years the winters were fairly open and ensured a good start to spring work. Crops were better in 1964 than might have been anticipated–particularly the soft fruit and grain crops. The 1965 season was the worst we have ever experienced here with soft fruits. Apart from the difficulties of harvesting the crops with inadequate labour in bad weather, losses from grey mould were excessive, particularly in strawberries, and prices were depressed. Although the grain harvest was late, we were more fortunate than many of our neighbours in getting at least a proportion of the crop off in good weather. Potatoes too yielded well, but lifting was not completed until mid-November. The long-range forecasts for the 1966 season, in circulation as this Report goes to press, afford unjustified grounds for optimism; one can only hope a proportion of them prove true.

There has been a variety of changes in policy for the cropping and utilisation of the estate during the past eighteen months. As mentioned in the last Report, we have ceased to keep winter-housed cattle, and the last animals were sold in October 1964. This in itself altered the crop rotation, in that root crops for winter feed, and grass for summer grazing were no longer essential. The expansion of the area under experimental crops–now 103 acres out of a total 243–and the need to devise a systematic rotation of fields used for experimental purposes called for a revision of cropping plans for the farm. Simplification of the rotation seemed feasible and, as a result, we have increased the area under grain crops and intend to extend this further by abandoning sugar beet and a part of the potato acreage. This has the merit of simplifying the organisation of farm work, and should make more labour available for attending to the needs of field experiments.

The Director's plans for re-organising some of the Institute's activities brought to light the need for making the maintenance of field experiments a centralised service. Previously the costs of these had been borne largely by individual sections. Budgeting for this necessitated the devising of a new system for scrutinising requests for land and allocating sites, and this has had beneficial results. In 1965 we were, for the first time, able to produce a complete catalogue of field experiments which has aided co-ordination of interests within the Institute.

The returns from the farm and experimental crops reflect some of the changes mentioned above. We grew more grain in 1965, but yields were less that year than in 1964. Per acre, barley gave 35.5 cwt. in 1964, 32 cwt. in 1965; wheat gave 42 cwt. in 1964 and 40 cwt. in 1965. The sugar beet crop suffered from herbicide damage in 1964 and yielded only 10.6 tons/acre compared with 12.4 tons/acre and a sugar content of 15.88 per cent, in 1965. Potatoes, as elsewhere in Britain, produced a heavy crop in 1965.

Dry weather in June delayed the swelling of fruit in 1964, and total yields of strawberries (15.5 tons) and blackcurrants (1.25 tons) were less than in 1963–blackcurrants considerably so–but we harvested more raspberries (35.25 tons) than in 1963. In 1965 blackcurrants picked well (5.0 tons), but we lost a fair proportion of the strawberry and raspberry crops from grey mould. Raspberries yielded 17.25 tons and strawberries 11.25 tons.

Apples produced 700 bushels in 1964 but the plums yielded poorly. In the spring of 1965 the area devoted to top fruit was drastically reduced and this has effected considerable economy in the labour expended on pruning, fruit-thinning and harvesting.

Vegetable production followed the now customary pattern. Of the marketable crops, Brussels sprouts yielded some 4.5 tons in 1964 but only 1.5 tons in 1965. Cabbages did well in 1964–15 tons were clamped for winter storage trials and 6 tons were sold off the field–but they yielded only half this total in 1965. We have persisted with carrots as a commercial crop, despite the fact that few areas on the farm are eminently suited to this crop. Whilst the gross return is encouraging, the problems of harvesting and grading the crop adequately are a deterrent.

A survey of the Institute's electricity supply system in August 1964 revealed that the ring-main system was dangerously close to being overloaded and quite inadequate to meet the extra demands precipitated by the installation of controlled environment equipment in the new, general-purpose building. Emergency measures were called for, and these enabled us to instal a new distribution system and to complete the heating, lighting and interior fitment of the general-purpose building erected in 1963. Two Silsoe-designed growth cabinets were installed in this building in November 1964, and work has continued throughout the two years on the set of growth cabinets designed by the Plant Physiology section. One half of the general-purpose building is now entirely devoted to controlled environment equipment and provides ancillary laboratory facilities.

Glasshouse accommodation was increased by the completion, in 1964, of the two 124 ft. by 12 ft. timber-and-glass houses mentioned in the previous Report. Though useful, these are far from satisfactory because of their dimensions and lack of adequate ventilation, and the heating system installed is far from ideal. We look forward to watching the performance of three new glasshouses, designed for use by the Plant Physiology section, the construction of which began in August 1965. Each house is 28 ft. by 22 ft., built of aluminium alloy, and equipped with thermostatically controlled heating and ventilating systems.

Little maintenance work was needed on the estate, but some changes of layout in the vicinity of the main buildings have been initiated as part of plans to re-organise the glasshouse area and to improve the landscaping of the approaches to the Institute.

Pomology

C. A. WOOD

Perhaps because of the wet conditions in 1963, raspberry canes grew taller than usual that year, and the yields in 1964 were the highest recorded since 1960 despite the dry weather in July. Strawberries too suffered from the drought, and the apple crop was poorer than usual in yield and quality because the fruit failed to swell. In 1965, the shortage of pickers and the cool, wet weather provided ideal conditions for a severe outbreak of grey mould. The early varieties of raspberry suffered, but the damage was greatest in strawberry where over half the marketable crop was lost, despite the amount of protective spraying done at flowering time. The fruit-picking seasons began earlier than usual in 1964–30 June to 30 July for strawberries, 8 July to 20 August for raspberries. In 1965 the dates were nearer to the average–5 July to 6 August for strawberries and 15 July to 27 August for raspberries.

The apple crop was again poor, partly due to bad fruit-set and partly because of failure of the fruit to mature. Even some of the early varieties did not ripen fully.

As I left the Institute in January 1965 to take up appointment as head of the Department of Horticulture in the West of Scotland Agricultural College, my former colleagues have been largely responsible for compiling the material for this report. They have also–in particular Dr D. L. Jennings and Mr M. M. Anderson–been responsible for co-ordinating the Pomology research programme during 1965.

Apart from myself, the section suffered other losses. In August 1964, we were exceedingly sorry to bid farewell to Mr W. Fordyce on his appointment to the staff of the Edinburgh and East of Scotland College of Agriculture. In the years spent at the Institute he had, for a person of his years, acquired a unique knowledge of tree fruits and distinguished himself as an able horticulturist. Mr M. R. Cormack was promoted Assistant Experimental Officer to fill the vacancy thus created and his post in turn was used to appoint Miss E. Carmichael in April 1965 as Scientific Assistant to Miss Topham.

The weed control work also suffered a series of staff changes. Mr R. J. Stephens went in September 1965 to a lectureship in the Applied Biology Department in the new University of Bath. Prior to that, Mr D. W. L. Scott left in August 1964 and in his place Miss E. A. Dickie was appointed Assistant Experimental Officer in March 1965. In September 1965, Mr J. Stoa replaced Mr M. McK. K. Willock who left in April of that year to join the Horticultural Inspectorate of the Department of Agriculture and Fisheries for Scotland.

Aided by a travel grant from the Agricultural Research Council, I went to Scandinavia in the summer of 1964 and visited horticultural research centres and fruit-growing districts in Denmark, Norway, Sweden and Finland. In 1965 a grant-in-aid enabled Dr Jennings to attend the 4th Eucarpia Conference held in July at Lund, Sweden, and to visit the Bålsgard Fruit Breeding Station: Mr M. M. Anderson visited the Agricultural Institute at Kinsealy, Malahide, Co. Dublin in September to discuss work on black currant diseases.

Warm congratulations go to Dr D. L. Jennings on the award by the University of St. Andrews of the degree of Ph.D. for his thesis on 'Plant breeding and genetic studies in the red raspberry *Rubus idaeus L.*'

RASPBERRY BREEDING

The main objective is to meet the demands of the processing and fresh fruit markets by breeding early varieties with fruit of the requisite qualities. Some success has been obtained in transferring to red raspberry the firm fruit texture usually characteristic of the black raspberry (*Rubus occidentalis*), and several selections from the second backcross to red raspberry of a hybrid between these two forms also had an attractive red fruit colour. These and other selections are being propagated for further trial.

Genes which affect both vegetative growth and the development of fruiting laterals have been found in the varieties Malling Jewel, Norfolk Giant and Baumforth's Seedling B. The results of studies on these were published. Another study was begun to see whether a major gene or genes of similar action determine some of the differences in fruiting and vegatative habit which distinguish the red raspberry from some of its relatives. Some evidence for the segregation of such a gene was given by progenies obtained by backcrossing raspberry × *R. innominatus* hybrids to the raspberry but not by comparable progenies involving other *Rubus* species.

Resistance to diseases and pests

Further work was done to incorporate into lines of good fruit quality the genes *H* (hairy canes) and *s* (spine-free canes) which enable canes to escape attack by certain fungal pathogens, and the genes A_1 and A_2 or A_3, which confer resistance to strains of *Amphorophora rubi*. Selections were also indexed for the presence of three genes which control immunity from three nematode-borne viruses. Much of this material proved susceptible to powdery mildew (*Sphaerotheca humuli*) but two good sources of resistance were found–one a hybrid derived from Malling Exploit and the other the hybrid between red and black raspberry referred to above. (D. L. Jennings, B. M. Tulloch, P. B. Topham).

Further observations on hybrids related to *Rubus phoenicolasius*, *R. innominatus* and *R. kunzeanus* confirmed that only *R. phoenicolasius* is a useful source of resistance to the raspberry beetle (*Byturus urbanus*). However, although the species itself seemed an unacceptable host for the beetle, neither F_1 hybrids between it and raspberry nor backcrosses of these to raspberry showed any clear evidence of resistance. Resistance is probably recessive, and it may be associated with the large epidermal glands characteristic of *R. phoenicolasius.* Glands were present on the F_1 hybrids but they were always rudimentary, and there were no seedlings with large glands even in progenies obtained by inbreeding: hence association between the two characters has not yet been established. The hybrids were all sub-fertile, however, and it seems probable that the full array of genotypes did not survive, especially in the families obtained by inbreeding. (C. E. Taylor, D. L. Jennings).

Hardiness

In a manurial experiment with raspberries, planted in 1957, plots receiving farmyard manure or inorganic nitrogen have shown consistent reductions in yield since 1962. A possible explanation is that these treatments decrease cane hardiness. To investigate this and to assess breeding material for hardiness, a laboratory test was used. The impedance of plant tissue to the passage of an electrical current is lost if the cells are killed. Consequently, changes in this property following a low-temperature treatment can be used to assess the proportion of cells killed. Samples of canes from the manurial experiment were tested in this way at intervals from October 1964 to March 1965, and were also used for measurements of seasonal changes in water content. The water content decreased progressively until January and then began to increase, the rise occurring first at the bases of the canes. These changes were closely correlated with the amount of damage done by the low temperature treatment applied. However, no major influence of the nutritional treatments was detected by the laboratory tests, despite the fact that the incidence of winter injury in the field was again increased by farmyard manure and nitrogen. Current work is paying attention to the rate of cooling used in the test, following some evidence that the nutritional factors may affect the capacity of canes to harden in response to slow cooling. (D. L. Jennings, M. M. Anderson, M. R. Cormack).

Fertility studies

Diallel crosses, involving either diploid or diploid and tetraploid stocks of the same raspberry varieties, were used to study variation in drupelet-set and in seed and embryo sizes.

Application of 500 p.p.m. gibberellic acid to emasculated flowers resulted in the development of parthenocarpic fruits notable for the regularity of their individual drupelets. This was true even for forms which are normally highly infertile. A very small proportion of the nutlets contained embryos and some germinated. The seedlings are being grown on to determine their genetic constitution. Apparently the maternal tissues responded rapidly to the gibberellic acid and caused abortion of the embryo sac. The experiment is therefore being repeated with low concentrations of gibberellic acid to see if a higher proportion of embryos survive. (P. B. Topham, D. L. Jennings).

BLACK CURRANT BREEDING

The immediate objective of the black currant breeding programme is to produce commercially acceptable varieties suitable for mechanised harvesting, and combining immunity or resistance to common diseases and pests with the earliness, productivity and good fruit qualities of Brödtorp and its derivatives. Progenies derived from F_1 selections of Brödtorp × Silvergieter's Black and Brödtorp × Baldwin backcrossed to each of the parent varieties cropped for the first time in 1964, but fruit yields in both 1964 and 1965 confirmed the belief that the most vigorous, erect-growing seedlings were also the least productive. In a series of crosses made to obtain late-flowering and hence spring-frost-escaping selections, the latest-flowering seedlings were recorded in the S_2 progeny of a selection from the cross Seabrook's Black × Amos Black and in the S_2 progeny of a Baldwin seedling. These families also contained a small proportion of dwarf, slow-growing seedlings which began flowering up to 8 weeks later than Amos Black.

Resistance to diseases and pests

An outbreak of American Gooseberry Mildew (*Sphaerotheca mors-uvae*) in the late summer of 1964 provided an excellent opportunity to screen a wide range of seedlings derived from British and foreign parent varieties. Seedlings obtained by selfing Laxton's Giant, Brödtorp and an F_1 from the cross Brödtorp × Janslunda showed a very high degree of resistance, and seedlings apparently resistant were also recorded in the progenies of Golubka, Gornoaltajszkaja, Vistavotnaja and Dotsch Altaja. Mildew did not reappear on these seedlings in 1965, and confirmation of previous results was sought by inoculating cut shoots in the glasshouse in July and August. All the seedlings tested, including the selfed seedlings of Laxton's Giant, eventually succumbed to the disease, but several appeared to resist initial infection, and under the conditions of this test the Brödtorp × Janslunda derivatives were clearly the most resistant. In another glasshouse test, well-established, pot-grown plants were repeatedly and thoroughly inoculated with mildew spores and then kept in contact with severely infected plants. Under these conditions two of three of the Laxton's Giant seedlings remained completely free of disease, and the parent varieties and progenies of Gornoaltajszkaja, Dotsch Altaja and Golubka showed a slight to moderate degree of resistance. Comparable plants of Seabrook's Black, Laxton's Giant, Magnus, Bija, Consort and Vistavotnaja all became severely infected. The Brödtorp × Janslunda derivatives were not included in this test.

In 1965, segregation for mildew resistance was observed in two first backcross families derived from *Ribes dikuscha* and previously selected for immunity from leaf spot (*Pseudopeziza ribis*). The highest degree of resistance, however, was shown by seedlings from crosses involving Vistavotnaja and an F_1 seedling from the cross Baldwin × Silvergieter's Black.

Of the 570 F_2 *R. dikuscha* seedlings mentioned in the 1963-4 Report, 183 have remained apparently immune from leaf spot disease and a further 96 have maintained a very high resistance. Among a further 368 seedlings raised in spring 1964, 161 have so far remained free of leaf spot, and 20 of these were also highly resistant to American Gooseberry Mildew. Although immunity from *Pseudopeziza ribis* has only been found in *R. dikascha*, very high degrees of resistance occur among the varieties of *R. nigrum*. Of those tested, the most resistant are Anger von Oeffelt, Champion, Roodknop, Brödtorp, Vistavotnaja and Gerby. In 1962 and 1964 tests of varieties and seedlings of *R. nigrum* for resistance to black currant midge (*Dasyneura tetensi*) were unrewarding. In a non-replicated trial planted in 1965, however, *R. ussuriense* escaped infestation while all the seedlings of *R. nigrum* in the test became infested. A more comprehensive test of *R. ussuriense* seedlings is planned for 1966.

THE CULTIVATION OF RASPBERRIES

The series of raspberry cultural and manurial experiments planted in 1957 and 1958 was continued in 1964. The new canes produced in 1963 made excellent growth in the unusually wet late-summer, and yields in 1964 were high despite a period of dry weather during the picking season. Yields were lower in the cool, wet summer of 1965, however, largely due to losses by *Botrytis* which were aggravated by a shortage of casual fruit-picking labour.

In the factorial nutritional experiment planted in 1957 to compare the effects of three levels each of nitrogen, phosphorus, potassium and farmyard manure on the growth and yields of three varieties–Lloyd George, Malling Exploit and Norfolk Giant–yields in 1964 and 1965 were again progressively decreased by increasing the annual dressing of inorganic nitrogen from nil to 40 and 80 lb. per acre, and by increasing the biennial dressing of farmyard manure from nil to 15 and 30 tons per acre. The greatest reductions in yield occurred where the highest rates of farmyard manure and inorganic nitrogen were applied in combination. The effects of increasing the levels of phosphorus and potassium were marginal. Over the eight-year cropping period of this experiment, the effects of the high nitrogen application were most beneficial during the first half of the plantation's life (the first six years in the case of Norfolk Giant)–largely due to a more rapid increase in cane numbers–and, in Lloyd Goerge and Malling Exploit, highly deleterious during the second half. Compared with the nil-nitrogen treatments, the highest cumulative increases in yield in Lloyd George, Malling Exploit and Norfolk Giant–1 ton (6 per cent.), 2.2 tons (18 per cent.) and 5.2 tons (27 per cent.)–were recorded in the fourth, third and sixth year of cropping respectively. The overall effect of the highest rate of farmyard manure, averaged for the three varieties, was to decrease the cumulative yield by 2 tons (7 per cent.). The effects of both potassium and phosphorus are difficult to interpret, since they show strong interactions with nitrogen, farmyard manure and varieties: the full significance of these results will not become clear until the analyses have been completed. Collection of the information this experiment was designed to yield was completed with the recording of the 1965 crop, but the experiment has been retained in order to study the treatment effects on cane hardiness. In connection with these studies, three levels of borax were superimposed on each of the original treatments in April 1965.

During the past three seasons a distinct pattern of cropping has emerged in the experiment planted in 1958 to compare combinations of eight pre-planting methods of preparing the ground for raspberry growing and eight post-planting systems of manuring. The variety grown is Malling Exploit. An analysis of total yields over the period 1959-1965 showed that the highest annual yields (averaging 4 tons/a. annually and not differing significantly from each other) were from plots (i) where the pre-planting treatment was green manure (April-sown tick beans followed by July-sown rye) and the post-planting treatments were annual applications in spring either of a slow-acting, organic nitrogen-based fertilizer (33 lb. N/a.) or a quick-acting, inorganic raspberry fertilizer (34 lb. N/a., 59 lb. after 1962), (ii) where a pre-planting application of 5 tons of horticultural peat (equivalent in dry weight to 15 tons of farmyard manure) was given and the post-planting treatment was an annual mulch in spring of horticultural peat supplemented by the inorganic fertilizer, and (iii) where the inorganic raspberry fertilizer alone was applied annually in spring. The general trend of the results confirms the conclusion that nitrogenous manuring of raspberries can easily be overdone, with detrimental effects on cropping.

In the experiment designed to compare six systems of soil management for Malling Exploit–a grass and clover cover crop, a permanent straw mulch and four methods of clean cultivation each at two nitrogen levels–fruit yields in 1964 were highest following a shallow cultivation system (3.4 tons/a.) and lowest in the straw-mulch treatment (2.9 tons/a.). For all six treatments the low-nitrogen sub-plots gave the higher yields. By the summer of 1964 the consequences of infection with tomato black ring virus–which first became evident in 1960–had become so severe, especially in the cover-crop plots, that the experiment was terminated after fruiting. Over the seven-year period of this experiment the yield of the straw-mulch treatment, unadjusted for the effects of virus infection, was significantly higher ($P<0.05$) than that of the other five treatments, none of which differed significantly. Yield differences between the high and low nitrogen treatments also were not significant. These results support the belief that, provided the traditional method of cultivating raspberries with the plough and draw-hoe is done skilfully, it is not inferior to other systems of clean cultivation which minimise root disturbance.

The 1963-64 Report described an experiment comparing stocks of Malling Jewel and Lloyd George, freed from virus by heat treatment, with the mildly virus-infected material of these varieties which was issued as nuclear stock prior to 1958. Three planting treatments–double planting at 3 ft., and single planting at 1½ ft. and 3 ft.–were combined factorially with these comparisons. In 1964, for the fourth year in succession, there were no significant differences in yield between stocks of different health status, but highly significant differences persisted between the planting methods. The effect of differences in health status, an overall increase of 2.7 tons, was however significant in the analysis of the cumulative 1957-64 yields. Over the total period the increase in yield of Lloyd George from double planting compared with single planting at 3 ft. was not significant, but the increase with Malling Jewel–1¼ tons (8 per cent.)–was significant. This experiment was terminated after cropping in 1964. (C. A. Wood, M. M. Anderson).

AUCHINCRUIVE STRAWBERRY SELECTIONS

In the 1962 trial described in the 1963-64 Report, where Templar and Crusader (formerly known as A45) are being compared with Talisman and Cambridge Favourite, both new varieties cropped well in the contrasting seasons of 1964 and 1965. In 1964 non-defoliated plants of both varieties cropped at the equivalent of 5.3 tons/a.: Cambridge Favourite yielded 4.2 tons and Talisman 2.6 tons. The low yield of Talisman was due largely to the dry season which adversely affected fruit size and development, and partly to a low number of inflorescences; that of Cambridge Favourite was the result of a killing of the crowns in the 1962-63 winter. In 1964 the yields of Crusader, Templar, Cambridge Favourite and Talisman were 8, 6.75, 6.5 and 5.3 tons per acre respectively. The total increment in yield resulting from defoliation in early August (in both 1963 and 1964) was 4.5 tons for Talisman and 1.0 ton for Templar. In Cambridge Favourite and Crusader, however, defoliation decreased yields by 2 tons and 0.75 tons respectively. Since the inflorescence numbers on intact plants of Crusader were high in both 1964 and 1965, it should not be inferred from such limited experience that the variety is always as unresponsive to defoliation as Cambridge Favourite.

In 1964, Crusader and Cambridge Favourite ripened on 30 June and Templar about one day later. Talisman was two days later than Templar, and this difference increased to five days by midseason. In 1965, which was a late, cool and wet season, Crusader was easily the earliest to ripen and was ready for picking on 5 July, three days earlier than both Talisman and Templar and five days earlier than Cambridge Favourite. After one week of picking, 40 per cent. of its total marketable crop had been picked; the comparable percentages for Talisman, Templar and Cambridge Favourite being 25, 22 and 19 respectively. The effect of defoliation on season of ripening varied according to variety and kind of season: in the dry, warm summer of 1964 the fruit on the mown plots of Crusader and Talisman ripened earlier, but in the cool, wet summer of 1965 the fruit of Crusader, Cambridge Favourite and Talisman was slightly later and that of Templar slightly earlier on the mown than on the unmown plots. Grey mould was not a problem in 1964 but losses were heavy in 1965: expressed as percentages of the total crop, the losses in Cambridge Favourite, Templar, Talisman and Crusader averaged 23, 34, 36 and 38 respectively.

In a second trial, planted in April 1964, Crusader cropped at the equivalent of 7 tons per acre, Redgauntlet and Talisman 6 tons, and Templar and Cambridge Favourite averaged 5.3 tons. Crusader ripened 3-4 days earlier than Templar, Cambridge Favourite and Talisman, and a week earlier than Redgauntlet. Approximately 70 per cent. of the marketable crop of both Crusader and Templar attained the two upper grades (minimum berry weight 0.75-0.5 oz.) compared with percentages for Talisman, Cambridge Favourite and Redgauntlet of 60, 50 and 40 respectively.

Samples of 30 seedlings were received from Auchincruive in 1964, and a further 36 in 1965. Twenty of these have been propagated for testing on a larger scale. (M. M. Anderson).

TOP FRUITS

Experience since the early nineteen-fifties has shown that a very wide range of varieties of apple will crop satisfactorily under Mylnefield conditions and that fruit of excellent colour and very good maturity can be produced. However, in 1964 climatic factors adversely affected the performance of top fruit at the Institute for the fourth year in succession, particularly in the apple variety-rootstock trials planted in West Laboratory Field, where exposure to strong prevailing winds had for some years retarded and in some cases distorted the growth. For these and other reasons it was decided to terminate the trials of standard varieties on the older Malling rootstocks and the trees were grubbed in March 1965. However, the 1953-64 elimination trial showed that early-maturing varieties such as Exeter Cross and George Cave, and second-early kinds of Canadian origin, will produce good crops of fruit in most seasons. Of the two trials which have been retained one includes the promising early variety Exeter Cross, and the other, varieties originating in North America (planted December 1962). The first of these contains three varieties–Worcester Pearmain, Laxton's Fortune and Exeter Cross–and compares ten rootstocks of the Malling (M) and Malling (M.M.) series. It was planted in three phases, the Worcester in 1954, the Fortune in 1959 and the Exeter Cross in 1962, each phase being fully replicated. Results from the Worcester section indicate that the M.M. stocks produce higher yields, but that the fruits are slightly smaller and possible have inferior colour to those on the M. stocks.

The trial of cherry varieties was also grubbed early in 1965 after all efforts to harvest a crop had been frustrated by overwhelming competition from birds.

The collections of apple and pear varieties were maintained. Field work on aspects of bacterial canker control in plums is being continued in co-operation with Dr A. E. W. Boyd of the Edinburgh and East of Scotland College of Agriculture, Dr A. M. Paton of the University of Aberdeen, and the Mycology section. (M. R. Cormack).

SCOTTISH REGIONAL FRUIT TRIALS

The first pairs of blocks of the 1961-1963 co-operative strawberry defoliation experiment, which is being conducted at each of the four Scottish trials centres (see 1961-62 and 1963-64 Reports) have received the full range of defoliation treatments and been discarded after a four-year life. Provisional results show that Talisman responded to defoliation better than Cambridge Vigour. Defoliation in either the first or second week of the previous August induced substantial increases in yield in Talisman but Cambridge Vigour responded erratically. Defoliation in the third or fourth week of August depressed yield, especially in Cambridge Vigour. These results confirm the importance of early defoliation and suggest that plantations of responsive varieties such as Talisman, having once been defoliated, should continue to be defoliated for the remainder of their life.

Cane growth in the 1960 trial of initially virus-free raspberry varieties was favoured by the wet summer and autumn of 1963; the canes were the tallest ever recorded here. The 1964 yields of six of the seven varieties were the highest recorded for them to date: Lloyd George 5.75 tons, Malling Promise 5 tons, Norfolk Giant, Malling Jewel and Malling Seedling 69/139 4.5 tons, and Malling Exploit and Malling Enterprise 4 tons. The new canes produced in 1964 were on average 15 in. shorter, but, despite this and the wet unfavourable season, the 1965 yields were only slightly lower: Malling Seedling 69/139 gave 5.25. tons, Malling Jewel 4.5 tons, Lloyd George, Malling Promise and Malling Enterprise averaged 4.25 tons and Malling Exploit and Norfolk Giant each cropped at over 3.5 tons.

The consequences of the wet late-summer and autumn of 1963 were also apparent in the older (1952) raspberry variety trial. At the end of the eleventh year of growth, the mean number of canes per stool before thinning was higher than at any time in the plantation's life, and the mean cane height was the tallest recorded since 1958. In 1964, Malling Promise yielded nearly 5 tons per acre, Lloyd George and Malling Jewel slightly over 4.5 tons and Malling Exploit 4.25 tons. Norfolk Giant and Malling Enterprise averaged 3.5 tons. The mean yield–4.25 tons–was the highest recorded since 1960. In five of the six varieties the yields were higher in the sub-plots receiving the lower level of nitrogen (22 lb./a. compared with 80 lb.). Cane numbers in 1965 exceeded those of the previous year, but the mean cane height was the lowest ever recorded. Yields in 1965 were on average a ton lower than in 1964: Malling Jewel and Norfolk Giant cropped at 4 tons per acre, Malling Promise yielded 3.5 tons, Malling Exploit 3 tons and Malling Enterprise and Lloyd George averaged 2.25 tons. In three of the six varieties yields were higher in the low nitrogen sub-plots. (M. M. Anderson).

PUBLICATIONS

JENNINGS, D. L. (1965). The manifold effects of a gene affecting fruit size and vegetative growth in the raspberry. *Heredity*, Lond., **20**, 647 (Abs.).

(Paper read to the Genetical Society at the University College of Wales, Aberystwyth).

JENNINGS, D. L. (1966). The manifold effects of genes affecting fruit size and vegetative growth in the raspberry. I. Gene L_1. *New Phytol.* **65**, 176-187.

(A mutation found in the raspberry variety Malling Jewel had bigger fruiting laterals, flowers and fruits than the parent stock. The results of breeding experiments were consistent with the hypothesis that the change was caused by mutation of a single gene from the homozygous to the heterozygous state, and that the gene concerned has functions whose effects are seen at each stage of development. These effects were to depress slightly the amount of vegetative or first year's growth and to increase the amount of reproductive or second year's growth. The mutant gene is useful for plant breeding purposes. Its possible effects on the physiology of the plant are also discussed).

JENNINGS, D. L. (1966). The manifold effects of genes affecting fruit size and vegetative growth in the raspberry. II. Gene l_2. *New Phytol*, **65**, 188-191.

(Seedlings with 'miniature' fruits or with 'blind' fruiting laterals were found to segregate when the raspberry varieties Norfolk Giant and Baumforth's Seedling B were inbred. It was concluded that in each family both abnormalities were caused by the same recessive gene (l_2) which had pleiotropic effects on each stage of growth. Its action was to decrease growth by amounts which increased progressively with each stage of the plant's development. The effects of the gene are compared and contrasted with those of gene L_1).

JENNINGS, D. L. and TOPHAM, P. B. (1964). Seed set and fertility in *Rubus idaeus*. Tenth International Botanical Congress, Abstracts of Papers, p. 394. (Demonstration given at the Tenth International Botanical Congress in Edinburgh).

Vegetable Crops

C. NORTH

Much of the activity was directed towards the consolidation of experimental work already in progress and relatively few new projects were undertaken. However, studies on the physiology of *Brassica* crops were recommenced, and for this purpose mobile blackout covers were constructed for controlling the daylength in field-grown crops of cabbage. This work cannot be fully developed until controlled environment chambers become available for use–probably in 1966–though reasonable progress has been made with their design and construction. Responsibility for the project was transferred to Dr J. Dancer when he joined the staff in September 1964.

A symposium on the breeding of *Brassica* crops was held at the Institute on 27-30 September 1964 at the request of Dr O. Banga, president of the Horticultural Section of Eucarpia (The European Association for Plant Breeding), and the Vegetable Crops section undertook the organisation. The papers (summarized in *Hort. Res*., **5**, 39-58) embraced work on both horticultural and agricultural *Brassica* crops. Special attention was given to the utilisation of heterosis effects, and to the breeding for resistance to clubroot disease. Most of the European and U.K. breeders of this group of plants were represented amongst the forty persons who attended.

A one-day conference on the growing of carrots, also organised by the section, was held on 23 September 1965. Invited speakers from the south joined in the proceedings and a valuable discussion on the problems of the crop followed.

Miss Priestley was the only member of the section to travel abroad during the period under review. With the aid of an A.R.C. grant, she spent ten days in West Germany visiting Government stations and private breeding firms to study work on *Phaseolus* and *Brassica* breeding.

Mr Gledhill has done much to raise the interest of the Institute staff in the extended use of electronic computers to process experimental data. He has familiarised himself with coding systems by attending several courses on the use of computers and has been responsible for arranging for the purchase of a teleprinter so that computer tapes can be prepared at the Institute. He also arranged for a course in statistics to be given for the Institute staff by members of the A.R.C. Unit of Statistics at Aberdeen.

Mr Taylor acted as examiner for the City and Guild examinations in Horticulture and Dr North was invited to serve on the Horticulture Committee of the Scottish Agricultural Improvement Council.

Miss S. C. Fergusson resigned from her post of Scientific Assistant in October 1964 and was succeeded by Mr D. Bruce.

BEANS

The two S.H.R.I. varieties of dwarf French beans gave promising results in N.I.A.B. trials for three consecutive years. Arrangements are therefore being made with the N.I.A.B. for the multiplication and release of one of them under the name Glamis. It is a very early-maturing 'snap-pod' type suitable for mechanical harvesting.

Other varieties are being developed which incorporate resistance to anthracnose and still greater tolerance to cool weather conditions. It was fortunate that it was possible to select rigorously for the last feature in 1965 when the unusually cold summer prevented seed set in many varieties causing them to form small curled pods. One line, originating from a cross between 'Record' and 'Slavia,' was outstanding for the quality of its pods under the adverse weather conditions, so selection will be continued with this material. (W. G. Priestley, I. Duncan).

BRUSSELS SPROUTS

A series of variety trials have confirmed the superiority of the new F_1 varieties Thor and Avoncross for growing in Scotland for marketing fresh. It was difficult for unskilled labour to recognise and discard inbreds in Avoncross and this, coupled with a tendency to bolt when raised under glass, sometimes caused the crop to lack uniformity, but the plants nevertheless gave very high yields of good quality sprouts. Thor is, by contrast, a very uniform variety which is not prone to 'bolting.' (H. Taylor, D. Mason).

Two F_1 hybrids bred at S.H.R.I. and provisionally designated No. 9 and No. 13 gave promising results. Number 9, which is being tested in N.I.A.B. trials, produces small, very firm sprouts of a good bright green colour and uniform size. It may prove a useful competitor to Jade Cross for the processing industry. Number 13 is the first of a series of F_1 varieties bred at S.H.R.I. utilising the glossy-foliage character to facilitate the recognition of inbreds. It produces a tall vigorous plant with widely-spaced sprouts. The search for other suitable genetic markers to aid in the production of F_1 seed is being continued. (W. G. Priestley).

An agricultural machinery company has made progress with the development of the Brussels sprout stripping machine invented at S.H.R.I., and it is possible that it may become available commercially in the near future. The application of such a machine will necessitate a re-appraisal of varieties and growing techniques to obtain the maximum yield from a single destructive harvest. Other varietal characteristics such as the facility for cleavage of sprouts from the main stem, and for the removal of leaves, and the straightness of the main-stem, will have to be taken into account. (C. North, J. Dancer).

CABBAGE

Preliminary trials have begun on a number of varieties bred at S.H.R.I.; one of the stocks seems to be especially promising. It is an F_1 that forms plants similar to January King, but lacking the purple coloration of the heads. More extensive trials will be started with this variety. (W. G. Priestley).

Because of the increasing interest being taken in the clamp-storage of cabbage heads, the effects of several chemicals on storage life have been examined. The application of TCNB and Dichloran dusts reduced storage losses by about 10 per cent., but further experiments will be necessary before the general use of these materials can be recommended. (H. Taylor, D. A. Perry).

Studies on the heading of cabbage were recommenced. Since daylength has been shown to have an effect on head formation in lettuce, an experiment was set up to find whether it would influence the development of cabbage. The light periods to which plants grown in the open field were subjected, were controlled by mobile black-out covers and supplementary artificial lighting. The results of the treatments on heading are complex, but it is clear that supplementing the daylength (eight hours of daylight) with lights from tungsten-filament lamps, affected the distribution of growth. Plants treated with supplementary lighting had larger main stems and wider internodes, and in 1965 they initiated flowers earlier than the controls. (J. Dancer, C. North).

CARROTS

In collaboration with the Virology section good progress has been made toward the breeding of carrots tolerant to motley dwarf virus disease. Plants artificially infected in the field showed similar varietal ranking for tolerance in two consecutive years but, with each variety, the amount of reduction of yield resulting from virus infection depended on the density of the plant population. A glasshouse test which gives assessments comparable to those from a field test, has been developed; this has the advantage that it may be conducted during the winter and thus spread the time available for assessments. (H. J. V. Gledhill, A. F. Murant).

Field-scale experiments at Invergowrie have confirmed that higher yields of small roots for canning whole can be obtained from the bed system than from the single row or 'ridge' systems. Sowing rates as high as 12 lb./a. with the bed system (56 in. centres) have given the highest yield of canning carrots.

The principle cause of variation in root size is variation in time of emergence of seedlings. Those which develop late are soon over-shadowed by their neighbours and their development is retarded. Experiments showed that inter-plant competition can be reduced by sieving out the small seeds, which normally germinate late, but that grading into medium- or to large-sized seeds gives no additional advantage. Some of the differences in time of seedling emergence and subsequent development are attributable to genetic variation which can be reduced to a minimum with an F_1 variety. The prospects for developing an F_1 variety utilising male-sterile material are being examined. (H. J. V. Gledhill).

SWEET CORN

Variety trials at Invergowrie have clearly indicated that, given a suitable variety, it should be possible to grow commercial crops of sweet corn in the more sheltered areas of Scotland. The varieties Prima and Spring Gold, which mature very early, have consistently given good crops of high quality cobs, except during the exceptionally cold summer of 1965. It will probably always be necessary to raise the seedlings in a glasshouse for transplanting to the field early in June, rather than by sowing direct in the field and singling, and it is essential to take measures to control frit fly (*Osinella frit*). (H. Taylor, D. Mason).

HORSERADISH

Some interest is being shown in the growing of horseradish for processing in Scotland. A number of clones are available and several are being used for this purpose, but none is eminently suitable. To obtain new clones for selection of more suitable types it is necessary to raise seedlings, but viable seed of this crop is not produced in nature, even though the plants frequently flower. Two seedlings have, however been obtained by bud pollinating plants of a Swedish clone, and these seedlings have been propagated for further examination. (C. North).

CAULIFLOWER

Winter cauliflower plants are often killed during severe weather in many parts of central Scotland, and plant size at the onset of cold weather is said to be one of the factors which have a considerable influence on their survival. Experiments to test this belief, using the hardy variety St. George, confirmed that relatively small plants (raised from seed sown in late May) survived better than larger plants (seed sown in March) during the cold winter of 1963-64 but not in the mild winter of 1964-65. Plants from the earlier sowings gave larger curds, and matured a few days earlier than those from the later sowings.

The Institute acted as one of the centres for a trial of cauliflower varieties sponsored by the Horticulture Committee of the Scottish Agricultural Improvement Council. In both 1964 and 1965 the varieties Malina and Van der Berg 35 matured earliest from sowings made under glass in late February. Stocks of Finney's Every Day and All the Year

Round were the latest to mature–some 25 days later than the earliest in the trial. (H. Taylor, D. Mason).

Studies on the effects of environment on the curding of cauliflower have been started. It is generally assumed that curd formation is linked with flower induction, and several reports suggest that plants grown at high temperatures–which do not permit flower induction–fail to form curd. However, when the varieties Snowball and Delta were raised and kept at temperatures about 20°C. they formed branched curd-like structures bearing many blanched bracts but no flower initials. This result throws some doubt on the view that curd formation is merely a stage in the onset of the flowering condition. (J. Dancer).

PUBLICATION

PRIESTLEY, W. GRETA (1965). Practical techniques in Brassica breeding. *Hort. Res.*, **5**, 49-51.

(This is a summary of the paper read at the Eucarpia Symposium on Brassica Crops held at the Institute in 1964. Techniques of inbreeding, test-pair crossing, and controlled cross-pollination for the production of F_1 hybrid seed are discussed).

Plant Physiology

C. G. GUTTRIDGE

The section was unfortunate in losing the services of Dr P. A. Thompson in November 1964, when he left to take up appointment as Physiologist at the Jodrell Laboratory, Royal Botanic Gardens, Kew. Dr Thompson has an enviable record of achievement acquired during his seven years at the Institute, and he did much to help the section's establishment during the early years.

Dr P. B. Goodwin was appointed in August 1965 to the vacancy and we are pleased to welcome him. In his post-graduate work on potato physiology at the University of Nottingham, Sutton Bonington, Dr Goodwin acquired experience in the use of biochemical techniques which will be of great aid to the research on growth substances associated with fruit development which he is now doing.

Mr A. Gordon joined us in 1964 from the Botany Department, University of Edinburgh, and Miss M. Edward and Miss C. A. Chambers were appointed Scientific Assistants in 1964 and 1965 respectively. Mr J. B. Garrie was transferred from the Genetics section in 1965. Mr W. Scott Stewart left us to take up a commercial appointment in agriculture.

Mrs O. Abdel-Galil came in November 1965 to work on growth hormones. She is a graduate of Alexandria University, U.A.R. and is registered as a research student in the University of St. Andrews.

Under a new scheme for prospective post-graduate students to gain experience in research institutes, Miss A. H. C. Wheeler, University of Edinburgh, spent three weeks in July 1965 studying the interaction of CCC and gibberellic acid on seedling lettuce and strawberry.

During 1965, Dr Mason has been acting as Scientific Liaison Officer for the Institute. He also found time to assist the librarian in the preparation of an annotated bibliography of the culture and physiology of strawberry. I gave a paper at a research symposium on CCC arranged in Geneva, Switzerland by Cyanamid International.

CHEMICAL REGULATION OF PLANT GROWTH

The hormone regulation of growth in strawberry

Environmental studies have shown repeatedly that exposure of strawberry plants to long day-length induces the production of a stimulus which can be transported from the donor plant along the connecting stolon to a receptive daughter plant, where it stimulates elongation of petioles and induction of runners. Flower formation is inhibited by this stimulus, although this may be an indirect effect. These effects are simulated by applied gibberellic acid, and there is circumstantial evidence that the native stimulus is a hormone which is related to or connected in some way with the gibberellin system. However, the chemical or chemicals transported from leaf to receptive region, cannot be gibberellic acid (A_3) nor gibberellins A_1, A_4, A_7 or A_9, because all these induce elongation of the vegetative main stem, a tissue which does not normally elongate. It is possible that the transported hormone could be a gibberellin precursor, which is converted to an active gibberellin in those regions where the appropriate enzyme or enzyme complex is active; or it could be an active gibberellin (other than those mentioned above) whose activity is suppressed in non-responsive tissues by enzymatic break-down or blocking at the molecular level; or the observed effects might result from transport of substances unrelated to or only remotely connected with gibberellins. The fact that gibberellic acid does not entirely substitute for long photoperiods in promoting the growth of petioles suggests that gibberellins or gibberellin precursors cannot be the only stimuli emigrating from the leaf in long photoperiods. The bio-assay of plant extracts on strawberry seedlings appears to offer the possibility of analysing this experimental situation.

Gibberellin-like activity is detectable in extracts from various organs of the strawberry and can be assayed on strawberry seedlings. Use is being made of this system to characterise and study the native hormone. (C. G. Guttridge, A. Gordon).

Interaction of gibberellins and growth retardants

In general terms, growth retardants have the opposite effect on plants to the gibberellins. The opinion current is that the retardants (among other activities) inhibit or restrict the biosynthesis rather than the activity or metabolism of native gibberellins. This seems to explain the behaviour of strawberry plants treated either with (2-chloroethyl) trimethylammonium chloride (Cycocel or CCC) alone or with CCC mixed with gibberellic acid. Essentially, CCC applied alone simulates the effects of short photoperiods except that it does not promote flower formation. The effects of CCC are nullified if gibberellic acid is applied at the same time, as would be expected if it were replacing a suppressed native gibberellin. Gibberellic acid also induces elongation of the vegetative stem but this is not countered or antagonised by concurrent application of CCC; this result suggests that CCC does not interfere with the metabolism of gibberellic acid. Indeed in some experiments CCC actually enhanced this elongation, but this apparent synergism is open to more than one interpretation.

Difficulty with interpretation also arises with another experiment in which pairs of parent and daughter plants, joined by the stolon, were arranged in the growth cabinets so that the long-day photoperiodic stimulus was generated either in the daughter plants themselves or in the attached parent plant. Under both sets of circumstances, application of CCC to the daughter plants depressed the growth of their petioles. This could mean that CCC blocks the biosynthesis of gibberellin at some step which occurs in the meristematic and elongating regions of the plant rather than in the leaves where the long-day stimulus originates. However, other interpretations are possible. (C. G. Guttridge, H. McC. Anderson).

Effects of growth substances in Fuchsia

In general gibberellic acid simulates the effect of long days and promotes the flowering of some long-day plant species in short days. In long-day varieties of *Fuchsia* (*fulgens* × *magellanica*) however, gibberellic acid not only fails to promote flower induction in short days but actually inhibits it in long days, although it has no effect on the flowering of the day neutral *Fuchsia triphylla* hybrid, Thalia. Because of this unusual response other species of *Fuchsia* were tested. The species which flowered only in long day-lengths, *F. gracilis*, *F. lycioides*, *F. magellanica* and *F. magellanica alba* were prevented from flowering by weekly sprays of 125 p.p.m. gibberellic acid. Gibberellic acid decreased but did not inhibit the flowering of *F. microphylla*, which is a quantitative long day species. In one experiment, the flowering of *F. fulgens* (a long-day species) was unaffected by gibberellic acid sprayed weekly at 100 p.p.m. but in another, flowering was considerably increased by 5 p.p.m. sprays but decreased by 125 p.p.m. sprays. The flowering of *F. procumbens* was sparse and irregular in both long and short days and gibberellic acid did not improve it.

Since CCC generally has the opposite effect to gibberellic acid on plant growth, the effect of these two substances applied separately and in combination on the flowering of the cultivar Howlett's Hardy was examined. At rates up to 4.0 gm. per plant applied to the soil, CCC had no effect on flowering; it neither inhibited flower induction in long days, nor did it counter the inhibitory effect of gibberellic acid or promote flower formation in short days.

Increasing amounts of gibberellic acid increased internode length in both long and short days. From the shape of the response curves, it appeared that either the gibberellic acid had to overcome some inhibitory effect when applied to plants grown in short days, or that it was acting independently of the daylength stimulus. By the end of the experiment the controls frequently had longer internodes than the plants treated with 125 p.p.m. gibberellic acid, suggesting that some exhaustible growth factor had been utilized in larger quantities by the greater elongation following treatment.

In further experiments, plants of the *Fuchsia* species, *fulgens*, *gracilis*, *lycioides*, *magellanica*, *magellanica alba*, *microphylla*, *procumbens*, *serratifolia triphylla* (Thalia) and the cultivars Howlett's Hardy and Winston Churchill growing in long days in the glasshouse in summer, were sprayed weekly with a 100 p.p.m. aqueous solution of one of the following auxins; 3 indolyl butyric acid (IBA), 245 trichlorophenoxyacetic acid (245T), 245 trichlorophenoxybutyric acid; the antiauxins 246 trichlorophenoxy-acetic acid (246T), 235 tri-iodobenzoic acid (TIBA); and the growth inhibitors coumarin, sodium benzothiazole 2 oxyacetate (BTOA)* and thiouracil. BTOA reduced internode elongation. 245T killed some plants although its analogue 246T did not. None of the growth substances inhibited flowering, and IBA, BTOA, 245T and TIBA increased the number of fruits set.

The ability of a flowering stimulus to pass across a graft union has been demonstrated in a variety of plants, and grafting has been a useful technique in physiological studies of flowering. With this in mind, grafts were made between the day-neutral variety Thalia (*F. triphylla*) and the long-day variety Howlett's Hardy. Although no flowering stimulus was transmitted, some interesting responses were obtained. Scions of Howlett's Hardy were inhibited from flowering in long daylengths when grafted to a flowering stock of Thalia, but flowered normally when self-grafted. Control scions of Howlett's Hardy failed to flower in short daylengths when self-grafted or grafted on to Thalia stocks.

Because gibberellic acid inhibits flowering in Howlett's Hardy but not in Thalia, these results could mean that a gibberellin-like substance originating in Thalia stocks was crossing the graft union and inhibiting flowering in the scions of Howlett's Hardy. This situation appears to lend itself to further analysis by grafting and other techniques, and further work is in hand. (D. T. Mason).

Flower differentiation in tulips

Preliminary studies on the suitability of Scottish-grown tulip bulbs for forcing were begun and the progress of flower formation observed by dissecting samples of bulbs from stores kept at 68°F. (D. T. Mason, D. H. Turner†).

FIELD INVESTIGATIONS WITH STRAWBERRY

Post harvest defoliation and nutrition

Experiments at Invergowrie and Auchincruive have shown that, in circumstances where its predecessors Auchincruive Climax, Talisman and Redgauntlet would be expected to respond to defoliation, the variety Templar does so too, although the response may not be as great. All these varieties respond because plants normally fail to initiate enough trusses to enable them to produce their maximum yield when grown on highly fertile soils in Scotland.

Failure to initiate sufficient trusses is associated with low temperatures in autumn and cloching of non-defoliated plants in autumn tends to counteract this. Thus, cloching from 31 August to 4 November 1963,

*Supplied by American Cyanamid Company.
†Edinburgh and East of Scotland College of Agriculture.

increased initiation from 0.7 to 1.4 truss per crown in Redgauntlet; cloching for a similar period in 1964 increased initiation from 0.55 to 0.83 truss per crown in Templar. Analysis of the meteorological records for the past ten years suggests that early initiation of trusses is promoted by temperatures lower than average during late August and early September, and, subsequently, by temperatures above average. Because of this, defoliation would be expected to be less frequently beneficial in the south of England than in Scotland.

Certain conditions of soil fertility and site can also lead to deficiencies in truss numbers. There is no doubt that poorly growing plantations are unlikely to benefit from defoliation, first because of an already optimal level of flower initiation, and secondly because the reduction in vigour following defoliation is likely to be damaging. Comparisons between plots grown at different sites at Invergowrie have shown a relationship between height and width of plant on the one hand and number of trusses and crop on the other. In intact control plants, the highest yields were from plants of intermediate size; smaller plants lacked vigour, and larger plants lacked sufficient numbers of flower trusses. Defoliation corrected the latter fault so that, among defoliated plants, the highest yields were from the most vigorous plants.

Excessive vigour, leading to a sub-optimal number of trusses, has been induced in plants growing in a peat/sand mixture outdoors by increasing nitrogen. But when plants receiving the highest level of nitrogen were defoliated, they initiated the highest number of inflorescences per crown. An increase in potash increased the numbers of trusses within the bud, but this was due either to delayed summer initiation or retardation of leaf emergence and not to an increase in level of initiation. (D. T. Mason, C. G. Guttridge).

Adverse effects of defoliation

Comparison of the numbers of trusses initiated on the main axes of crowns in the autumn with the number of flower trusses per plant emerging the following summer showed that a lower proportion of initiated trusses reach maturity and flower in defoliated plants than in intact plants. Over many experiments with Talisman, Redgauntlet, Cambridge Favourite and Cambridge Vigour the mean loss of crop attributable to this was 10 per cent. Mechanical damage to the crowns and reduced branching are partial causes but, as the loss can be reduced by sprays of thiram, pathogens are involved, which, it is suggested, enter through the cut surfaces of the petioles and occasionally penetrate into the crowns. A further loss of about 10 per cent. arises from a decrease in the size and yield of individual trusses. These harmful effects of defoliation, amounting to 20 per cent. reduction of the potential yield, occur irrespective of whether the rate of truss initiation is promoted, unaffected or decreased by defoliation. As defoliation increases truss initiation in Talisman even where no barren crowns are present in the intact plants, this variety is less likely than others to suffer a decrease in yield from defoliation under unwarranted circumstances. By contrast, Cambridge Favourite, which is unlikely to respond by increased truss initiation, almost always yielded less when defoliated in our experiments. It is clear, therefore, that only where substantial increases in initiation can be expected will defoliation increase the crop. (C. G. Guttridge, D. T. Mason).

Runner control

Compared with plants which are allowed to runner freely, maidens from which all the runners are removed by hand, may produce up to 50 per cent. more fruit the following year. To eliminate the need for hand labour, maleic hydrazide or a contact herbicide (paraquat) have been used to kill the runners. Experiments with the growth retardants (2-chloroethyl) trimethyl-ammonium chloride (Cycocel or CCC) and N-Dimethylamino succinamic acid (B995 or B9) have shown that these are less destructive, as they only suppress elongation of runners and of leaf stalks. With a sufficient dose, elongation of runners is completely prevented and the buds may develop later as branch crowns, resulting in an increase in plant size. Both chemicals temporarily depress the growth of the parent plants. Cycocel, but not B9, also causes chlorosis and partial necrosis of leaves emerging at and soon after spraying, although subsequent leaves are undamaged and the plants soon recover.

In 1964, two sprays of 4 per cent. Cycocel, the first applied at an early stage of flowering in late May and the second about 6 weeks later, almost completely suppressed runner formation in Talisman for the whole season. Occasional runners were produced, but these were mostly on short stolons and rooted within the canopy of leaves of the parent plant. Single sprays applied in May (8 per cent.) or July (4 per cent.), or 1.6 gm. per plant (in aqueous solution) injected into the soil near the roots in early June controlled runners effectively for part of the season. The free-runnering controls yielded 10 oz. of sound fruit per plant; all chemical treatments increased yields to 14-15 oz. per plant as did removal of runners by hand. The general level of cropping was depressed by infection with *Botrytis cinerea*. The effective control of runners by hand-removal or chemical treatment increased the size of the parent plants and almost doubled the number of crowns.

In 1965, similar rates of application did not control runnering in Cambridge Favourite or Redgauntlet and were less effective on Templar than they were the previous year on Talisman. This inadequate control resulted merely in a shortening of the runners and is of little value.

In a further experiment, maleic hydrazide (MH) and Cycocel were sprayed separately or together on plants of Templar on 15 July 1964, after some runners had formed. As expected from earlier work, sprays of 0.15

and 0.075 per cent. MH on the parent plants effectively killed the growing tips of unrooted runners and depressed the growth of the parents. The addition of Cycocel to the MH spray increased the duration of runner control but also increased the severity of the damage to the parent plants. All treatments, ranging from 0.075 per cent. MH alone to a mixture of 0.15 per cent. MH and 4 per cent. Cycocel, increased yields, confirming that partial control of runnering, even with a measure of damage or growth restriction, results in increased fruit yield the following year. (C. G. Guttridge, H. McC. Anderson).

Cold storage

By careful attention to detail, especially the precise control of temperature, strawberry plants dug in winter or spring can be stored until summer. However, the plants begin to break down and rot soon after this, and there is little latitude for mistakes or mechanical failure of equipment. Moreover, some cryptic kind of deterioration undoubtedly occurs during storage.

In one experiment on deterioration, batches of plants were removed from store at intervals through spring and summer. On each occasion samples were analysed for carbohydrates in the Biochemistry Department of the Macaulay Institute for Soil Research at Aberdeen, while other plants were potted and grown on in a controlled environment cabinet at Invergowrie. The chemical analyses showed progressive depletion of total carbohydrate (anthrose values), and of the starch, sucrose, glucose and fructose fractions in plants stored at 32°F.±2°F. Severe depletion did not occur in plants stored at 30°F.±1°F. until after the June sampling. In the plants grown on in the cabinets, the incidence of death or severe damage, apparently caused by pathogenic infections, increased with increasing periods of storage; together, the results suggest regressive resistance to pathogens. The increased incidence of infections vitiated any attempt to relate depletion of food reserves with changes in growth.

Carbohydrate analyses were also done on plants which had been stored for twelve months. Compared with fresh, untreated plants, the starch and sugar reserves in plants stored for twelve months were decreased by about two-thirds. Nevertheless, before succumbing to pathogens, stored plants grew, initially, with greater vigour than the fresh plants, but this only demonstrated the known influence of low temperature chilling in promoting vegetative growth and breaking dormancy. (C. G. Guttridge, H. McC. Anderson).

In conjunction with the Mycology section, some attempts to mitigate the adverse effects of cold storage were made. Bundles of 12 runners of Redgauntlet and Cambridge Favourite (lifted in December) were each wrapped in wet-strength paper impregnated with one of five volatile fungicides before storage in closed 200-gauge plastic bags. The fungicides used were tetrachloronitrobenzene, pentachloronitrobenzene, o-phenyl phenyl acetate, o-phenyl phenyl *iso*butyrate, o-phenyl phenyl laurate at 25 mg. and 50 mg. rates of application. After 10 months at 30°F., the runners were planted and scored for survival. Although Redgauntlet survived better than Cambridge Favourite, the number of surviving plants both in controls and treatments was so low that it was evident that none of the fungicides had been effective in controlling rotting.

In a second experiment, bundles of 12 runners of Cambridge Favourite, lifted in February, were packed and stored with moderate-release paper pads impregnated with 5 gm. or 1.25 gm. or 0.31 gm. of the fungicide DBTCE* (dibromotetrachloroethane) per bundle. Other plants were washed in water and packed wet, or washed and dried before packing by laying out on thick blotting paper, or were stripped of all leaves before packing. Control plants, stripped plants and those treated with fungicide were unwashed. The experiments were replicated eight times, each bundle of 12 plants being separately bagged. After storage at 30-31°F. for eight months the runners were planted and scored for survival. The largest number (93 out of 96) of plants survived when plants were washed and packed wet. There was no difference between those which had been washed and dried and those which had been subjected to the lowest rate of application of DBTCE; these produced the next best survival figures (80 out of 96). Stripped plants had a good appearance upon removal from storage but did not survive well after planting. A disturbing feature was the variation in survival figures for different bundles of controls. (I. G. Montgomerie, C. G. Guttridge).

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*Supplied by Crown Zellerbach Corp., Camas, Washington, U.S.A.

PUBLICATIONS

GUTTRIDGE, C. G. (1966). The interaction of (2-chloroethyl) trimethylammonium chloride and gibberellic acid in strawberry. *Physiol. Pl.*, **19**, 397-402.

(Applications of CCC, by foliar spray or to the soil, shortened petioles and decreased top and root growth of strawberry plants. Application of GA_3 increased petiole length and fresh weight of tops but not of roots. Applied together, GA_3 overcame the depression of growth in weight of tops induced by CCC and countered the depression in petiole lengths. GA_3 induced elongation of internodes of the vegetative stem and elongation was increased substantially by concurrent application of CCC.

The synergism in stem growth indicates a lack of antagonism between CCC and exogenous GA_3 in strawberry).

GUTTRIDGE, C. G., ANDERSON, H. M. and STEWART, W. S. (1966). The control of strawberry runners in the field with CCC. *Exp. Hort.* (In press).

(This paper reports work described on p. 35 of this Report).

GUTTRIDGE, C. G. and MASON, D. T. (1966). The effect of post-harvest defoliation on truss initiation, crown branching and yield in strawberry. *Hort. Res.* (In press).

(Post-harvest defoliation of strawberry plants increased truss numbers and fruit yields more often in the variety Talisman than in Redgauntlet but decreased both in Cambridge Favourite. Yield increments were due to increased initiation of trusses, giving more trusses per crown. Potential crops, based on truss initiation rates, were not fully realized in defoliated plants, especially when defoliation was delayed until early September, because of (a) crown death and a decreased capacity to form new branch crowns, and (b) a decrease in the yield of fruit per truss, compared with uncut controls. Sprays of thiram reduced crown death, suggesting that pathogens were involved. Commercially useful increments in fruit yield from defoliation are likely only when truss initiation rates are sufficiently low to permit worthwhile increases).

MASON, D. T. (1964). A survey of numbers of *Endogone* spores in soil cropped with barley, raspberry and strawberry. *Hort. Res.* **4**, 98-103.

(Soil from the root regions of barley, raspberry and strawberry plants was wet-sieved and the numbers of *Endogone* spores present were recorded. The results suggested that the spore numbers decreased when young roots were present and that they increased during periods of reduced root growth, but that in addition they were affected by fluctuations in soil temperature and moisture).

MASON, D. T. (1966). Inflorescence initiation in the strawberry. 1. Initiation in the field and its modification by post-harvest defoliation. *Hort. Res.*, **6**. (In press).

(Defoliation of the varieties Talisman and Redgauntlet in August frequently increased the final autumn level of inflorescence initiation. Sometimes the rate of initiation decreased immediately after defoliation but later increased sufficiently to give a total level of initiation surpassing that in the intact plants. Defoliation also immediately decreased the rate of inflorescence initiation in Cambridge Favourite and Royal Sovereign but in these varieties any increase which subsequently occurred was usually insufficient to raise the final level to that in the intact plants).

MASON, D. T. and STEPHENS, R. J. (1965). The use of chemicals for the post-harvest defoliation of strawberry plants. *Weed Res.*, **5**, 305-310.

(Chemical sprays were tested as alternatives to mechanical means of defoliating strawberry plants. Rapid desiccation of the foliage was obtained with dinoseb, sodium monochloroacetate, magnesium chlorate and sulphuric acid but the use of these chemicals normally resulted in lower yields than those obtained by mechanical defoliation. The reductions in yield appeared to be due to the less vigorous growth of the plants rather than to a lower level of inflorescence initiation).

Genetics

G. M. L. HASKELL

Mention has been made in the General Report (p. 9) of Dr Haskell's appointment to the headship of the Department of Biological Sciences, Portsmouth College of Technology. He left the Institute in August 1965, and pressure of work in his new post has prevented him from preparing his own contribution to this Report. Therefore the following account of work in the Genetics department contains no information on the topics which were Dr Haskell's personal concern–*Rubus* genetics, tomato breeding and chromatographic analysis of plant material. The last two of these have, of necessity, been discontinued for the time being and Mr J. B. Garrie, who was engaged in the chromatographic work was transferred to the Plant Physiology department. Dr Jennings has acquired Dr Haskell's blackberry material and will be associated with any future breeding work with this crop. Dr A. B. Wills, Mr E. B. Paterson and Miss R. S. Archer now form part of the new Plant Breeding section. There are no extra-mural activities to report. Much work has, however, been done by Dr Haskell and Dr Wills on the preparation of a practical handbook on cytological techniques and by Dr Wills and the Librarian, Mr W. Anderson, on a review of the literature on strawberry breeding and genetics.

CYTOGENETICS OF BRASSICAE

As breeding work with varieties and species of *Brassica* forms an important part of the Institute's work, investigation of the cyto-genetic behaviour of *Brassica* species has been revived. Evidence that the basic chromosome complement (2n=18) is of partly polyploid origin was reported in 1959 and more recent observations confirm this. Strong clumping of bivalents in prophase, stickiness between bivalents, secondary associations, multivalent associations and disturbances at metaphase and anaphase were observed in cabbage (*B. oleracea var. capitata*), Brussels sprout (*B. oleracea var. gemmifera*) and in all other species examined. The balance of cytological evidence suggests that true quadrivalent formation occurs. This would imply that polysomic as well as disomic segregations are to be expected in monogenomic *Brassica* species. This could well be of importance in the production of F_1 hybrids and the synthesis of new types of Brassicae.

Only few characters determined by single genes are known in *B. oleracea*–glossy leaf and white flowers are two–and more such are needed before adequate tests for polysomic inheritance can be made. In an effort to induce suitable mutations, seed of cabbage and Brussels sprout were exposed in 1956 to neutron and gamma irradiation. Treated and untreated seeds, stored since 1956, were sown in 1965. Both lots of seed germinated less well than in 1956 and the viability of cabbage seed was affected more, both by irradiation and storage, than that of Brussels sprout. Plants of Brussels sprout were allowed to flower and set seed in the field and progenies from these are being grown on. (A. B. Wills, R. S. Archer).

STERILITY IN THE HORSERADISH

Horseradish (*Amoracia rusticana*) appears never to set seed naturally and only rarely when artificially pollinated but cytological examination of sterile clones from Sweden and Yugoslavia revealed no obvious reason for this. Each clone had the same chromosome number ($2n=32$). Despite the fact that flowers on all plants developed abnormally, meiosis was usually regular but occasional quadrivalents and bridges were seen. Meiotic behaviour is compatible with a diploid or allotetraploid constitution and there is little evidence to support the idea that horseradish is a diploid interspecific hybrid.

MALE STERILITY IN CARROT

Male sterility in carrot would offer a means of obtaining F_1 hybrid seed on a large scale, thereby possibly overcoming some difficult problems in carrot breeding. However, the expression of male sterility varies between and within lines, and may not be constant even within one plant. To investigate the developmental changes in male-sterile lines, pollen meiosis and anther and microspore development were examined in unrelated lines of male-sterile carrots grown by the Vegetable Crops Department.

In two greenhouse-grown lines, microspores were present, although their viability was doubtful, and male sterility was associated with collapse of anther filaments and shrivelling of anthers without dehiscence. In two field-grown lines the anther contents degenerated shortly after meiosis. One plant, chosen for detailed analysis from a third field line, showed a syndrome comprising all stages of microspore degeneration, varying from flower to flower and even varying between anthers within the same flower. Inclusions, staining faintly with orcein and deeply with safranin, were present in many degenerating microspores. However, anther dehiscence was normal and this line was therefore difficult to classify by field inspection.

Meiosis was normal in field lines, except for the rare occurrence of two univalents in place of a bivalent. However, pollen mother cells failed to dissociate freely, even at the tetrad stage, thus revealing the presence of early cytoplasmic changes in the male-sterile lines. (A. B. Wills, R. S. Archer).

THE BREEDING SYSTEM IN RIBES

As part of a search for morphological characters that might be of use in predicting relationships between sub-groups of the genus *Ribes*, the external morphology of mature pollen grains has been examined. For this purpose, a novel method of staining has been developed which displays the sexine patterns on the grains.

Pollen grains of the two sub-genera *Ribesia* and *Grossularia* show differing structure. Typically, those of *Ribesia*, represented by sections *Eucoreosma* and *Ribesia*, have grains with few pores and sexine patterns generally restricted to the vicinity of the pores, and species in sections *Symphocalyx* and *Calobotrya* have grains with more elaborate structure. By contrast the pollen grains of species of *Grossularia* have higher numbers of pores and sexine patterns in the form of longitudinal straps, varying in number. *Calobotrya* was the only sub-section of *Ribesia* possessing species with sculptings and pore numbers approaching those found in *Grossularia*. (A. B. Wills).

PUBLICATION

WILLS, A. B. (1966). Meiotic behaviour in the Brassicae. *Caryologia*, **19**, 103-116.

(At meiosis in *Brassica oleracea* (cabbage and Brussels sprout), *B. pekinensis* and the related *Sinapis arvensis* and *Eruca sativa*, multivalents were common and numerous secondary associations of bivalents were detectable in all species from diplotene into metaphase. Quadrivalent formation in cabbage and Brussels sprout usually involved an increase in chiasma frequency per cell and there is evidence that the potential quadrivalent frequency is limited at least partly, by limited chiasma formation. Secondary associations are thought to represent lapsed multivalents. Extensive duplication of chromosomes (or of large chromosome segments) is therefore implied, and polysomic rather than diploid breeding behaviour should be expected for many gene loci).

Virology

C. H. CADMAN

My appointment, first as Acting-Director in September 1964 and subsequently as Director in February 1965, meant the severance of the intimate association with the work of the section which my authorship of this Report implies. Throughout this period I am much indebted to Dr C. E. Taylor for acting in my stead as head of section, and co-ordinating an increasing diversity of activities during a particularly difficult phase of the Institute's development. Apart from myself, the section has not lost any senior members of staff and has in fact acquired two new ones. Dr P. R. Thomas joined the section in March 1965 to do research on ectoparasitic nematodes concerned in virus transmission. Dr S. Allen was appointed in December 1965 to the new post of biochemist and began work in March 1966 on the nucleic acid chemistry of tobacco rattle virus. Miss H. P. Holmes came in October 1965 as Assistant Experimental Officer to help Dr Taylor with work on the biology of aphids and raspberry beetle (*Byturus urbanus*). Of the Scientific Assistant staff, Miss S. Alexander left in March 1965, Mr W. M. Robertson and Miss M. J. Cameron were appointed in September and November respectively, and Mr B. A. A. Robertson worked as a temporary assistant during the year.

After spending three years in the section working for a higher degree in the University of St. Andrews, Mr A. M. Yassin, Faculty of Agriculture, University of Khartoum, left in January 1966 to return to the Sudan. Under the auspices of the British Council's scheme for exchange of workers between the U.S.S.R. and the United Kingdom, we were pleased to welcome, in September 1964, Mrs Mara Kilevits of the Plant Protection Department, Latvian Agricultural Academy, Riga. She rapidly became a popular and useful member of staff and her stay ended in July 1965 with mutual regret. At this time, Dr R. H. Converse of the U.S.D.A., Beltsville, Maryland, came to spend six months in the section to acquire experience in virological techniques. As one of the few United States workers in the field of raspberry viruses, he was specially welcome and his stay was productive both in fostering exchange of information in this country and in Europe, and in research results. Our main regret was the briefness of his stay which ended in December 1965. In October 1965 Mr H. S. Abu Salih of the Gezira Research Station, Republic of the Sudan began post-graduate studies jointly supervised by staff of the Virology section and the Botany department of Queen's College, Dundee. In January 1966, Mr Tor Munthe of the Agricultural College, Vollebek, Norway, came to spend a year in the section to acquire experience in plant virus work, and in February, Mr Liam Staunton of the Agricultural Institute, Kinsealy, Eire, arrived to spend a few months for the same purpose.

The past two years seem to have been more than usually productive of meetings, both at home and abroad, in which members of staff have participated. Under the auspices of the International Society for Horticultural Science, a symposium on virus diseases of ornamental plants, to which I was invited, was held in June 1964 at the Glasshouse Crops Research Institute, Littlehampton. The International Entomological Congress, held in London in July 1964, was attended by Dr Taylor, and the proximity of the 7th International Botanical Congress in Edinburgh that month induced several members of staff to attend; I contributed a paper to a symposium on 'Relations between Plant Viruses and their hosts.' Whilst on a private visit to the U.S.A., I attended and lectured to the Small Fruit Workers Conference held at Beltsville, Maryland, in January 1965. With the aid of travel grants from the Agricultural Research Council in 1965, Mr Chambers and I attended the 6th Symposium on Fruit Tree Virus Diseases in Europe held at Belgrade, Yugoslavia in July, where a paper on apple viruses by Dr Lister and myself was read; also in July Dr Lister, Dr Murant and I attended the Conference on Plant Viruses held at Wageningen, Netherlands where Dr Lister read a paper; he subsequently visited the Institute of Phytopathology, Aschersleben, East Germany, at the invitation of its director, Prof. M. Klinkowski; in September Dr Taylor attended and read a paper to the 8th Symposium of European Nematologists held at Antibes, France.

At home, members of staff took part in technical conferences held at Harpenden and East Malling, contributed to symposia organised by the British Mycological Society and the Association of Applied Biologists and talked about their work to members of the British Mycological Society who visited the Institute in July 1965. Dr Taylor attended and read a paper by Dr Murant and himself to the British Insecticides and Fungicides Conference at Brighton in November and Dr Lister contributed to a programme of seminars organised by the Edinburgh School of Agriculture.

The proximity of the Botanical Congress brought an unusually large flock of visitors in 1964, among whom we were glad to see many friends from the U.S.A. Dr G. Giussani from the Institute of Plant Pathology, Milan, and Mr N. Paludan from the State Plant Pathology Institute, Copenhagen, spent some days with us earlier that year. In 1965, Dr Shanta, Central Coconut Research Station, Kerala, S. India, and Dr L. Stubbs, Victoria Department of Agriculture, Plant Research Laboratory, Burnley, Australia, included us in their itinerary before returning home.

Major items of equipment acquired during the period covered by this Report include an LKB ultra-microtome for cutting sections of nematodes for examination with the electron microscope; an LKB fraction collector with an ultra-violet scanning device for the analysis of density gradients and column effluents, and a Spinco L2 ultracentrifuge. Mr J. Cathro built a new high-vacuum evaporation plant for the preparation of carbon films and metal shadow-casting. All of these are very material aids to the work in progress.

As a rule the preparation of an annual report is an unpalatable task because the achievements of a twelve-month always seem to fall short of anticipation. In this respect the lapse of two years is no disadvantage, for the following summary shows that progress has been made with a wide diversity of problems.

NEMATODE-BORNE VIRUSES

Occurrence and properties

Infected weed seeds are important reservoirs of tomato black ring and raspberry ringspot viruses transmitted by *Longidorus* spp. So far we have no evidence of this with arabis mosaic, a virus transmitted by *Xiphinema diversicaudatum*, though natural infection has now been looked for in seeds of common broad-leaved weeds in infective soils from five sites in England and one in Southern Germany. Only a single natural infection was discovered in a total of 444 seedling plants tested: this compares with an estimated total of 250 infections out of 2,265 weed seedlings tested among these germinating in air-dried soils from eight Scottish outbreaks of tomato black ring virus.

Similarly, in 1964 tests made in Indiana, U.S.A., with soil from an outbreak of tobacco ringspot virus (transmitted by *Xiphinema americanum*) showed not a single infection among 202 weed seedlings tested. The persistence of viruses transmitted by *Xiphinema* spp. thus seems less closely linked with the presence of reservoirs of infection in weed seeds than does that of viruses transmitted by *Longidorus* spp. (R. M. Lister, A. F. Murant).

In 1961 arabis mosaic virus (AMV) was found infecting raspberry in Aberdeenshire, strawberry in Lanarkshire and elderberry in Perthshire but there has always been doubt as to whether these outbreaks were native, because the nematode vector of AMV, *Xiphinema diversicaudatum*, was not found at these sites. This nematode was not in fact recorded in Scotland until 1964 when Dr P. Osborne, Edinburgh and East of Scotland College of Agriculture, discovered an infestation in an old rose garden in Midlothian. The occurrence both of *Xiphinema* and AMV in soil from this site was confirmed by tests made at the Institute. In 1965, an outbreak of AMV in Malling Exploit raspberry, associated with *X. diversicaudatum*, was found in the experimental gardens of the Edinburgh and East of Scotland College of Agriculture, Liberton, Edinburgh. The virus was also isolated from diseased plants of Lloyd George, Malling Promise and Norfolk Giant, varieties previously considered immune from infection.

X. diversicaudatum was present in low numbers in soil samples from the raspberry plots. Large populations (about 1 per g. soil) were found in association with the roots of Myrobalan plum (*Prunus cerasifera*) and elderberry (*Sambucus nigra*) in an adjacent hedge. (C. E. Taylor, P. R. Thomas, R. H. Converse).

Samples of the Hampshire isolate ('T39') of strawberry latent ringspot virus (see p. 69 10th Annual Report) and its antiserum, were sent on request to various workers and have aided in the identification of viruses from clover, flower bulbs and rhubarb at Rothamsted Experimental Station, the Glasshouse Crops Research Institute and the National Vegetable Research Station, respectively. A virus isolated from *Euonymus europaeus* sent here from Eastern Germany also proved to be strawberry latent ringspot virus. As anticipated, this virus may be quite widespread in Europe, though its importance as a cause of disease in economic plants is still unknown. (R. M. Lister).

Arabis mosaic, raspberry ringspot, tomato black ring and strawberry latent ringspot viruses were found infecting stocks of Double White narcissus; tobacco rattle virus was found in the variety Helios. It seems that nematode-borne viruses are wide-spread in local stocks of narcissus. (W. P. Mowat).

The variant of raspberry ringspot virus (RRV) isolated from diseased Lloyd George plants at Coupar Angus, Perthshire, possesses several unusual properties. Graft tests have confirmed the validity of earlier claims that the varieties Burnetholm Seedling, Lloyd George and Malling Seedling V are immune from the common Scottish form of RRV but all these are susceptible to the Lloyd George variant of the virus. *Chenopodium quinoa* plants containing the Lloyd George variant were not protected from infection by the much more severe, common form of RRV. Difficulties in establishing whether *Longidorus elongatus* transmits the Lloyd George variant are caused by the mutability of the virus when propagated in many of the customary herbaceous test plants and these difficulties are still unresolved. (A. F. Murant, C. E. Taylor, J. Chambers, R. A. Goold).

Field surveys and glasshouse experiments, involving the infection of plants by exposure to infective soils or by grafting have provided information on the susceptibility of a wide range of European and North American strawberry varieties to various nematode-borne viruses. Of the varieties tested, Huxley seems exceptional in being immune to tomato black ring virus in both graft- and soil-exposure tests, for, where adequate tests have been made with the other varieties, each has proved susceptible to each virus. However, even this indication of immunity must now be suspect in face of the recent evidence of variation in pathogenicity of raspberry ringspot and arabis mosaic viruses. (R. M. Lister, J. Chambers).

Two forms of virus-specific product can be isolated from plants infected with tobacco rattle (TRV) and pea early browning (PEBV) viruses: a stable form which is readily transmissible using sap, and an unstable form, which has only been transmitted readily when special methods, such as extraction of leaves in phenol, are used.

Preparations of the stable forms, but not the unstable forms, are antigenic and contain characteristic 'long' and 'short' tubular nucleoprotein particles, about 180 mμ × 25 mμ and 76 mμ × 25 mμ respectively in the case of the potato ring necrosis strain of TRV, and about 200 mμ × 25 mμ and 100 mμ × 25 mμ respectively for an English isolate of PEBV. It appears that only the 'long' particles are infective. Furthermore, inoculation of tobacco (TRV) or *Phaseolus vulgaris* (PEBV) with purified preparations causes local lesions, only some of which contain the stable forms whereas others contain the unstable forms.

Recent results are consistent with the idea that the 'short' particles are essential for the production of new stable virus. One interpretation of this is that the ribonucleic acid of 'long' particles is deficient in the information required for some stage of the process leading to the enrobement of viral ribonucleic acid with virus protein and hence gives rise to infections of the unstable type. The ribonucleic acid of 'short' particles on the other hand, though containing at least the information lacking in that of the 'long' particles, is inadequate to mediate other stages of the infection cycle.

It is tempting to suppose that the information missing in the ribonucleic acid of the 'long' particles, but present in the ribonucleic acid of the 'short' particulars, includes that coding for virus protein. (R. M. Lister).

Biology of nematode vectors

Soil samples from strawberry crops in many areas in southern Scotland have shown that *Longidorus elongatus* is widely distributed but not always in association with ringspot viruses. The largest populations have been found in the Coupar Angus area, Perthshire, where many of the strawberry and raspberry crops show evidence of virus infection. Populations of the nematode fluctuated throughout the year, with maxima about October, when many first instar larvae were found, and minima about June. (P. R. Thomas).

Laboratory studies have shown that the life cycle of *L. elongatus* occupies about 16 weeks at a temperature of 20°C. The females are long-lived, and eggs are produced at the rate of two or three a week for eight weeks or more. In the field, it would seem that the first instar larvae produced in the autumn are unlikely to reach the adult stage before the spring. There may be two generations per year; alternatively the same females may have two seasonal phases of egg-laying. (A. M. Yassin).

Populations of *L. elongatus* build up rapidly on strawberry, but comparable increases occur on rye grass (*Lolium perenne*), mint (*Mentha sativa*) and chickweed (*Stellaria media*). On raspberry, however, *L. elongatus* fails to reproduce and populations decline, although crops may become infected with viruses transmitted by the nematode. In strawberry crops, control of weeds decreases the spread of nematode-transmitted viruses but chemical treatment of the soil to kill the vector is the only effective means of control. Both quintozene (pentachloronitrobenzene or PCNB) and D-D (dichloropropane-dichloropropene) prevented infection of Talisman strawberry for four years after treatment. In a more recent experiment using Redgauntlet strawberry, a variety more susceptible to nematode-transmitted viruses than Talisman, quintozene, applied at 300 lb. per acre of the 20 per cent. product, effectively controlled both the nematode and virus infection. This experiment is still in progress, but in the first fruiting season 90 per cent. of plants in the untreated plots were infected compared with 3 per cent. in plots treated with D-D and no infection in those treated with quintozene; fruit yields increased by 500 per cent. in D-D plots and 400 per cent. in quintozene plots.

Quintozene has certain advantages over D-D in that it can be applied as a powder without the use of special machinery, and appears not to cause phytotoxic effects in strawberry. It is no less effective than D-D against *L. elongatus*, although it does not act quickly and does not produce the stimulatory effects on growth that follows D-D treatments. Its disadvantages are its lengthy persistence in soil and its possible toxicity to crops other than strawberry. Lloyd George raspberry grown on plots treated five years previously with quintozene at the rate of 1,200 lb. 20 per cent. product per acre, were dwarfed and the leaves mottled; sugar beet grown under the same conditions produced roots that were twisted. It is unknown whether these symptoms result from toxicity of quintozene residues in the soil or from an increase of fungal species inimical to the plants. (C. E. Taylor, A. F. Murant).

Electron-microscopy of nematodes

A study of the fine structure of *Longidorus* and *Xiphinema* nematodes was begun in 1965. Fixation in glyceraldehyde and embedding in methacrylate, cross-linked with styrene to increase hardness, yielded good preparations and sections 400Å thick which, when stained with uranyl acetate, could be examined at magnifications up to ×40,000. These have revealed the complex nature of the multi-layered cuticle of *L. elongatus* and the fact that all layers are shed during moulting. Studies are continuing on the morphology of the oesophageal regions of *L. elongatus* and *X. diversicaudatum*. (C. E. Taylor, P. R. Thomas, J. Cathro, I. A. Roberts).

TOBACCO NECROSIS VIRUS and *Olpidium Brassicae*

Although tobacco necrosis is one of the commonest of soil-transmitted viruses and has a wide host range, the virus is usually confined to the roots. Tulip is one of the few hosts in which the virus causes an economic disease–Augusta disease–through invading the foliage and flowers of susceptible varieties. This disease is known in more than 40 varieties other than Queen Augusta from which its name derives. The losses caused are sporadic and troublesome, principally in forced tulips, and may account for

5-20 per cent. of the crop or, on occasion, the entire crop. Despite the spectacular nature of the typical disease symptoms–necrosis of the stems, leaves and flowers–tests have shown that tulips commonly contain virus only in their roots and that, sometimes, systemic infection of the tops may be associated either with leaf mottling or no symptoms whatever. Viruses isolated from infected plants have proved to be either of the D serotype or mixtures of the A and D serotypes accompanied or unaccompanied by satellite virus and there seems no consistent association between type of virus and systemic infection.

The factors inducing movement of virus from roots to tops and the development of symptoms in susceptible plants are still a mystery but the results of a forcing experiment in 1964 suggest that stocks of a given variety may differ in behaviour. The trial compared samples from several sources of the varieties Korneforos, Princess Beatrix, Alberio and Queen Augusta planted in highly infective soil. The most informative results were from Korneforos where, out of 160 bulbs from each of three sources and 80 from a fourth, 19, 6, 1 and 0 respectively produced diseased plants, though sampling at the end of the experiment indicated that the roots of all the plants were infected with tobacco necrosis virus.

As tulip bulbs presumably become infected only when exposed to colonisation of the roots by *Olpidium brassicae* in the presence of tobacco necrosis virus, information has been sought on the ecology of the virus in soils and on the properties which distinguish transmitting from non-transmitting isolates of the fungus.

The results of field experiments, begun in 1963 on a site at the Institute, show that the level of infectivity varies erratically. It seems likely that the maintenance of infectivity depends on the continuous presence of host plants for both virus and fungus. Although a high proportion of the roots of tulips grown on this site in 1963-64 became infected with virus, no Augusta disease developed that season nor in the progeny bulbs when these were forced or grown in the open in 1964-65.

Precise measurements of the electrophoretic mobilities of zoospores of a transmitting and a non-transmitting isolate of *O. brassicae* showed that, in 0.0067M phosphate buffer at pH7, the two isolates carry a net negative surface charge differing significantly in magnitude. The observed mobilities were -2.3 ± 0.21 and -1.2 ± 0.35 μ/sec/volt/cm. respectively. (W. P. Mowat).

APHID-BORNE VIRUSES

Raspberry

Improvements in the system of producing root-cuttings of virus-free mother plants enabled us to raise some 6,000 plants in 1965–about double the 1964 output. This has been achieved mainly by allowing the mother plants to root into large boxes filled with ashes in place of soil, and by substituting sand for John Innes compost when boxing the root cuttings.

In 1964, half the output of glasshouse-grown plants was grown at East Craigs, Edinburgh, and half at a site near the Institute. In 1965, the bulk of the output was planted at a third site in Perthshire where establishment has been exceptionally good and the nurseries promise to yield a heavy crop of canes in 1966. Routine spraying with demeton-methyl at each of the local sites failed to prevent colonisation by raspberry aphids (*Amphorophora rubi*) and the discovery of virus infection in some of the Lloyd George plants in the 1964 planting necessitated the destruction of the entire stock of this variety. The maintenance of healthy stocks of Lloyd George presents so many difficulties that this variety may well have to be abandoned. (J. Chambers).

Plots of Malling Jewel, planted in spring 1965 and treated with disulfoton granules every 6 weeks or sprayed with dimethoate at 21-day intervals from early June to mid-September remained practically free from aphids under conditions where untreated plants carried up to 2,000 aphids per plant. Other plots that received insecticides at longer intervals became colonised as soon as the effects of the insecticides had dissipated. Thus, continuous protection against aphid colonisation seems necessary; it remains to be seen whether the treatments have effectively lessened or prevented spread of virus. Granular formulations, being easy to apply to raspberry cane nurseries, offer advantages and their usefulness is being explored. (C. E. Taylor, J. Chambers, W. I. Pattullo).

Carrot Motley Dwarf virus

Populations of *Cavariella aegopodii* on carrots reached higher levels in 1965 than in any year since 1962 when observations were begun. Crops in Angus suffered considerable loss of yield because of motley dwarf disease and several crops of Autumn King at North Berwick, E. Lothian, were almost completely destroyed.

Carrots with motley dwarf disease contain two persistent aphid-borne viruses one of which, red-leaf virus, is not sap-transmissible and its presence seems necessary before aphids can efficiently transmit the second, sap-transmissible component of the disease, carrot mottle virus. Partial purification of carrot mottle virus by column chromatography on brushite columns, followed by equilibrium or rate-zonal density gradient ultra-centrifugation, has yielded preparations which contain somewhat variable, bag-like particles of approximately 52 mμ diameter which may be the virus. These particles have only been seen in the most highly infectious preparations from infected plants and never in healthy preparations.

Carrot mottle virus has a very low buoyant density in sucrose, approximately 1.13. This, together with the instability of the virus in chloroform, ether and other organic solvents, suggests that the particles contain appreciable quantities of lipid.

For the third year in succession, a virus indistinguishable from carrot mottle virus has been transmitted to a low proportion of coriander test plants by *C. aegopodii* taken from willow trees in the spring but the virus has not been isolated from willow by sap-transmission. The results suggest that carrot mottle, but not red-leaf virus, can infect willow trees. (A. F. Murant, R. A. Goold).

Parsnip viruses

As a by-product of the work on carrot viruses, a number of apparently undescribed viruses have been recovered from parsnips and a start has been made on characterising these. The commonest has isometric particles 29 mμ in diameter and the name parsnip yellow fleck virus is proposed. It is distantly serologically related to a virus recovered from *Anthriscus sylvestris*. Attempts to transmit the parsnip form by aphids have failed, although the *Anthriscus* isolate is transmitted as a persistent virus by *Cavariella aegopodii*. (A. F. Murant, R. A. Goold).

The virus content of plants infected with parsnip yellow fleck virus fluctuates widely with seasonal changes in temperature and light intensity and a study on these effects was begun. (A. F. Murant, H. S. Abu Salih).

OTHER VIRUSES

Raspberry bushy dwarf

As reported previously, the results of work done at the Institute and at the Department of Botany and Plant Pathology, Purdue University, Indiana, showed that raspberry bushy dwarf disease is caused by a virus that has a wide host range among woody rosaceous species and is the cause of chlorotic leaf spot in the Russian apple seedling R12740-7A. Although this virus was first described from raspberry, the name chlorotic leaf spot virus has gained currency and its adoption in place of the more cumbersome and less familiar raspberry bushy dwarf virus has been recommended.

Experiments in 1964 showed that chlorotic leaf spot is present in the pollen of infected plants of *Chenopodium quinoa* and in the pollen and seeds of infected apple and raspberry. The virus is transmitted with high frequency (50-60 per cent.) through the seeds of infected Lloyd George raspberry, rarely through those of *C. quinoa* and apparently not at all through those of apple in the limited tests made. Pollination experiments with raspberry showed that healthy Lloyd George plants became systemically infected with chlorotic leaf spot virus within a few weeks after pollination of the flowers with pollen from infected Lloyd George plants. This result explains the rapidity with which the virus spreads in the field in Lloyd George: other varieties, for example Norfolk Giant and Malling Exploit, became infected less readily and some varieties, such as Malling Jewel and Malling Promise, seem immune. (C. H. Cadman).

Viruses in black raspberry

Investigations have been started in co-operation with the U.S. Department of Agriculture into the characterisation of viruses remaining in stocks of black raspberry (*Rubus occidentalis*) freed, by heat therapy, from viruses detectable in *Rubus henryii*. Such viruses were recently detected, by sap-transmission tests to *Chenopodium quinoa*, in raspberry stocks thought to be virus-free, and also in a proportion of seedlings raised from plants of such stocks.

So far the viruses isolated appear to fall into two groups: chlorotic leaf spot (=raspberry bushy dwarf) types, and another exemplified by an isolate from a stock with the serial number New Logan–64. Work on this isolate has been difficult, as, besides having a very limited host-range in suitable test plants, it seems unstable. Of various methods tried, extraction in buffer systems containing antioxidants, followed by a chloroform clarification procedure, differential ultracentrifugation and separation on density gradients seems the most promising so far. Infective preparations made in this way contained icosahedral particles about 30 mμ in diameter, which may be the virus. Attempts to prepare antisera have not so far been successful. (R. H. Converse, R. M. Lister, C. H. Cadman).

Viruses in potato

A highly infectious virus isolated from potato in the summer of 1964, during routine virus-testing by Mr J. M. Todd, at East Craigs, Edinburgh, has been identified serologically with the one named apple latent virus 2 by Kirkpatrick *et al.* (*Phytopathology* **55**, 286-290, 1965). Later attempts to re-isolate it from potato plants sent from East Craigs and forced in the glasshouse during the winter of 1965 were unsuccessful. No specific symptoms were seen in any of the potato source material, and the significance of the virus as a possible pathogen in potato remains obscure. (R. M. Lister).

Viruses in narcissus

Antisera, kindly supplied by the Laboratory for Flower-bulb Research, Lisse, Netherlands, enabled two viruses isolated from narcissus to be identified with narcissus yellow-stripe virus and narcissus mild mosaic virus (NMMV), respectively. Both viruses have flexuous rod-shaped particle and the properties of NMMV have been studied and an antiserum to it prepared. Electron micrographs show that the particles have a characteristic length of 550-560 mμ, whether in crude sap from infected plants or in partially purified preparations. Attempts to transmit the virus by means of aphids (*Myzus persicae* and *Neomyzus circumflexus*) failed. (W. P. Mowat).

In co-operation with other sections, work was begun on the cause of blindness in stocks of Double White narcissus. This condition is characterised by normal development of the flower stems and atrophy of the flower buds, and is considered common to most if not all commercial stocks of this variety. Stocks have been collected from various sources and attempts are being made both to analyse the cause and to produce virus-free plants by meristem culture. (W. P. Mowat, D. H. Turner).

PUBLICATIONS

CADMAN, C. H. (1963). Affinities of viruses infecting fruit trees and raspberry. *Plant Disease Reptr.*, **47**, 459-462.

CADMAN, C. H. (1965). Filamentous viruses infecting fruit trees and raspberry and their possible mode of spread. *Plant Disease Reptr.*, **49**, 230-232.

(*Malus*, *Prunus* and *Pyrus* are hosts of serologically related strains of a virus that causes chlorotic leaf spot disease in the apple indicator R12740-7A and is widespread in raspberry, causing bushy dwarf disease in the variety Lloyd George. The name chlorotic leaf spot for this virus is proposed in place of the original but cumbersome name of raspberry bushy dwarf virus.

The virus has long, filamentous particles resembling those of sugar beet yellows virus and for this, and other reasons, it was thought that it might have an aphid vector. Subsequent work showed that, in raspberry, the virus is seed- and pollen-borne and that healthy plants become infected when pollinated with infected pollen. The virus has been detected in apple pollen and in freshly-harvested apple seeds but tests provided no evidence that seedlings were infected. Pollen transmission and rare transmission through seed are suggested as possible modes of spread of the virus in woody hosts).

LISTER, R. M. (1966). Possible relationships of virus-specific products of tobacco rattle virus infections. *Virology*, **28**, 350-353.

(In infections with viruses of the tobacco rattle type, some kind of interaction between 'long' and 'short' particles is required for the completion of an infection cycle, including all the processes involved from virus establishment to the production of new virus. A possible interpretation of this is that information missing from the ribonucleic acid of 'long' particles can be provided by that present in the 'short' particles).

LISTER, R. M., BANCROFT, J. B.[1] and NADAKAVUKAREN, M. J.[1] (1965). Some sap-transmissible viruses from apple. *Phytopathology*, **55**, 859-870.

(Twenty-seven of 40 apple trees from the Purdue clonal collection yielded sap-transmissible viruses classifiable into two groups (Type 1 and Type 2) on the basis of symptoms in *Chenopodium quinoa*. Host range, physical properties, sedimentation characteristics, and serological behaviour of representative isolates parallelled this grouping. Viruses of Type 1 and Type 2 which had respectively half lives of about 12 and 105 min. at 45°C. were partially purified by differential centrifugation from bentonite-clarified sap followed by sucrose density-gradient centrifugation. Sedimentation coefficients for Types 1 and 2 were about 98 S and 120 S, respectively. Partially purified preparation contained flexuous filamentous particles presumed to be virus from their close association with infectivity and serological activity. Particle widths for both virus-types were about 12 mμ; lengths were close to 620 mμ for Type 2 viruses and in the range of 500-700 mμ for Type 1 viruses. Investigations along similar lines with various viruses recently isolated by others from apple and other rosaceous hosts suggested that all could be classified as Type 1 or Type 2 viruses).

LISTER, R. M. and CADMAN, C. H. (1966). Relationships and possible mode of spread of filamentous viruses infecting woody rosaceous plants. *Proc. 6th Symposium on Virus Diseases of Fruit Trees in Europe, Belgrade*. (In press).

(Two groups of serologically distinct viruses possessing flexuous filamentous particles resembling those of sugar beet yellows virus have been transmitted mechanically from

woody rosaceous hosts to herbaceous test plants. The largest group, Type 1, includes viruses causing or associated with chlorotic leaf spot of apple, bushy dwarf disease of raspberry and undescribed diseases of *Prunus* spp. Viruses of the second group, Type 2, have been isolated only from apple and have not been associated unequivocally with any specific disease. Type 1 viruses are seed- and pollen-borne in raspberry and *Chenopodium* s. *quinoa* and it is suggested that they may also be so in apple and other hosts).

MURANT, A. F. (1965). The morphology of cucumber mosaic virus *Virology*, **26**, 538-544.

(Preparations of cucumber mosaic virus were examined using the negative contrast technique. The particles had a mean diameter of 30 mμ and many were hexagonal in outline. Evidence is produced to show that the particle has 5:3:2 symmetry and is probably composed of 42 ring-like capsomeres).

MURANT, A. F. and TAYLOR, C. E. (1965). Treatment of soils with chemicals to prevent transmission of tomato black ring and raspberry ringspot viruses by *Longidorus elongatus* (de Man). *Ann. appl. Biol.*, **55**, 227-237.

(The use of chemical soil treatments to control the nematode *Longidorus elongatus* was studied in a 4-year field trial. In untreated soil after an overwinter fallow the nematodes lost their 'infectivity' but regained it in the spring from germinating infected weed seeds. Transmission of virus to Talisman strawberries was prevented throughout the 4-year period of the experiment by D-D and quintozene but metham-sodium and thiram were only partially effective at the doses used. After the first year, both DD and quintozene treatments led to significant increases in fruit yield reaching 130 per cent. in the third fruiting season).

THOMAS, P. R. (1965)[2]. Morphology of *Acrobeles complexus* Thorne, cultivated on agar. *Nematologica*, **11**, 383-394.

(The morphology of the nematode *Acrobeles complexus* is described and illustrated from a study of serial cross sections, totomounts and live specimens).

THOMAS, P. R. (1965)[2]. Biology of *Acrobeles complexus* Thorne, cultivated on agar. *Nematologica*, **11**, 395-408.

(The biology of *Acrobeles complexus*, cultivated in the presence of its associated micro-organisms on agar, was studied with special reference to features of its life history and factors affecting its maintenance in the laboratory).

THOMAS, P. R. (1965)[3]. Methyl bromide fumigation of Narcissus bulbs infested with *Ditylenchus dipsaci* (Kühn) Filipjev. *Hort. Res.*, **5**, 76-80.

(The exposure of narcissus bulbs to methyl bromide fumigation necessary to control the stem nematode, *Ditylenchus dipsaci*, was found to be phytotoxic).

THOMAS, P. R. (1966)[3]. Stem nematode infestation of *Narcissus* related to growth of the host for one season. *Plant Path.* (In press).

(*Ditylenchus dipsaci*, inoculated into soil around narcissus bulbs, increased in the plant tissue about 25 weeks after planting, reached a peak about 10 weeks later and then declined. Leaf weight increased and bulb weight decreased up to the twenty-fifth week after planting, but after flowering these trends were reversed).

THOMAS, P. R. and ALLEN, M. W.[4] (1965)[2]. Two new species of *Acrobeles* and a redescription of the type, *A. ciliatus* Linstow, 1877. *Nematologica*. **11**, 373-382.

(Acrobeles ciliatus is redescribed from specimens collected in Germany and the Netherlands. *A. ensicaudatus* n. sp. and *A. chelatus* n. sp. are described from Florida and Australia, respectively).

TAYLOR, C. E. (1966). The association of ringspot viruses with their nematode vectors. (Abs.) *Proc. 8th Europe. Nematological Conf.* (In press).

(Comparison is made between raspberry ringspot virus, which persists for only a few

weeks in *Longidorus elongatus* and is maintained in soil in weed seeds, and grape fanleaf virus, which is not seed-borne but persists in the adult stage of *Xiphinema index* for several months).

TAYLOR, C. E., CHAMBERS, J. and WINIFRED I. PATTULLO (1965). The effect of tomato black ring virus on the growth and yield of Malling Exploit raspberry. *Hort. Res.*, **5**, 19-24.

(Tomato black ring virus (TBRV) causes mild symptoms in Malling Exploit raspberry, and for the first few years in the life of a plantation it may have no detectable effect on growth and fruit yield. Later, infected plants produce shorter canes than healthy ones and yield less. Fruits from TBRV infected plants are malformed, with many undeveloped drupelets, and weigh less than healthy ones. The nematode vector of TBRV, *Longidorus elongatus*, does not thrive on raspberry, and populations decline when this crop is planted, but weeds and certain cover crops in plantations may maintain populations, as well as being reservoirs of virus infection).

TAYLOR, C. E., and MURANT, A. F. (1966). The use of quintozene (PCNB) as a nematicide. *Proc. 3rd Br. Insect. and Fungicide Conf.* (In press).

(This paper described experiments which demonstrate that quintozene may be used successfully for the control of *Longidorus elongatus* and to prevent the spread of viruses transmitted by this nematode).

RASKI, D. J.[4], HEWITT, W. B.[4], GOHEEN, A. C.[4], TAYLOR, C. E. and TAYLOR, R. H.[5] (1965). Survival of *Xiphinema index* and reservoirs of fanleaf virus in fallowed vineyard soil. *Nematologica*, **11**, 349-352.

(*Xiphinema index* were found to depths up to 360 cm more than four years after the removal of grapevine host plants. Survival of roots from the grapevines is considered to provide the source of food for the survival of the nematodes over this long period. Fanleaf virus was recovered from new growth from some of these roots. The decay of host plant roots may eliminate the virus reservoir and for control of the virus in future plantings a minimum of at least five years' rotation is indicated).

RASKI, D. J.[4], HEWITT, W. B.[4], TAYLOR, C. E. and TAYLOR, R. H.[5] (1965). Survival of *Xiphinema index* and fanleaf virus in fallowed vineyard soil. (Abs.) *Nematologica*, **11**, 44-45.

(Populations of *Xiphinema* index declined by about 95 per cent. during a period of five years after the removal of the grapevine crop and with the land subsequently fallowed during the summer and sown with non-host grain in winter. Grapevine roots dug from the soil produced callus and new rootlets within four weeks when stored in the same field soil in plastic bags in the laboratory. Some of the rootlets yielded fanleaf virus. Roots of *Convolvulus* sp. and seed of many weeds from the same soil were not infected, indicating that vine roots act as a reservoir of fanleaf virus).

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[1]Department of Botany and Plant Pathology, Purdue University, Lafayette, Ind., U.S.A.

[2]These papers report work done at the University of California, Davis, U.S.A.

[3]These papers report work done at the National Agricultural Advisory Service, Starcross, Exeter.

[4]University of California, Davis, U.S.A.

[5]Plant Research Laboratory, Burnley, Victoria, Australia.

Mycology

A. R. WILSON

During the period under review the scientific staff of the Section increased considerably. Dr I. G. Montgomerie joined us in April 1964 from the West of Scotland Unit and, while continuing with some aspects of her work on strawberry red-core, has taken over the investigation of raspberry stamen blight from J. S. W. Dickens (1963-64 Report, p. 74) who completed his Ph.D. thesis in 1965. Work on potato diseases now includes a project on gangrene; this is being undertaken by Mr R. A. Fox who joined the staff in October 1965 from the Rubber Research Institute of Malaya. Mrs D. Spencer (Miss D. Glendinning) completed the term of her Potato Marketing Board Postgraduate Studentship in September 1965 and was thereupon appointed to work on other aspects of the infection of potatoes by *Rhizoctonia solani* under a 3-year Research Grant from the Board. Miss Pamela A. Majer joined the staff in October 1965 as Scientific Assistant to Mrs Spencer. In 1964, Mr D. R. Bain and Mr R. Lowe replaced Miss Oswald and Mr H. M. Wilson respectively as Scientific Assistants, Mr Wilson having been appointed to the Experimental Officer grade.

In July 1965, Dr D. A. Perry was seconded for 3 months to the Institute for Agricultural Research, Samaru, N. Nigeria, to investigate premature death of groundnuts in the context of the aflatoxin problem.

Joint Seminars with the Botany Department of Queen's College, Dundee, inaugurated in Autumn 1962 with the enthusiastic co-operation of Dr T. H. Nicolson and his staff, have continued each winter with considerable success.

The Council of the European Association for Potato Research held their annual Ordinary Meeting at the Institute in May 1964. We were particularly glad to welcome them in view of the increasing interest of the Section in the potato crop. In July 1965, the British Mycological Society held its annual Plant Pathology Field Day jointly at the Institute and the Botany Department of Queen's College, Dundee. As well as seeing comprehensive demonstrations of the work of the Institute, the party saw much of plant pathological interest during an afternoon's tour of Strathmore.

The number of European and overseas visitors to the Section was greatly increased in 1964, largely because of the International Botanical Congress in Edinburgh; particularly welcome was a large contingent from the University of California. Earlier, we were especially honoured by a visit from Emeritus Professor E. C. Stakman.

In addition to those mentioned in the text of the Report, we are indebted to the many people who gave facilities and advice to the Section, and who supplied samples of fungicides, seeds and other materials.

Varietal susceptibility

Grey mould fruit rot was much worse in 1965 than in 1964, and in each year there were great differences in susceptibility between varieties of both raspberry and strawberry. For example, the proportion of infected strawberries (per cent. w/w) picked from randomized blocks of six varieties in 1964 and 1965 was respectively: Talisman 9.8, 34.6; Redgauntlet 5.5, 30.9; Cambridge Rearguard 11.4, 30.9; Royal Sovereign 18.4, 26.3; Merton Princess 5.5, 20.9; Cambridge Favourite 4.2, 17.6. For raspberries, the 1965 figures were: Malling Exploit 30.5; Malling M 29.5; Malling Promise 25.1; Malling Jewel 18.7; Norfolk Giant 9.4.

Attempts are being made to find whether there is any connection between the flowering and fruiting habits of raspberry and strawberry varieties and the incidence of infection at various stages in flower and fruit development. There are wide differences between varieties in degree of inflorescence exposure, rates of flower and fruit development, petal retention and the closeness of berries in the truss, but so far no conclusions of any significance on the role of these factors in infection by *Botrytis cinerea* have been drawn.

In 1965, 8 lb. samples of picked fruit of a number of varieties of blackcurrant were inoculated by spraying with a spore suspension of *Botrytis cinerea*. After incubation at about 15°C. for 3 days the samples were placed in the following order of increasing amount of rot: Laxton's Perfection, Gerby, Invincible Giant Prolific, Kajaanin Musta, Consort, Brödtorp, Tinker, Bogatyr, Merveille de la Gironde, Baldwin, Ahornblättrige, Laxton's Giant.

Control of post-harvest grey mould fruit rot

While losses of raspberries, strawberries and blackcurrants from grey mould fruit rot in the field may be considerable, sometimes up to 50 or 60 per cent. in eastern Scotland, the spread of the disease in the picked crop may be rapid and complete. A high proportion of the pre-harvest rot results from the development of latent infection established at flowering time in moribund flower parts, and it is believed that post-harvest rot in fruit, symptomless when picked, is largely initiated from the same source.

The onset of the transition of the mycelium from a quiescent to an aggressive state can be considerably delayed by certain precautions which include careful picking and grading to avoid damage, the exclusion of suspect berries, picking early in the day, and the rapid removal of field heat by temporary storage in the shade and later, chilling. During the last two years the feasibility of fumigation with sulphur dioxide has been investigated.

In 1964, there was little grey mould in strawberries and raspberries in the field, and picked fruit was generally of high quality, i.e. firm and dry.

Batches of fruit, fumigated at packing shed temperatures (about 55° - 60°F.) in atmospheres of 0.125 and 0.25 per cent. SO_2 v/v (nominal) for 20 minutes remained virtually rot-free for 3 days and only about 1 per cent. had rotted after 5 days' storage at packing shed temperatures; untreated fruit was almost completely rotted in the same time. Treated fruit remained clear and bright and no off-flavour was detected.

In 1965, the picking season was wet and fruit was of very poor quality, i.e., soft and susceptible to handling damage; even so, fumigation with SO_2 gave encouraging results. Husked strawberries (var. Talisman) treated for 20 minutes at 55°F. had 26.6 per cent. (by number) of rotten berries 1 day after fumigation in 0.25 per cent. v/v SO_2 and 54.5 per cent. in 0.125 per cent. SO_2 as against 97.3 per cent. in untreated fruit. When fumigated complete with husk, there were 11.2, 18.7 and 98.1 per cent. rotten berries respectively for the two treatments and control. Poor quality raspberries (var. Malling Exploit), receiving the same treatments, showed 38.0, 50.2 and 69.5 per cent. rot respectively, after 3 days' storage, while for good quality raspberries, the corresponding figures were 6.4, 9.0 and 31.5 per cent. after 3 days' storage and 50.0, 50.8 and 98.0 per cent. after 5 days' storage.

Blackcurrants were also successfully treated; exposure to 0.25 and 0.125 per cent. SO_2 for 20 minutes at 55°F. gave 0.7 and 7.7 per cent. rot respectively, as against 12.2 per cent. in untreated fruit, after 1 day. There was considerable improvement in appearance of treated fruit at both SO_2 levels; it remained clear and bright as opposed to the glaucous appearance of untreated fruit. It is supposed that this effect results from inhibition of surface yeasts and other organisms. No off-flavour was detected in treated fruit.

Various concentrations of SO_2, various periods of exposure and multiple exposures were tried, but those given above proved the most satisfactory. Poor quality and bruised fruit was sometimes bleached but the colour returned within an hour or two after clearing the fumigation chambers with fresh air. When the gas was constantly circulated throughout the exposure period, residual SO_2 in the fruit was usually between 15 and 70 p.p.m. and, even when there was no circulation, rarely exceeded 100 p.p.m. The factors affecting the uptake of SO_2 by the fruit are not yet understood, but higher concentrations generally occurred in poor quality wet fruit.

Exposure of strawberries, raspberries and blackcurrants for various periods to 110°F. and 98 per cent. R.H. (Smith and Worthington, *Pl. Dis. Reptr.*, **29**, 610, 1965) was unsuccessful in controlling rotting, probably because of the poor quality of the picked fruit. The amount of rot was reduced but the fruit was unsaleable.

The volatile fungicide *sym*-dibromotetrachloroethane[1] (DBTCE) was used to prolong the storage life of blackcurrants. Paper pads impregnated with the fungicide and so constructed as to give three rates of release were

[1]Kindly supplied by the Central Research Division of the Crown Zellerbach Corporation, Camas, Washington, U.S.A.

enclosed with 250 gm. samples of blackcurrants (var. Baldwin) in plastic bags and stored at 40°C. Rotting was considerably retarded, even at low fungicide levels; in many cases no rot appeared in 25 days, and even after 11 weeks some fruit was still clear of rot although there was then considerable deterioration in quality. DBTCE, however, is not commercially available and its use on food is not sanctioned. (W. R. Jarvis).

GREY MOULD OF TOMATOES

Control of stem infection

The following treatments were applied to plants growing in the glasshouse border at each time of deleafing, the wounds being first dusted with a suspension of spores of *Botrytis cinerea*: thiram 80 per cent. W.P. cream, captan 50 per cent. W.P. cream, dichlofluanid[1] 50 per cent. W.P. cream (all painted on) and captan 15 per cent. dust. Optimum conditions for infection were provided for 4 days after each series of inoculations. While 36 per cent. of inoculations were successful in untreated plots, only 6 per cent. were successful after treatment with dichlofluanid cream, 7 per cent. with thiram cream, 9 per cent. with captan cream and 25 per cent. with captan dust. All these differences from the control were significant (P=0.001). Dichlofluanid cream was not significantly better than thiram cream but both were better than captan cream (P=0.05) and all three better than captan dust (P=0.001).

For a number of years, inoculation with spore suspension of the ends of 2 in. petiole stubs on young resistant plants growing in small pots has been observed to induce their rapid abscission and fall. The possibility of using this reaction to avoid stem infection after deleafing was examined in plants under commercial conditions in the glasshouse border. These plants although still resistant were older, larger and stronger when deleafed and inoculated than the pot plants referred to. Abscission and fall of the stubs was erratic, slow and frequently incomplete, and the incidence of stem lesions was twice that obtained by direct inoculation of wounds on the stem nodes such as occur in normal practice. Partially attached and infected stubs provided an ideal saprophytically-based inoculum. In the same experiment, no difference was found in the incidence of stem lesions following inoculation of wounds left by breaking or by cutting off leaves close to the nodes. (A. R. Wilson).

STAMEN BLIGHT OF RASPBERRY

A survey of young (1-3 year old) and old (5-6 year old) plantations on 88 raspberry farms in Angus and East Perthshire was made in the summer of 1965 in co-operation with the Edinburgh and East of Scotland College of Agriculture (N. Area) and the A.R.C. Unit of Statistics, Aberdeen. The results showed that stamen blight (*Hapalosphaeria deformans*) was present

[1]Elvaron, kindly supplied by Baywood Chemicals Ltd.

in 22 per cent. of the younger and 65 per cent. of the older plantations. The proportion of farms with the disease varied from region to region but the meaning of this is still not clear.

The two most disturbing aspects of stamen blight are its mode of spread and the disfiguring effects of infection on the appearance of the fruit. Careful examination of an infected plantation of Malling Jewel showed that buds at all nodes on the canes produced diseased flower trusses but most of these occurred at the 8th and 9th nodes from ground level. All flowers on an infected lateral are not necessarily diseased; in fact only in 66 out of 144 examined was this so. Whatever may be the mode of spread of the fungus, tests have shown that secondary infection of flowers is unlikely because no symptoms developed when unopened flower buds were injected with a spore suspension.

Infection seems to inhibit the swelling of some fruits and the formation of viable seeds in all fruits. Pollination experiments showed that emasculated flowers developed fruits when the stigmas were dusted with raspberry pollen, but not when dusted with pycnospores of *H. deformans*. The disfiguring bloom on fruit from diseased flowers is not due either to invasion of the skin of the fruit by the mycelium of the fungus or to the masses of pycnospores shed from the anthers, but to the natural, dense covering of hairs on the surface of the fruit which, as a result of irregular growth and swelling of individual drupelets, are much closer together than is normal. (I. G. Montgomerie).

COLD STORAGE OF STRAWBERRY RUNNERS

After 11 months in cold storage, wrapped in paper impregnated with volatile fungicides, runners of Cambridge Favourite strawberry suffered more severely from rot than those of Redgauntlet (see Plant Physiology Section Report, p. 36). In each variety, rotting–visible when the crowns were cut open–was of two distinctive types, one involving mainly the external, the other extending into the internal tissues. The causes of these were not identified. There was some evidence that the fungicides used were phytotoxic.

In a second experiment runners of Cambridge Favourite, stored for 12 months under two conditions–just below 0°C. with air circulation, and at a temperature fluctuating above and below 0°C. without air circulation, were sampled at monthly intervals to determine the sequence of rotting and to identify any pathogens involved. With air circulation, plants remained sound for 2 months. Some decay of leaves and petioles occurred in 3-7 months and all plants developed areas of rot after 9-12 months though none was completely rotten. Without air circulation, rotting was visible after 1-4 months and by the end of the experiment all plants had decayed.

Samples of petioles and leaves most frequently yielded *Botrytis* sp.; a *Penicillium* sp. and a pycnidial fungus were less common. The majority of isolates from rootstocks have not been identified, but *Botrytis* sp. was a rarity among these and earlier reports ranking it as a major cause of rotting may be wrong. (I. G. Montgomerie).

RED CORE OF STRAWBERRY

Tests with American and Canadian races of *Phytophthora fragariae* on the British standard differential varieties Huxley Giant, 52AC18, Perle de Prague, Redgauntlet, Talisman, Cambridge Vigour and Siletz showed that all except two (American A-1 and Canadian C-4) were similar to one or other of three indigenous races. Those which were different were not more pathogenic than other British races described (1963-64 Report, p. 82). (I. G. Montgomerie).

DIE-BACK OF RASPBERRY

Observation plots 1961-64

All plots had a high incidence of fruiting canes showing die-back symptoms in 1961 (20-50 per cent.) but these symptoms decreased in 1962 and again in 1963. There was a steady decrease in cane growth and cane numbers in 1961 and 1962, but in 1963 the canes increased in height on all plots and in number on 75 per cent. of the plots. In a few plots in 1964 there was again an increase in the proportion of canes showing die-back symptoms.

Pot experiments 1960-65

Plants grown in canisters filled with soil from die-back plantations were invariably stunted in growth. Autoclaving the soil prevented stunting but the effect could be re-introduced by adding a small quantity of the original untreated soil before planting.

Treating such soils with either formalin or dazomet, at the standard rates, greatly improved growth although the effect was never as good as that obtained by autoclaving. (T. G. Rubens[1]).

DISEASES OF POTATO CAUSED BY *RHIZOCTONIA SOLANI*

Black Scurf

Three haulm treatments and two times of harvesting were compared for their effect on black scurf incidence. The percentage of infected tubers following acid spray kill, natural death and haulm-pulling (13, 8 and 5 per cent. respectively) differed significantly (P=0.05) 4 weeks after treatment but there were no significant differences after 10 days. Similar results were obtained in the glasshouse.

[1]Edinburgh and East of Scotland College of Agriculture.

Stolon infection

Pruning stolons to simulate varying intensities and times of attack showed that only early or severe pruning significantly affected yield, the former decreasing totals ware and seed weight, the latter decreasing ware but increasing chat weight. The effects of severe pruning were not reproduced when plants were grown in the greenhouse in soils heavily amended with homogenised cultures.

Using beet seed inocula and controlled moisture regimes, infection experiments in the greenhouse showed that dry soil conditions favoured initial infection of the stolons which were then most susceptible in their mid-region. Lesion extension, most rapid at the stolon base, was not affected by soil moisture. Superficial wounds did not enhance initial infection. Seven weeks after planting, stolons were significantly more susceptible and at 11 weeks, more resistant, to infection than at other times. Similar results were obtained using soils amended, as above, with homogenised cultures. (D. Spencer).

STORAGE OF POTATOES FOR PROCESSING

Difficulties encountered applying polyurethane, expanded *in situ*, directly to the underside of the asbestos cement roof sheets of the experimental store at Aberfeldy[1] (1963-64 Report, p. 81) led to the abandonment of this form of insulation. Before the 1964 harvest, the store was re-roofed with a composite structure of mineral felt, insulation board and 2 in. slabs of cement-bonded wood wool. This proved reasonably satisfactory in reducing both heat loss and condensation under the severe conditions imposed by storing potatoes at a minimum stack temperature of about 50°F. during the winter. On clear cold winter nights, the temperature of the outer surface of the roof was sometimes as much as 15°F. below outside air temperature. This suggests that further decrease, both in heat loss and condensation, might be achieved more economically by providing some form of radiation shield on the outside rather than by increasing internal insulation.

Over the past two seasons, information has been collected on the behaviour of the wood-wool slab insulation commonly recommended for the walls of potato stores. The level of insulation normally provided (to give a U-value of 0.2 - 0.17) to prevent contact freezing of the tubers, is inadequate to prevent condensation of moisture on the inner surface of the wall in cold weather. Streaming of water down the inside of the wall under these conditions, a phenomenon never previously encountered with this type of wall structure, was found to result from the use of too rich a mix for rendering. A mix of 1 : 1 : 6, cement, lime, sand, has been found sufficiently absorbent and otherwise satisfactory and is being adopted as a

[1]Grateful acknowledgment is again made of the co-operation of Mr M. D. Henderson and of the facilities provided by him at Carse Farm.

standard recommendation. The air in the wood-wool slabs during the storage season is frequently saturated and condensation evidently occurs within them in cold weather. As the effectiveness of the material has never noticeably decreased under these conditions, the large air spaces in it may permit condensation to drain away so leaving the k-value relatively unaffected. Evidence has been obtained from various sources that prolonged wetness does not lead to decay of the slabs.

Thermostatically controlled heating of the air over the potatoes, with occasional forced-draught circulation through the stack at the rate of 5 c.f.m./ton, was a satisfactory method of maintaining a stack temperature of about 50°F., with a vertical gradient of only 2°-3°F., during the coldest weather. Condensation on the roof was controlled by top ventilation of the store as required.

Gas chromatographic estimations of the sprout depressant, nonanol, in the airstream during typical treatment cycles were carried out during the 1964-65 season by the Ditton Laboratory.

During the work at Aberfeldy, it became evident that control of storage temperature is not in itself sufficient to ensure good crisping quality (e.g. low levels of reducing sugars). Stack temperature can be maintained at that originally advocated (*ca.*50°F.) in a simple farm store, even under severe winter conditions, with the addition only of slightly more roof insulation and a moderate amount of heating. However, this knowledge is not likely to be of great practical value until more is known of factors controlling the sugar content of crops at lifting. Further co-operative work with the Ditton Laboratory on this problem is contemplated. (A. R. Wilson, P. T. G. Twiss[1]).

PRE-EMERGENCE FAILURE IN PEAS

In 1964 and 1965 the emergence of a total of 92 seed samples of various pea varieties in the field was compared with their germination and other characteristics determined in the laboratory. The results showed that field emergence varied greatly between samples, particularly under the adverse conditions of early planting, and that it could not always be predicted by laboratory germination. A count of the entirely normal seedlings in a germination test gave a better indication of the probable field emergence than total germination, and the relation was closest for late-planted fungicide-treated seed. Poor emergence was not confined to any variety nor to seed originating from any particular country. No statistical correlation between hollow heart or seed coat injury and field emergence was found although a high incidence of either condition in a sample tended to be associated with poor emergence when planted early or when untreated. However, some samples with poor emergence ability had a low incidence of these conditions. The response of a poor sample to thiram seed dressing was

[1]A.R.C. Ditton Laboratory, Larkfield, Maidstone, Kent.

proportionately greater than a good sample; occasionally no benefit was recorded in seed of high emergence ability. Similarly, poor samples were more influenced by adverse environment than good samples.

When 22 of the seed samples used in the 1964 trial were sown in field soil in the glasshouse, their emergence was significantly correlated ($r=0.89$) with that in the field, but the correlation only held good if the soil used in the glasshouse was from the field in which the trial was done. When 5 seed samples were sown in 3 widely different soils at comparable moisture levels there were significant differences in emergence between soils and there was a significant interaction between soils and seed samples.

In moist soil (20-30 per cent. m.h.c.) most emergence failure was the result of a rapid, post-germination, seedling rot, whereas in wet soil (60-70 per cent. m.h.c.) the seed rotted before it germinated. The extent of failure was more sensitive to changes of soil moisture than to soil temperature. *Pythium ultimum* was isolated from rotting seedlings of several seed samples in field soil at normal temperatures and at a constant temperature of 4°C. The fungus was not seed-borne. When *P. ultimum* was mixed with sterilised soil it caused symptoms on germinating seed similar to those found in field soil, and seed of poor emergence ability were more severely attacked than good seed. In moist soil the plumule or more rarely the hypocotyl became infected, while in wet soil the cotyledons were attacked before germination. Concurrently with plumule infection by *P. ultimum*, the cotyledons of poor seed in field soil were rapidly colonised by bacteria of which some isolates were pathogenic to seed when incorporated in sterilised soil.

The Vigour Test Committee of the International Seed Testing Association consider that vigour is the property which determines the ability of seed to produce normal seedlings when planted in the field, and therefore seeds with poor field emergence ability are, by definition, of low vigour. When, as is usually found, the failure of peas to emerge is caused by fungal or bacterial attack, vigour must be synonymous with resistance to soil-borne pathogens. The reasons for the variable disease reaction of germinating pea seed are being investigated. (D. A. Perry).

FLUORESCENT VITAL STAINING

A wide range of optical brighteners was screened to select those stable in fungal and bacterial structures and retentive of a high degree of fluorescence under u.v. light. Out of 50 compounds tested only two, Tinopal 4 BMT[1] and Uvitex S2R High Conc.[2] (both stilbenic derivatives), proved suitable; these are now being used in routine work. Similarly, a wide range of solvents was tried to find one which readily dissolved the compounds, was non-toxic and did not itself fluoresce. A 20 per cent. v/v aqueous solution of glycerol met these requirements and over a two-year period has shown no deleterious effect on any of the organisms used.

[1]Supplied by Geigy (U.K.) Ltd. [2]Supplied by Ciba Clayton Ltd.

The concentrations finally adopted were 3 per cent. brightener w/v in 20 per cent. v/v aqueous glycerol, added to basal liquid media in a 1:10 dilution.

Mycelia of non-sporing fungi, e.g. *Rhizoctonia solani*, were readily labelled by growing the organism for 10-12 days in liquid media incorporating optical brightener. Sporing fungi with abundant aerial hyphae, e.g. *Botrytis cinerea*, grown similarly, showed little or no fluorescence in the spores after 5-6 days, though hyphae in direct contact with the medium became fluorescent. To overcome this difficulty, non-labelled spores of *B. cinerea* were collected and stained directly for 12 hr. in a 1:1 dilution of brightener solution in water. Movement of labelled spores in tomato xylem was traced by u.v. microscopy. Bacteria, grown on solid media incorporating optical brighteners, were similarly located in tobacco and bean tissues.

The two optical brighteners mentioned appeared to be readily taken up by fungal protoplasm and to a lesser extent by the fungal cell wall, though the relative staining of cytoplasm and wall can vary greatly with the organism used.

No change was noted in the colour or intensity of fluorescence of living fungi labelled with optical brighteners during prolonged exposure to u.v. light. The opposite of this was found with bacteria. (H. M. Wilson).

MISCELLANEOUS

Carrot storage

Trials to determine the best methods of prolonging the life and reducing disease losses of carrots in shed storage were made in 1963 and 1964 on the farm of Mr Porter at East Scryne, Carnoustie, over a period of 14 weeks from early December to March. In the first year, the need for ventilation to prevent the development of bacterial soft rot, the ability of 3 per cent. tecnazene dust (Fusarex) to reduce losses from *Sclerotinia* rot, and the suppression of sprouting by 2.4 per cent. propham dust (Tuberite) were established. In 1964 the efficiency of tecnazene in controlling storage rots was confirmed, but a pre-storage dip in 1 per cent. solution of sodium o-phenylphenate (Topane), although prolonging storage life, did not entirely prevent rotting. There was less loss in untreated control lots in field clamps than in any of the shed storage treatments. (D. A. Perry, T. G. Rubens[1]).

Cabbage storage

Trials of several fungicides to reduce losses in field clamps, caused mainly by *Botrytis cinerea*, gave promising results. These are presented in the report of the Vegetable Crops Section. (D. A. Perry, H. Taylor).

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[1]Edinburgh and East of Scotland College of Agriculture.

PUBLICATIONS

JARVIS, W. R. (1965). Strawberry Diseases by A. G. Plakidas. (Book reviews). *Trans. Br. mycol. Soc.*, **48**, 498-499 and *Scott. Agric.*, **44**, 326-327.

√JARVIS, W. R. (1966). The biological basis for the design of control measures in Botrytis diseases. *Proc. 3rd Br. Insect. and Fungicide Conf.* (In press). (A survey).

LEAKEY, C. L. A.[1] and PERRY, D. A. (1966)[2]. The relation between damage caused by insect pests and boll rot associated with *Glomerella cingulata* (Stonem.) Spauld & von Schrenk (*Colletotrichum gossypii* Southw.) on Upland cotton in Uganda. *Ann. appl. Biol.* **57**, 337-344.

(The conidial form of *Glomerella cingulata*, which causes anthracnose on cotton bolls in Uganda, was avirulent on undamaged bolls at normal humidity but formed a latent infection which became aggressive when the bolls were put in a saturated atmosphere. Mechanical damage and injury caused by insect feeding were associated with extensive rotting by the fungus at normal humidity).

√PERRY, D. A. and HOWELL, P. J.[3] (1965). Symptoms and nature of hollow heart in pea seed. *Pl. Path.*, **14**, 111-116.

(Hollow heart of pea seed is a common physiological disorder, which appears after germination and is characterised by a concavity at the centre of the adaxial cotyledon face. The cells lining the concavity are dead, their starch reserves unused, and they are readily colonised by pathogenic and saprophytic micro-organisms. The dead tissue extends into the cotyledon and is deepest at the centre of the concavity. Dry seeds never show hollow heart but may be predisposed to it, possibly by conditions during maturation. Hollow heart is distinguished from marsh spot by lack of discolouration and independence of manganese levels in the seed).

PERRY, D. A. (1966)[2] Multiplication of *Xanthomonas malvacearum* in resistant and susceptible cotton leaves. *Emp. Cott. Grow. Rev.*, **43**, 37-40.

(*Xanthomonas malvacearum* multiplied at a similar rate in the leaves of resistant and susceptible varieties of cotton for the first two days after inoculation; thereafter, the rate in the resistant variety was less than that in the susceptible).

WILSON, A. R. (1965). Principles of potato storage. (Abs.) *Conference on Crop Storage* 14 *and* 15 *December*, 1964. *Edin. Sch. Agric.* (mimeographed), pp.67-70.

WILSON, A. R. (1966). Infection of tomato stems by *Botrytis cinerea* Fr. (Abs.) *Acta Hort.* (In press).

(The resistance of young stem tissue to attack by *B. cinerea* is reflected in the *in vitro* growth of the pathogen in tissue extracts and excised internodes. Addition of 1 per cent. glucose to extracts of young, resistant tissue raises the level of growth of the fungus to near that obtained in extracts of old, susceptible tissue.

High soil moisture and restriction of root growth accelerate transition of the host from the resistant to the susceptible phase.

Dry spores applied to fresh deleafing wounds are rarely drawn into the vessels. When pressure in the vessels is raised above that of the atmosphere by stopping transpiration, these spores become suspended in exudate and some are drawn into the vessels when transpiration is resumed and vascular pressure again becomes sub-atmospheric. It is suggested that this mechanism may be involved in much of the infection which takes place in commercial houses, particularly when lack of heating results in large diurnal fluctuations of air temperature.

Available evidence suggests that much if not all latent infection is established in this way).

WILSON, H. M. (1966). Conidia of *Botrytis cinerea*: labeling by fluorescent vital staining. *Science, N.Y.*, **151**, 212.

(As a model system, conidia of *B. cinerea* have been vitally stained with optical brighteners to facilitate their location in plant tissues).

WILSON, A. R. and TWISS, P. T. G.[4] (1966). Moveable partitions for potato stores. *The Seed Potato*, **6**. (In press).

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[1]Makerere University College, Uganda.

[2]This paper reports work done at the Cotton Research Station, Namulonge, Uganda.

[3]Department of Agriculture and Fisheries for Scotland, Scientific Services, East Craigs Edinburgh.

[4]A.R.C. Ditton Laboratory, Larkfield, Maidstone, Kent.

West of Scotland Unit (Auchincruive)

R. D. REID

The Unit suffered a grievous loss by the untimely death on 6 March 1965, of Mr A. M. Sutherland, C.D.H. at the age of 46. In 1938 he joined the then Strawberry Disease Investigation of the Department of Agriculture for Scotland, and, except for a period of war service from 1939 until 1946, had been with us ever since. He had an intimate knowledge of all branches of the work, and his loyalty, enthusiasm and critical judgment were invaluable. In April 1965, Mr K. C. McConnell was promoted to fill Mr Sutherland's place as Experimental Officer and Mr W. I. A. Jack was appointed Assistant Experimental Officer. Dr I. G. Montgomerie moved in April 1964 to the Institute's headquarters at Invergowrie but some of her material has been maintained at Auchincruive and she has visited the Unit periodically.

Members of staff talked about their work to visitors and visiting parties on a variety of occasions, and my activities included lecturing to growers in Norfolk and Worcestershire. I served on the Strawberry Sub-committee of the National Fruit Trials, on the Strawberry Sub-committee set up by the Plant Variety Rights Office and as vice-president of the Scottish Branch of the Horticultural Education Association.

Despite the fact that, as a matter of policy no fungicidal sprays are used, we did not suffer the heavy losses of fruit from grey mould complained of by most commercial growers in 1964 and 1965. Indeed, the tonnage of fruit harvested and the cash returns for these two years were the highest yet recorded. This may result from the fortunate coincidence of good weather with the comparatively early fruiting season at Auchincruive, because the main ripening season elsewhere tended to be one or two weeks later. This only serves to emphasise the narrow margin of chance separating success from failure. At the same time, the fact that we grow a very large number of selections in comparatively small plots possibly lessens the risk attendant on the growing of a large area of one or two varieties.

STRAWBERRY BREEDING

New introductions

In our last report, the release of a new strawberry variety, Templar, was announced, and arrangements are in progress for the release, in spring 1966, of seedling A45, to be named Crusader. Descriptions of each of these will be found elsewhere in this Report.

Templar has performed excellently at Auchincruive and some very enthusiastic reports have been received from commercial growers; others have been more qualified. With the present trends in the industry, it becomes increasingly obvious that there is now less need – such as existed when Climax was at its peak of popularity–for the general-purpose variety. Nowadays growers' requirements are becoming increasingly specialised and the need for a wider range of varieties with characters suited to special purposes and localities is more evident than seemed possible–or even desirable–fifteen years ago. No breeder can hope to produce varieties tailor-made to suit all needs; the alternative is the production of a range from which the grower can select those which most nearly conform to his requirements.

Our two most promising selections, A41 and A45, have been tested extensively at our own stations and, more recently, at other centres in Scotland, England and Ireland. The first of these seemed a useful variety for cloche cultivation as it has the virtues of earliness, good colour and excellent flavour. In almost every trial, the first fruits to ripen were excellent in most respects, but the bulk of the crop consisted of medium- or small-sized fruits. These ripened at the same time as, and were therefore not competitive with, the largest fruits of main-crop varieties. Because of this, A41 has been withdrawn and co-operating stations have been asked not to propagate it. The second selection, A45–now named Crusader–promises to be a useful addition to the current range of varieties. It has performed well at all centres, produces fruit of attractive colour and good size and has shown promise as a berry for processing.

Assessment of seedlings

The layman tends to assess the intensity of work in a plant breeding project by the numbers of seedlings handled annually, but, as anyone versed in the art knows, this provides no reliable index, especially where, as in our case, tests of seedlings may persist over eight or ten years. Depending on circumstances, our annual production of seedlings varies from 5,000 to 20,000. But any year's work is made up of two streams of activity: on the one hand, there is rigorous culling of the products of any year's crossings in an effort to reduce the initial 10,000 to the final 'one' which may become a new variety, and on the other, the assessment–usually on increasing numbers of plants per unit–of survivors from earlier years. It is these that hold the promise for the future.

Crosses made in 1956-57 yielded about 12,000 seedlings, and some 180 of these were selected in 1959. By the summer of 1964 these had been reduced to 53 but the future of these has been difficult to decide. This series has already yielded Templar and Crusader and another four seedlings whose merits cannot yet be positively appraised. At the end of 1964, eight of these 1957 seedlings seemed to have a possible future, but 1965 proved a critical year in that we were able to decide, in some cases very reluctantly, against several whose considerable merits were offset by equally significant weaknesses. As always, the common failing is inconsistent performance from year to year, a failing which we have rigidly selected against, but one's judgment can be upset on occasions. For example, one selection which has been of marginal interest for about five years in succession was outstanding in 1965 and appeared one of the best we have ever handled. Further testing is obviously necessary in such instances. We have, therefore, at the end of 1965, four seedlings raised in 1957 which are still under close scrutiny.

Crosses made in 1958 and 1959 were not very rewarding and there seems little likelihood of anything of promise emerging. Those made in 1960 and 1961 yielded some good seedlings and some 107 were selected in 1963. All have been retained for fruiting in 15-plant units and 25 have been marked for special attention in 1966.

Some of the progenies from crosses made in the years 1962-64 have fruited but of these nothing can yet be said.

Field resistance to Red Core

From time to time, we have been criticised for placing excessive emphasis on resistance to red core disease and suspected of using techniques which result in the elimination of too large a proportion of potentially useful seedlings. Whilst it is true that the entire strawberry breeding programme sprang from a local need to combat red core disease–a need now greatly diminished–it would be rash to assume that this disease is no longer economically important, as recent unpleasant experiences elsewhere in Britain testify. The rigorous screening methods we use, in fact, result in our handling a larger through-put of seedlings than would otherwise be the case, and our chances of finding good material are therefore correspondingly increased. Where the comparison has been made between progenies planted directly in the field and those subjected to a preliminary screening in the glasshouse for susceptibility to red core, the results bear out the time-wasting nature of the first procedure. Not only do the seedlings occupy at least twice as much land; one is left with a preponderance of material of indifferent worth and vigour, infinitely more troublesome to assess and discard.

As reports in recent years have emphasised, the main criterion of selection is ability to survive rather than ability to escape infection by red core. Normally the procedure is to discard, after the first winter season, seedlings which are obviously infected. Those which are kept are scored for infection a year later (in March), assessed for vigour of growth the following June and selected for fruiting characters in July. In 1965, an attempt was made to correlate the extent of root infection observed in spring with the vigour and appearance of plants in June. The results showed that, most commonly, 'normal' vigour was associated with mild infection of the roots though occasionally with degrees of infection lesser or greater than this. Field assessment of vigour at fruiting time is probably a truer indication of survival value than apparent absence of root infection at the time of examination. Ability to survive may in fact be associated with an inherent ability of the plant to produce a profusion of new roots whereas apparent absence of infection may simply indicate escape from pathogenic races of the fungus which may be localised in the soil. Equally the balance may be upset by climatic conditions or severe waterlogging, and plants normally able to survive may succumb to severe infection. Whatever the precise nature of field resistance–and this is a problem which merits closer attention–it provides us with a more practical means of combatting red core than the alternative and probably fruitless search for immunity to an unstable pathogen.

New sources of breeding material

In 1962, by courtesy of the U.S.D.A., we received 14 new varieties or numbered selections from Dr D. H. Scott, Beltsville, Maryland, which promised to possess both the desirable fruit qualities and the resistance to a wide range of races of *P. fragariae* which we have been trying to incorporate into our own seedlings. These new accessions were selfed in 1962 and used extensively in crosses with our own material in 1963.

As new sources of immunity, these American introductions were disappointing, but the Yaquina clone of *F. chiloensis* transmitted a high degree of field resistance to its progenies, also unfortunately its poor capacity for fruiting. Other selections were more useful as sources of good fruiting characters. Crosses with one in particular, Md.U.S.2700, have yielded interesting seedlings. Of the 126 seedlings selected from an initial 8,000 in 1965, 55 had Md.U.S.2700 as one parent.

Meteorological Records

1964 and 1965

J. SUNDERLAND

Meteorological records from Mylnefield and Auchincruive for the years 1964 and 1965 are summarized in the tables below, the figures for Auchincruive being taken from the Monthly Weather Report, issued by the Meteorological Office.

At Mylnefield, the two years 1964 and 1965 were contrasting in a variety of ways but neither were memorable in the positive sense. Except for March and June, the first six months of 1964 were warmer than average, but the rest of the year and almost the whole of 1965 was cooler than average. There were no lengthy warm periods in either year; the warmest days were on 3 August 1964 (25°C. : 77°F.) and 29 June 1965 (23°C. : 74°F.). Indeed, July 1964 and July and September 1965 were the only months free from ground frosts; 1965 gave us the coldest July and the coldest November since records began in 1954. There was less than average rainfall in 1964 and ripening of soft fruit crops was delayed for a time by shortage of water, and there was little loss of fruit from grey mould. By contrast, rather more than average rain fell in 1965; May, June and July were all wet months. The fruit-picking season was execrable and recorded losses from grey mould accounted for at least one-third of the strawberry crop.

At Auchincruive, the mean daily temperature maxima and minima were slightly higher than those at Mylnefield in both years. There was less sunshine there in 1964 but more in 1965 than at Mylnefield, and in each year longer periods free from ground frosts–July and August in 1964 and June to September in 1965. In 1964 11.02 in. and in 1965 10.68 in. more rain fell at Auchincruive than at Mylnefield.

Auchincruive 1964

Month	Temperature (°C.)[1] Mean of daily maxima		Temperature (°C.)[1] Mean of daily minima		Rainfall (in.)	Sunshine (hours)	Ground Frost (days)
January	7.2	**45.0**	2.2	**36.0**	2.50	43	17
February	7.2	**45.0**	1.8	**35.2**	0.70	85	18
March	7.6	**45.7**	1.4	**34.5**	0.72	78	19
April	11.5	**52.7**	4.8	**40.6**	1.60	129	10
May	15.8	**60.4**	7.9	**46.2**	2.60	178	2
June	15.9	**60.6**	8.9	**48.0**	2.29	149	2
July	16.8	**62.2**	10.9	**51.6**	2.41	122	0
August	17.1	**62.8**	10.1	**50.2**	4.38	157	0
September	16.1	**61.0**	8.9	**48.0**	5.57	131	1
October	12.0	**53.6**	5.3	**41.5**	3.61	74	9
November	9.8	**49.6**	4.1	**39.4**	3.33	59	12
December	6.5	**43.7**	1.0	**33.8**	4.26	46	24
Year	11.9	**53.4**	5.6	**42.1**	33.97	1251	114

Auchincruive 1965

Month	Temperature (°C.)[1] Mean of daily maxima		Temperature (°C.)[1] Mean of daily minima		Rainfall (in.)	Sunshine (hours)	Ground Frost (days)
January	5.4	**41.7**	0.4	**32.7**	4.79	75	18
February	6.1	**43.0**	—0.3	**31.5**	0.74	71	22
March	8.6	**47.5**	1.2	**34.2**	1.53	134	14
April	11.0	**51.8**	3.3	**37.9**	2.76	161	13
May	13.7	**56.7**	6.8	**44.2**	2.05	144	2
June	16.8	**62.2**	9.3	**48.7**	3.51	176	0
July	15.9	**60.6**	8.8	**47.8**	3.35	153	0
August	16.9	**62.4**	9.6	**49.3**	4.17	163	0
September	14.8	**58.6**	8.3	**46.9**	4.76	76	0
October	13.5	**56.3**	6.7	**44.1**	3.53	105	5
November	6.8	**44.2**	0.7	**33.3**	1.76	93	18
December	6.5	**43.7**	1.1	**34.0**	4.54	46	17
Year	11.3	**52.3**	4.7	**40.5**	37.49	1397	109

[1]Fahrenheit equivalents shown in bold figures

Mylnefield 1964

Month	Temperature (°C.) Fahrenheit equivalents shown in bold figures													Rainfall		Sunshine		Run of Wind
	Mean of Daily Maxima	Deviation From Average[1] (°C.)	Mean of Daily Minima	Deviation From Average[1] (°C.)	Accumulated Temperature		Highest Max.		Lowest Min.		Soil Temperature at 1 ft Depth		Ground Frost (days)					
					Above 5.6°C.	Below 5.6°C.	Temp.	Date	Temp.	Date	Mean	Deviation From Average[3]		Inches	Deviation From Average[2]	Hours	Deviation From Average[1]	Miles
January	6.8 **44.3**	+1.0	0.8 **33.4**	+0.5	17	69	13	31	—5	6	2.9	+0.9	23	0.72	—1.21	54	+4	5114
February	6.6 **44.0**	+0.2	1.1 **34.1**	+0.2	23	69	11	2	—6	22	3.1	+1.0	19	1.01	+0.84	76	0	5224
March	6.1 **43.0**	—2.5	2.1 **35.7**	+0.3	9	52	9	9	—3	7	4.0	—0.3	12	3.74	+1.89	41	—64	5990
April	11.6 **52.9**	+0.6	5.2 **41.4**	+2.0	94	9	17	27	1	5	7.5	+0.2	5	1.93	+0.32	127	—13	6089
May	14.9 **58.9**	+0.9	7.4 **45.3**	+2.1	176	1	19	17	4	20	11.3	+1.1	1	1.44	—0.56	191	+25	6740
June	17.2 **63.0**	—0.5	8.2 **46.9**	0	219	3	22	26	3	20	13.5	—0.1	2	2.34	+0.65	209	+27	5948
July	19.0 **66.3**	—0.4	10.1 **50.1**	—0.6	281	1	23	23	3	4	15.4	+0.1	0	1.04	—1.52	190	+36	6488
August	17.3 **63.1**	—1.4	9.3 **48.7**	—0.9	242	2	25	3	2	20	14.7	—0.1	1	3.80	+0.53	138	—3	4556
September	15.9 **60.7**	—0.5	7.4 **45.4**	—0.7	190	4	19	7	0	21	12.3	—0.6	3	2.49	+0.49	152	+30	4480
October	11.3 **52.3**	—1.3	4.6 **40.2**	—0.7	91	18	16	1	—1	10	8.7	—1.0	13	1.28	—1.32	74	—21	3020
November	8.9 **48.1**	+0.4	2.2 **35.8**	—0.3	49	51	14	24	—7	10	5.6	—0.3	19	0.83	—1.49	59	—4	4655
December	5.6 **42.0**	—1.1	—0.9 **30.4**	—2.1	12	112	12	6	—8	28	2.6	—1.1	28	2.33	—0.19	44	+3	5233
Year	11.8 **53.2**	—0.4	4.8 **40.6**	0	1403	391	—	—	—	—	8.5	0	126	22.95	—3.25	1355	+20	63537

[1] & [2]Recorded at official Dundee Meteorological Station, 1921-1950 and 1881-1915 respectively.
[3]Recorded at Mylnefield 1954-1961.

Mylnefield 1965

Month	Temperature (°C.) Fahrenheit equivalents shown in bold figures															Rainfall		Sunshine		Run of Wind
	Mean of Daily Maxima		Deviation From Average[1] (°C.)	Mean of Daily Minima		Deviation From Average[1] (°C.)	Accumulated Temperature		Highest Max.		Lowest Min.		Soil Temperature at 1 ft Depth		Ground Frost (days)					
							Above 5.6°C.	Below 5.6°C.	Temp.	Date	Temp.	Date	Mean	Deviation From Average[3]		Inches	Deviation From Average[2]	Hours	Deviation From Average[1]	Miles
January	4.7	**40.5**	—1.1	—0.5	**31.0**	—0.8	8	114	11	7	—5	30	1.4	—0.6	28	1.98	+0.05	74	+24	—[4]
February	6.6	**43.9**	—0.2	—0.1	**31.9**	—1.0	13	76	11	5	—7	2	1.9	—0.2	23	0.26	—1.59	73	—3	4393
March	7.1	**44.9**	—1.5	0.4	**32.6**	—1.4	32	88	18	29	—10	2	3.4	—0.9	19	1.34	—0.51	93	—12	5942
April	12.0	**53.6**	+1.0	2.0	**35.6**	—1.2	70	28	17	2	—3	21	6.9	—0.4	17	1.14	—0.47	193	+53	5869
May	13.3	**56.0**	—0.7	6.1	**42.9**	+0.8	135	7	22	13	—1	19	10.1	—0.1	3	2.48	+0.48	147	—19	4874[4]
June	17.1	**62.7**	—0.6	9.1	**48.5**	+0.9	228	1	23	29	3	1	13.4	—0.2	1	3.07	+1.38	165	—17	5566
July	15.4	**59.7**	—4.0	8.4	**47.1**	—2.3	196	1	19	20	3	30	13.6	—1.7	0	3.05	+0.49	135	—19	4221
August	17.0	**62.6**	—1.7	9.0	**48.2**	—1.2	233	2	20	17	3	8	13.4	—1.4	1	2.23	—1.04	158	+17	5064[4]
September	14.9	**58.9**	—1.5	8.4	**47.0**	+0.3	184	2	19	15	2	2	11.8	—1.1	0	3.72	+1.72	82	—40	4784
October	12.5	**54.5**	—0.1	6.8	**44.3**	+1.5	137	8	17	5	—1	20	10.0	—0.3	6	2.22	—0.38	70	—25	4556
November	6.3	**43.3**	—2.2	0.9	**33.6**	—1.6	23	82	13	8	—4	15	4.6	—1.3	19	3.07	+0.75	80	+17	6685
December	4.5	**40.1**	—2.2	—0.9	**30.4**	—1.3	3	120	9	15	—7	29	1.3	—2.4	29	2.25	—0.27	48	+7	3420
Year	10.9	**51.6**	—1.2	4.1	**39.2**	—0.7	1262	529	—	—	—	—	7.6	—0.9	146	26.81	+0.61	1318	—17	—

1 & 2 Recorded at official Dundee Meteorological Station, 1921-1950 and 1881-1915 respectively.

3 Recorded at Mylnefield 1954-1961.

4 Records missed through instrument failure.

[*Reprinted from* SCOTTISH AGRICULTURE, *Winter* 1963/64]

New Strawberry Cultivar 'Templar'

The Scottish Horticultural Research Institute will shortly distribute the first supply of plants of a further new strawberry variety raised by the staff of its West of Scotland Unit at Auchincruive, near Ayr. The name 'Templar' has been submitted for Registration under the provisions of the International Code of Nomenclature for Cultivated Plants*, in accordance with which the following description is published.

Name:	Templar. Breeder's Number: 57C33. Number in National Fruit Trials (Brogdale): A.38.
Introduction:	Spring 1964, by the Scottish Horticultural Research Institute, Mylnefield, Invergowrie, Dundee, Scotland.
Origin:	Seedling from cross made in 1957. Raised at the West of Scotland Unit (Auchincruive) of the Institute (Officer-in-charge: R. D. Reid).
Parentage:	Seedling Auchincruive 11 × Cambridge Vigour.
Plant:	Medium to large. Habit of growth very compact and upright on poorer soils, but on rich fertile soils large to very large and very vigorous, with foliage dense and upright. Flower trusses held upright, rather short, and characteristically protected by the canopy of foliage.
Lamina:	Medium to large. Colour medium to dark green, slightly shiny; sometimes shows mottling as in Cambridge Vigour. Surface of the whole lamina flat to convex in mature leaves.
Leaflets:	Shape approximately as long as broad, or slightly longer (e.g. average length = 1.08: breadth = 1.00). Leaflet base angle obtuse (average 128°). Leaflet base shape rounded. Leaflet surface generally convex or downward-cupped, sometimes wrinkled. Pubescence: numerous fine silky hairs on upper surface. Leaflet serrations: sharp, medium depth, moderately coarse.
Petiole:	Green, with base very slightly tinged pink. Width of cross section greater than depth. Petiole-furrow shallow. Petiole hairs fine, long and outright. Petiolule hairs very fine, short, outright.
Stipules:	Narrow, close-set, usually tinged pink.
Stolons:	Many, vigorous; green, tinged red. Hairs short, outright.
Inflorescence:	Truss short, not protruding beyond leaf canopy. Usually simple, breaking at about two-thirds length and bearing 6-8 fruits. A minority of trusses compound, breaking at half length.
Peduncle:	Short, thick, strong; hairs slight, short and outright.
Pedicels:	Hairs slight, outright.
Flowers:	Small, complete; anthers numerous, filaments long.
Fruit:	Globose conic to short conic, very symmetrical. Size medium-large to very large, maintained well throughout season. Colour light red, turning a dark red when fully ripe. Surface shiny, not downy. Achenes small, yellow or reddish, embedded, but surface not deeply pitted. Styles, when persistent, are small and inconspicuous.

**International Code of Nomenclature for Cultivated Plants* (*June* 1961), *published at Utrecht, Netherlands, by the International Bureau for Plant Taxonomy and Nomenclature.*

Flesh: Whitish, suffused light red, very rarely with cavity. Texture firm, juicy, solid, fine. Flavour rich, slightly acid.

Calyx: Not large. Sepals medium to short, remaining green, not very downy. On some of the earliest-ripening fruits the calyx may be embedded, clasping, and firmly attached; but in most fruits it is slightly reflexed, giving a short fleshy neck which breaks easily, leaving the plug, which is small, inside the fruit.

Season: Extends from 3 to 4 weeks. Normally a late maincrop, very similar to Talisman.

Diseases: This variety has been selected for resistance to Red Core Root Rot (*Phytophthora fragariae*). In laboratory tests it has been inoculated with isolates representing four races of the pathogen and has proved resistant to three of them and susceptible to one, the latter being the race which has been found pathogenic to all strawberry cultivars on which it has so far been tried.

[*Reprinted from* SCOTTISH AGRICULTURE, *Winter* 1965/66]

New Strawberry Cultivar 'Crusader'

The Scottish Horticultural Research Institute will shortly distribute the first supply of plants of a further new strawberry raised by the staff of its West of Scotland Unit at Auchincruive, Ayr. The name 'Crusader' has been submitted for Registration under the provisions of the International Code of Nomenclature for Cultivated Plants* in accordance with which the following description is published.

Name: Crusader.
Breeder's Number: 57E28.
Number in National Fruit Trials (Brogdale): A.45.

Introduction: Spring 1966, by the Scottish Horticultural Research Institute, Invergowrie, Dundee, Scotland.

Origin: Seedling from cross made in 1957. Raised at the West of Scotland Unit (Auchincruive) of the Institute. (Officer-in-Charge: R. D. Reid).

Parentage: Auchincruive Seedling 50X5 × Cambridge Vigour { Seedling 6M17 (Temple selfed). × Seedling 11 (Aberdeen open).

Plant: Large to very large. Foliage very vigorous, upright, very spreading and with coarse appearance; dark green. Flower trusses very spreading and displayed mostly round perimeter of plant.

Lamina: Large and flat.

Leaflets: Large. A very characteristic and distinctive feature is that leaflets are usually broader than long; the mean ratio of length to breadth 1.00:1.05. Leaflet base angle obtuse to very obtuse (average 125°). Leaflet base rounded, leaflet surface flat or slightly curled; upper surface shiny; veins depressed and conspicuous. Leaflet serrations coarse, shallow relative to size of leaf, ratio of depth to width at base 1.16:1.00; straight sided and pointed, infrequently with double points. Pubescence: very fine and almost imperceptible on upper surface, fine, silky and inconspicuous on lower surface. Fine hairs on edges of serrations.

Petiole: Green, occasionally reddened at base; long, usually 2 to 3 times length of terminal leaflet. Width of cross-section greater than depth, ratio 1.12:1.00. Petiole furrow shallow. Petiole hairs fine, long, numerous, silky and outright. Petiolule hairs outright.

Stipules: Small to medium, close set, green.

Stolons: Abundant but initially slow in being produced; vigorous but not as strong as in Templar. Stolons green; hairs very fine, short upright. Bracts on stolons small.

Inflorescence: Trusses spreading; very strong, usually branching high at $\frac{1}{2}$ to $\frac{2}{3}$ of total length. Branching usually compound but secondary branches very short. The manner of branching is very characteristic; many of the pedicels are at right angles to the peduncle and usually subtended by a large leafy bract. Simple truss has about six flowers; the more usual compound truss 8-10.

**International Code of Nomenclature for Cultivated Plants* (*June* 1961), *published at Utrecht, Netherlands, by the International Bureau for Plant Taxonomy and Nomenclature.*

Peduncle: Thick: hairs numerous, short outright.

Pedicels: Relatively short, hairs outright.

Flowers: Medium-sized and not very liable to frost damage. Petals 5-8. Flowers complete. Anthers may be weak on earlier flowers; those on later flowers have very large filaments.

Calyx: Sepals 10-18, fine, narrow, green and downy. On primary fruits, calyx may be firmly attached but in most fruits calyx is reflexed away from berry with short fleshy neck breaking away easily, leaving plug in fruit. Remnants of stamens persistent in calyx.

Fruit: Size large to medium, size usually well maintained. Primary fruits rounded, irregularly compound; most fruits are bluntly conical with a rounded apex. Achenes small to medium sized, yellow to dark red according to position, embedded. Styles persistent, short. Surface of fruit slightly pitted; surface shiny, light to dark red, bright but darkens after picking. When fruits are ripening, trusses are very spreading and lie well out on perimeter of plant; fruits tend to lie in heaps well clear of foliage.

Flesh: Fairly firm, crisp; white in centre suffused pink towards exterior. Plug moderate sized, not removed with calyx; usually no cavity. Core small to medium, solid. Flavour sweet, very pleasant full flavour.

Season: Early main crop. Usually slightly earlier than Redgauntlet. Picking season extends for 3-4 weeks.

Diseases: In field conditions is highly resistant to Red Core disease (*Phytophthora fragariae*). In laboratory tests when inoculated with isolates representing 7 races of the pathogen, was resistant to 4 races and susceptible to 3 (results similar to those obtained with Templar). In dry areas is susceptible to mildew (*Sphaerotheca humuli*) and protective spraying may be advisable.

No information on reaction to *Verticillium* or to virus diseases is available but tests are in progress. On the basis of graft tests to *F. vesca*, existing stocks appear to be virus free.

Comparison: Crusader bears some superficial resemblance to Templar when growing: the following distinctive characters are noted:

Crusader	Templar
Terminal leaflet	
1. Width is approx. 5 per cent. greater than length.	Width is always less than length.
Inflorescence	
2. Peduncle branches at approx. $\frac{3}{4}$ of total length. Truss is usually compound, final pedicels very short: a number are usually very characteristically at right angles to peduncle. Usually 8 to 10 flowers per truss.	Truss short and peduncle branches at $\frac{1}{2}$ to $\frac{3}{5}$ of length. Truss usually simple, infrequently compound. Angle of pedicels acute as in most other varieties. Usually 6 to 8 flowers per truss.
3. Practically no flower trusses in centre of plant; all are exposed and characteristically borne around perimeter of plant.	Trusses arise from centre of plant, are protected by canopy of leaves and do not descend to outer perimeter until fruit is swelling.

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