



The Scottish Horticultural Research Institute

16th Annual Report for the year 1969

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A. B. Wills, B.SC., M.S., PH.D.
H. McC. Anderson, S.D.H. *Resigned July 1969*
M. M. Anderson, N.D.H., S.D.H., D.H.E.
E. N. Bent†, B.SC. *Resigned August 1969*
Eleanor Carmichael
Adrienne Green†, B.SC. *Appointed September 1969*
K. C. McConnell†, S.D.H.
W. Greta Priestley, DIP.HORT. *Died December 1969*
A. J. Redfern, B.TECH. *Appointed October 1969*
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Marjorie Campbell†
Sheena K. Fyfe
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Joyce E. T. Walker

Virology

Head of Section B. D. Harrison*, B.SC., PH.D.
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A. T. Jones, B.SC., PH.D. *Appointed May 1969*
M. A. Mayo, B.SC., PH.D.
W. P. Mowat, B.SC., DIP.AGR.SCI.
A. F. Murant, B.SC., PH.D.
J. Chambers, B.SC.
A. A. Crockett *Appointed August 1969*
R. A. Goold
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D. C. Donald *Appointed September 1969*
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Mrs A. Zlata Stefanac, ING.BIOL., M.SC., PH.D.

Zoology

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W. M. Robertson

Assistants Wanda K. D. Noble *Resigned March 1970*
R. R. Crichton
Heather C. A. Baker *Appointed January 1970*

Staff

Director C. H. Cadman*, B.Sc., Ph.D., F.R.S.E., F.I.BIOL.

Deputy Director A. R. Wilson*, B.Sc., M.S., Ph.D., M.I.BIOL. *Retired*
October 1969

Crops Research

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T. W. Hegarty, B.Sc., DIP.AGR.SCI., Ph.D.
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D. K. L. MacKerron, B.Sc., Ph.D. *Appointed* October 1969
D. T. Mason, B.Sc., Ph.D.
Pauline B. Topham, M.A., B.Sc., Ph.D.
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Mrs Sylvia G. Pask *Appointed* April 1969
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Heather A. Ross

Visiting Worker N. Rath

Mycology

Heads of Section A. R. Wilson*, B.Sc., M.S., Ph.D., M.I.BIOL. *Retired*
October 1969
R. A. Fox*, B.Sc., B.AGR., M.I.BIOL. *From* November 1969
W. R. Jarvis, B.Sc., Ph.D., D.L.C., M.I.BIOL.
Isabel G. Montgomerie, B.Sc., Ph.D.
M. C. M. Pérombelon, B.Sc., M.Sc.
D. A. Perry, B.Sc., Ph.D.
E. Patricia Dashwood, B.Sc., M.Sc.
J. B. Garrie
J. G. Harrison, B.Sc.
D. M. Kennedy, B.Sc. *Appointed* August 1969
R. Lowe
M. Christine MacNaughtan, B.Sc., M.Sc. *Resigned* June
1969
H. M. Wilson

Assistants Mrs Isobel G. Anderson
Evelyn M. Ballantine *Appointed* March 1970
Janet D. Barclay *Resigned* March 1970
Janice M. Fergusson
Barbara J. Hume
I. M. McArthur *Appointed* August 1969

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Maintenance

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J. R. Caithness
A. Low
R. MacDonald
J. F. McLean
G. Merchant
D. J. G. Redford
A. Ryce
L. A. Swan

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Foreman F. Ritchie
Assistant Foreman R. W. Reid

Glasshouses

Manager J. Cantwell
Foreman R. D. Taylor

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Assistant Secretary A. P. Thomson
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General Report

C. H. CADMAN

Though it is a matter for congratulation, no one could envy Professor Burnett the difficult decision to accept the University of Oxford's invitation to succeed Professor G. E. Blackman in the Sibthorpean Chair of Rural Economy, coming, as it did, so soon after his appointment to the Regius Chair in Glasgow. What is Glasgow's loss is Oxford's gain and we flatter ourselves that, through persuading him to retain his Chairmanship of the Governing Body, he will retain his Scottish connections and the Institute a friend to whom it already owes so much.

In other respects this has been a year of change, not all of which makes pleasant reporting. We were saddened by Miss Greta Priestley's death in December after a brave fight against increasing odds which we were powerless to offset except by providing her with companionship in her determination to continue working. At the end of October Dr A. R. Wilson retired from the headship of the Mycology Section and the Deputy Directorship of the Institute. In this last capacity his retirement is a personal loss for he served as confidant and counsellor during some of the most difficult phases of the Institute's reorganisation. A special word of appreciation is also due to Mrs Wilson for liaison work behind the scenes which helped new members of staff and their wives to feel at home and compensated for some of the deficiencies of a batchelor Director. To them both we wish many years of happy and profitable retirement in their new profession as hoteliers. At the end of March we were also sorry to bid farewell to Fred Ritchie after 20 years of service at Mylnefield, 17 of them as farm grieve in the Institute's employ.

Some staff changes inevitably followed these events and others resulted from the creation of new posts or from resignations. In November R. A. Fox became the new Head of the Mycology Section. Earlier in the year he went to Ceylon at the invitation of the Royal Society to serve as a Visiting Professor in plant pathology in the University of Ceylon. Under the auspices of the British Council he also visited research centres in India, mostly those concerned with research in potatoes. At the request of the Commonwealth Development Corporation he acted as consultant in plant pathology to a working group which inspected rubber plantations in Eastern Nigeria in January. W. R. Jarvis left in August on a year's secondment to the Plant Diseases Division of the New Zealand Department of Scientific and Industrial Research at Auckland to help with work on post-harvest storage rots of fruit.

The affairs of the Plant Breeding Section were further disrupted by the departure in August of H. McC. Anderson to Long Ashton Research Station and the appointment in January of Dr Pauline Topham to the post of Statistician in the Crops Research Section, so some re-grouping of projects and personnel was done. Breeding work on cane fruits and black currants is now under the supervision of D. L. Jennings and we hope to use Dr Topham's vacancy for the temporary appointment of a post-graduate student to work on *Botrytis* resistance in raspberry. More of the Section's resources are being devoted to cyto-genetic work on Brassica crops and this is now under the leadership of A. B. Wills. A. J. Redfern replaced H. McC. Anderson and co-ordinates the field work on this project, and Miss Priestley's post is being used to invite a visiting worker to join the group to work on the genetics of incompatibility systems in *Brassica*. E. N. Bent left the West of Scotland Unit in August to go to Uganda and was replaced by Adrienne Green.

The world of computerisation grows ever more complex and more expensive so the appointment of a statistician to the Crops Research Section is a relief in the sense that there is now someone designated to look after the Institute's needs. The Section acquired an additional new member of staff in D. K. L. MacKerron who was appointed in October to a Scientific Officer's post resulting from the upgrading of the Experimental Officer vacancy left by P. J. Joy in December 1967. Dr MacKerron expects to work on the response of plants to shelter and is at present spending a year in Professor J. L. Monteith's department of Physiology and Environmental Studies at the University of Nottingham.

O. W. Barnett left the Virology Section in August to take up a university appointment at Clemson, Ohio, after having spent a most productive year at the Institute. This vacancy was used to appoint A. T. Jones, in the first instance for a limited term, to begin work on aphid-borne viruses of raspberry. The Potato Marketing Board awarded a research grant to B. D. Harrison for the continuance, under his direction, of work on spraing diseases of potato and this provided for the appointment of J. I. Cooper as Scientific Officer and D. C. Donald as Scientific Assistant. To enable him to accept an invitation from the Japan Society for the Promotion of Science to serve as a visiting professor, Dr Harrison has been granted leave of absence for the months of April, May and June 1970, during which he will be visiting university departments and research centres in Japan where work on plant viruses is being done.

The Zoology Section is collaborating with the Plant Pathology Department of the University of Bari in a project financed by the NATO Research Council and designed to investigate aspects of the biology of nematode species concerned in the transmission of viruses to grape vine and other crops.

Travel grants provided by the Agricultural Research Council aided further extension of international communication. In his capacity as Chairman of the Horticulture Section of Eucarpia, C. North attended meetings in Hannover and Brussels. A. B. Wills made an interesting tour in Holland and Germany of state-aided and commercial research centres concerned with

Brassica breeding. M. Pérombelon, R. A. Fox, A. R. Wilson and I attended the 4th Triennial Conference of the European Association for Potato Research held at Brest in September. In March P. D. Waister went to the International Horticultural Congress in Israel and W. P. Mowat and H. M. Lawson went to the 1st International Flowerbulb Symposium in Holland.

Continuing in this vein, Mr V. C. Lele, a Colombo Plan scholar from the Division of Mycology and Plant Pathology, Indian Agricultural Research Institute, New Delhi, came in May to spend 6 months in the Mycology Section. In September, Dr A. Z. Štefanac, a British Council scholar, returned to the University of Zagreb, Yugoslavia after spending 18 months in the Virology Section and N. Rath to the Irish Agricultural Research Institute at the end of a year's stay in the Crops Research Section. The Institute also acted as host during the year to a visiting party of potato storage experts from the U.S.S.R. and to delegates from the International Lily Conference. As it is sometimes doubted whether research institutes have adequate international communications, this record, which is a modest one by most standards is some evidence to the contrary.

Because of its impact on the work of the Institute, the Development Scheme has occupied a prominent place in domestic affairs throughout the year. With the approaching completion of Phase 1 of the Scheme and the accumulation of a certain amount of hard-won experience, we contemplate the way ahead with mixed feelings. Building the new laboratory block which constitutes Phase 2 of the scheme offers the inviting prospect of relief from the tiresome task of juggling with overcrowded and temporary accommodation. The way for it has been prepared by demolishing the old steading buildings and a start is expected some time in the financial year 1970/71. With the completion of the new Farm Buildings and the Plant Breeding and Mycology glasshouse blocks, working facilities have improved enormously. The Institute has begun to take on a new and more efficient look and past experiences of a purgatorial nature seem to have been worth while. As engineer of the scheme I owe a debt of thanks to Dr Wilson for his share of the Design Group's work and especially to J. H. Couttie, Head of the Maintenance Section, for his indispensable role as clerk of works, a burden which has proved much more onerous than I anticipated at the outset.

This year's Report is a creditable record of achievement, the most immediately obvious being the new plant varieties, bred by the Institute and recently released to the National Seed Development Organisation, whose descriptions are appended. To these must be added the new F_1 hybrid Brassicas—Celtic cabbage and Gleneagles Brussels sprout—seed of which may be in commercial circulation by 1971. Increase in membership of the Institute's Association to 200 is heartening evidence of increasing interest in our activities and in many ways it is stimulating to find the Institute playing an active role in developments which promise an expanding future for horticulture in Scotland and particularly in the eastern counties. Apart from much informal exchange and co-operation between the Institute and the Agricultural College advisory services, growers and processors, the Association's programme of meetings

during the year and the publication of the Association's Bulletin have helped to improve communications. Perhaps the most outstanding event of the year was the meeting held in January to review the prospects for raspberry marketing which attracted a large audience and provoked a stimulating exchange of views. It is to be hoped that some of the seeds sown will germinate effectively and that more of the potential of Scotland's premier horticultural product will be realised. Prospects for other aspects of horticulture were reviewed by Mr W. L. Hinton of the Department of Land Economy, University of Cambridge, at the Association's A.G.M. in May; Dr D. M. van Slogteren and Ir. C. J. Asjes of the Institute for Flowerbulb Research, Lisse, Holland, spoke at a meeting on bulbs jointly organised in April by the Association and the East of Scotland College of Agriculture; and field walks were held in July and November at which members were able to see and discuss work being done on soft fruit and vegetable crops. Smug though it may sound, there is some satisfaction to be had, amidst the current clamour about cost-benefits and the virtues of management techniques, in feeling that at least one small section of the horticultural industry understands and is appreciative of the efforts of the Institute on its behalf.

Farm and Experimental Crops

W. I. A. JACK

As the meteorological records show, the year started badly with a cold, wet spring which hindered farm operations and retarded the growth of most crops. The month of May, as well as being sunless, was the wettest on record for this part of the country. However, the balance was redressed by the fine summer and autumn; indeed we have almost forgotten what a wet fruit-picking season is like. The cereal crops were harvested in ideal weather, beginning with barley on 21 August and oats on 15 September. Winter wheat was dropped from the rotation this year; instead we grew 13 acres of Condor oats. These followed the 1968 vegetable experiments and were grown without additional fertiliser in order to assess residual manurial effects. Both the yield, 38.3 cwt/acre, and quality exceeded expectations and almost 80% of the crop was sold for milling. The entire barley acreage, 103.5 acres, was this year sown with Golden Promise which cropped at 38.2 cwt/acre, an increase of 11% on last year. There were outbreaks of mildew and 'take-all' in some fields but the moisture and nitrogen content of the grain were unaffected and the entire crop was sold for malting.

As the potato acreage is now virtually confined to experimental crops, yield figures are not very meaningful but the average was around 12 tons/acre. The decrease in populations of potato root eelworm revealed by this year's survey, for which we are indebted to the East of Scotland College of Agriculture, seems to indicate that earlier decisions to restrict the crop to relatively clean land and to use only Foundation Stock planting material were sensible.

Grass is now becoming an important rotational crop and, at intervals during the year, areas were sown with a ryegrass/cockfoot mixture. Its two-fold function in the rotation is to maintain fertility and to reveal inequalities in nutrient status. Uniform levels of fertility are an essential prerequisite to field experimentation and are difficult to attain in a rotation such as ours where the land is put to so many varied uses. In attempting to achieve the desirable, we receive much helpful information and advice from Mr K. Simpson and his colleagues of the Soil Science Department, East of Scotland College of Agriculture as a result of their annual survey of the Institute's land.

Changes in the type, size and lay-out of vegetable experiments have resulted in smaller quantities of produce for marketing but the crops of cabbage, calabrese, Brussels sprouts, carrots, swedes, beetroot, broad and

French beans, sweet corn and cucumber all yielded small returns. As there is an increasing demand for calabrese in the fresh market, attempts were made to achieve continuity of supply with successive sowings, direct drilled, of the variety Rex. Sowing on 11 April and again 4-5 weeks later resulted in a harvesting season lasting 15 weeks, from 5 August to 10 November, with yields equivalent to 92 cwt/acre from the first sowing and 62 cwt/acre from the second.

Innovations were made this year in the system of handling the harvest from soft fruit experiments with the two-fold object of improving the standards of supervision and fruit-picking and centralising the recording of data. These are inevitable steps towards making more effective use both of diminishing labour supplies and the improvements in data processing made possible by the growth in computerised techniques. Even so the system was under stress this year because of the shortness of the raspberry season in the warm summer weather and the fact that the peak of the crop coincided with the local holiday fortnight. Strawberry picking began on 9 July and raspberry picking on 21 July. Many of the younger plantations are now in full bearing and yields of raspberries (26.25 tons) and strawberries (11.7 tons) were considerably above those of 1968 from the same acreage. Black currant (1.4 tons) from a greatly reduced acreage of bushes of fruit-bearing age were marketed locally.

The prolonged spell of fine weather persisted into December and the autumn and winter work programmes of stubble cleaning, ploughing and estate maintenance were all well advanced by the time the land became unworkable. There was thus time to attend to the older windbreaks, planted in 1953 and 1956 on the west boundaries of Laboratory and East Loan fields and the north boundary of School field respectively. These have been posing problems of management, difficult to resolve. Because beech does so well in this area and makes such effective shelter for horticultural crops, the thinning programme designed for these windbreaks has been abandoned and other species removed with the object of allowing the remaining single row of beech to form a hedge. Unfortunately part of the beech hedge, west of the glasshouse area, planted in 1960 and now 15 ft high, had to be removed to allow of the building of the Plant Breeding glasshouses. A new windbreak consisting of a double row of beech has been planted west of the new approach road to the glasshouse area. The completion in February of drainage work for the Development Scheme enabled a start to be made with plantings of ornamental trees and shrubs in the west border of the main drive.

The recent disappearance of the old steading buildings marked a sentimental break with the past but there is no doubt that the new Farm Buildings which were at length ready for occupation in September, provide immensely better facilities for the farm and workshop staff, their equipment and ancillary activities.

Glasshouse Section

J. CANTWELL

The Development Scheme must once more have first mention as this is a major continuing influence on the Section's output. The sight of modern glasshouses under construction has, however, made tolerable the frustrations of dislocated services and temporary buildings.

The first plants were housed in the new Plant Breeding heated glasshouses in December 1969 and the complete block is gradually being brought into use. As each of the eight glasshouse compartments has its own set of automatic heating and ventilating controls it is hoped to grow plants in a near-optimum environment and at the same time provide enough room for easy working and management of the plant material.

The re-siting of the unheated glasshouses necessary to prepare the way for the building of the Plant Breeding and Mycology blocks, was a major upheaval in the early part of 1969. In the event, the re-organisation has proved well worthwhile. The scheme was completed during the year and the houses were provided with good access roads and services. The unheated dutch light frames have once again had to be moved and are now sited more rationally at the north end of the glasshouse area on rising ground with a southerly aspect. To meet the needs of the Crops Research Section for consistency in the quality of seedling material used for transplanting, a pilot scheme, using 1,000 sq ft of double span dutch lights, has been started with the object of designing a programme for this type of plant production.

The experimental programme was once more curtailed but some routine work was continued, particularly on soilless composts, insecticides, fungicides and artificial light sources. One soilless compost suitable for short-term plants is being introduced gradually and 25% of the plants produced for the Virology Section are now grown in this compost. Work is continuing with slow-release fertilizers in an attempt to produce a compost that will combine speedy initial growth with long-term nutrient availability. After tests with a wide range of plant species it proved possible in most plant production programmes to replace TEPP (tetraethyl pyrophosphate) with diazinon for the control of sciarid flies. The reduction in use of TEPP by 70% lessened risks to personnel, reduced the labour input and saved money on chemicals.

The principal disease under glass this year has been powdery mildew of raspberry and tests were carried out with various fungicides. One appears to be promising and will be tested further in the 1970 season. The same chemical may also be of use in the Brassica breeding programmes for the control of

Cystopus candidus which can be severe under glasshouse conditions.

Preliminary observations were made on high pressure sodium lamps using about twenty species of plants. Most species appeared to grow well under the lamp but *Nicotiana megalosiphon* suffered damage. The paradox remains that while in winter long periods of artificial illumination are necessary, in summer many species must be heavily shaded. Therefore efforts were made in co-operation with the Maintenance Section to develop a shading system using nylon fabric as an alternative to the cumbersome and inefficient water paint. The new system will be installed on a pilot scale, operated by hand, in the new Plant Breeding glasshouses this summer and it is hoped to develop the system further for use with photo-electric control gear.

The propagation of virus-free raspberry stock for the Scottish Nuclear Stock Association is undergoing a rigorous re-examination and preliminary observations on a limited scale indicate that gains may be possible in shoe production by increasing the temperature of the growing medium containing the root cuttings and by using a peat/sand medium rather than pure sand.

Because of the shortage of skilled glasshouse workers in this area the Section has been consistently understaffed throughout the year, and it says much for the foreman, R. D. Taylor, and the staff that they coped efficiently with all the demands made upon them. The labour difficulties were temporarily eased by student helpers from the Horticulture Department of the West of Scotland Agricultural College who included Miss E. H. Hamlet, a second-year sandwich student and whom we were most pleased to welcome.

Crops Research

P. D. WAISTER

New members of staff this year include D. K. L. MacKerron who was appointed in October and is at present spending a year in the Department of Physiology and Environmental Studies of the University of Nottingham. His work at the Institute will be to investigate the reasons underlying the response of soft fruit to shelter. In January we welcomed Dr Pauline Topham from the Plant Breeding Section to the new post of Statistician. Though on the staff of Crops Research she will be responsible for advice on experimentation and data handling for the Institute as a whole.

Mrs Sylvia Pask was appointed in April as Scientific Assistant for weed studies. N. Rath of the Agricultural Institute of Eire completed a year's work on components of yield in strawberries and returned to Eire in October.

The remit of the Section appears wide, ranging from investigation of effects of individual climatic factors on the one hand to experimentation to solve specific short term problems of the Scottish industry on the other. The objectives, however, may collectively be described as an attempt to make best use of the northern climate, and this requires an understanding both of climatic restrictions and the efficiency of crops in the partitioning of dry matter. This question of efficiency has stimulated investigations of yield components of cultivars under differing cultural conditions which have particular relevance to the need, particularly for processing, for produce in the lower size grades. This need may be met either by using genetically small cultivars or by close spacing of larger cultivars. The relative merits of the two methods determine not only the choice of existing cultivars but also help to indicate the desirable aims in breeding programmes.

In the past few years there has been a marked increase in production of crops for processing in Scotland and this has brought with it an increase in the number of problems requiring short-term investigation. Where results of such investigations are thought to be of immediate interest to the local industry, the information is published in the Bulletin of the Institute Association.

CROP ENVIRONMENT

Crop response to shelter

Increases in yield in response to shelter were again evident in experiments on strawberries and raspberries. The responses were smaller this year, perhaps due in part to the calm conditions during 1968 when the fruiting framework

for the 1969 crop was established. Wind run during the 1968 season was 20% lower than the mean for the 8 years during which records have been collected at the meteorological site.

The mean yield of raspberries was increased by 16% in the 0-3h zone plots sheltered from the west. Mean wind speeds measured at 18 in. above the crop at 2h were 3.8 mph and 2.7 mph for the exposed and sheltered plots respectively for the period August 1967 to August 1969. Strawberry plots 30 ft wide, sheltered from both west and east by 5 ft and 10 ft screens respectively, yielded 20% more fruit than the exposed controls. The experimental results are being checked with longer screens erected in raspberry and strawberry plantations on growers' holdings.

A pilot study of shelter effects on rates of increase of narcissus bulbs was commenced in 1969. The crop will be lifted in 1970.

Irrigation

In this, the second fruiting year of an experiment on strawberries there were again no significant differences in yield due to irrigation, but there was some indication that irrigation had increased runner production at the expense of cropping when the crop was grown on the spaced-plant system instead of the matted row.

The irrigated treatment in a raspberry experiment showed a 13% increase in yield over the non-irrigated control, probably reflecting the increased canopy growth reported in 1968, rather than any direct effects of irrigation in 1969 (P. D. Waister).

Seed germination and seedling emergence

In a sweetcorn variety trial incorporating a seed hardening treatment, the emergence of two varieties was increased by 83% and 176% over the untreated controls. Seed hardening did not appear to increase the earliness of the crop but plant height was increased by up to 7.5 in. (H. Taylor, T. W. Hegarty).

Carrot seed of a Chantenay variety, hardened in water or in solutions of 0.01 M K_2HPO_4 or 5 ppm. vitamin B_6 , was sown on 20 May at a rate of 4 seeds/sq ft in rows 9 in. apart. The hardened seed emerged 2 to 3 days earlier than the control seed, and the final emergence increased from 58.0% in the control plots to 65.0, 69.8 and 72.5% in the plots of the water-, vitamin B_6 - and K_2HPO_4 -hardened seed respectively. At harvests 13, 18 and 23 weeks later, the roots were separated into quarter-inch size grades. Though the variability in root size was not affected by seed hardening, there was an effect on yield of canning size roots. Mean canning yields from the control plots at the three harvests were respectively 19.9, 20.3 and 18.5 tons/acre, whereas the corresponding values from the plots with hardened seed were 22.9, 28.2 and 17.4 tons/acre. Thus the yields from the control plots were remarkably constant over the three harvests, whereas substantial benefits could have been obtained from the hardened seed if the crop had been harvested after about 18 weeks.

There is reason to believe that the beneficial effect of seed hardening on emergence is not general but may apply only to poorer seed lots and this is being investigated.

Consecutive sowings of eleven carrot seed lots (Chantenay and Nantes types), untreated and captan-dressed, were made on 1 April, 29 April and 27 May. Mean emergence of untreated seed (60.8, 56.5 and 42.4%) decreased at each successive sowing despite increasing soil temperatures, whereas emergence of captan-dressed seed (63.8, 65.2 and 54.4%) was reduced only at the third sowing. The mean time to 50% final emergence decreased at each sowing (34, 21 and 14 days) and was unaffected by captan. Relative performance in the field of captan-dressed seed could be better predicted from the results of laboratory germination tests at 10°C than at 20°C or from Official Seed Testing Station figures.

In preparation for studies on soil temperatures and moisture effects on the germination of red beet, techniques for germinating seed in the laboratory were examined. O.S.T.S. germination tests differ for rubbed seed and natural seed and a single standard test was sought for experiments where temperature was to be a variable. At 20°C, Boltardy beetroot seed showed satisfactory germination of both clusters and rubbed samples on saturated filter papers (without free water) regardless of whether normal dry clusters were used or clusters that had been washed and dried prior to the test. Samples washed and then sown wet required drier conditions for maximum germination. In general the behaviour was similar to that reported elsewhere for sugar beet. (T. W. Hegarty).

International Biological Programme (Production Processes Section)

The Institute is one of two centres in Britain co-operating in the Level 1 Photosynthesis experiment of the 'Production Processes' Section of the I.B.P.; the other is the Department of Agriculture, University of Oxford. The aim is to obtain information in the principal climatic zones of the world on the extent to which the potential rates of relative growth and net assimilation of plants freely supplied with nutrients and water are influenced by seasonal changes. The species used in this experiment are *Helianthus annuus* and *Phaseolus vulgaris*.

The method involves taking samples of relatively widely spaced plants at the beginning and end of a continuous series of standardised experimental periods, and determining the dry weights of the roots, stems and leaves together with the areas of the leaves. Each experimental period is of one week's duration, and serial sowings throughout the season give a regular supply of young plants at a standard stage of development.

Maximum relative growth rate and net assimilation rate for beans occurred during the weeks 12-19 August and 22-29 July respectively. Values were 0.116 $g\ g^{-1}day^{-1}$ and 0.090 $g\ dm^{-2}day^{-1}$ respectively. For sunflowers the maximum values were 0.196 $g\ g^{-1}day$ and 0.131 $g\ dm^{-2}day^{-1}$, both occurring during the week 10-17 July. (J. Q. Neilson, T. W. Hegarty).

Raspberry plantation management

Changes in husbandry as a result of the increasing use of herbicides has brought to light a number of management problems which require investigation. Current experiments are designed to answer two questions, namely which, if any, aspects of cultivation are beneficial, even in the absence of weeds, and can be incorporated into modern plantation management, and how important is the large quantity of unwanted sucker growth produced in uncultivated plantations and how frequently and by what means should be controlled.

In 1968, the results of the management experiment (planted in 1967) followed the pattern of 1967 with all treatments which involved some form of cultivation significantly outyielding those which did not. From April 1968 three of the uncultivated treatments were amended to include regular removal of unwanted sucker growth in the alleys and between the stools using tractor-mounted flailing and cutting tools. These treatments have not so far shown any clear-cut improvement in cane production or yield over the fourth treatment where paraquat/diquat is used for sucker control. In 1969, there were only minor differences between treatments in numbers of canes tied in an average heights of tipped cane, with the result that for the first time in several years, cultivated treatments as a group did not significantly outyield all uncultivated ones. The plantation showed no evidence of deterioration due to age, the average crop being 4.7 tons/acre.

In the third year of an experiment designed to isolate and measure the effect of the traditional practice of 'furring-up,' the ridged treatments showed no advantage in either cane growth or yield over the controls grown on the flat. The ridge does, however, facilitate chopping out of unwanted suckers either with hand tools or by mechanical means.

Two experiments were started in 1968 to investigate the effect of timing of removal of sucker growth in uncultivated plantations. In one, suckers growing between the stools were cut out in spring when they reached 6 in. high and whenever they reached that height thereafter. This resulted in 12% and 15% increases in yields in 1968 and in 1969 respectively compared with plots where sucker growth in the row was left untouched until the end of the growing season. In the other experiment, no responses in cane growth and yield have been obtained after two years of treatments involving the removal, at different stages of growth prior to fruit picking, of suckers growing in the alleys. Large numbers of suckers are produced in these uncultivated alleys between April and July and the weight of vegetation removed on plots which are not cut until access is required for pickers is very substantial. Competition between the crop and its own unwanted vegetation is being studied in greater detail in two new experiments.

Weed competition

In the experiment designed to assess the effects of weed competition of

Carlton narcissus (Ann. Rept. 1968) all plots were kept free from weeds in 1969, the second growing season. Plots unweeded in 1967/8 produced only two-thirds as many shoots as those which were kept weed-free. Other 1967/8 weeding treatments did not significantly reduce shoot numbers in 1969. The quality and size of flowers were unaffected by treatment. Plots kept weed-free from April to July 1968 produced more flowers in 1969 than plots left unweeded during this period. The number of flowers produced was not directly proportional to the number of shoots recorded because treatments varied in the percentage of non-flowering shoots. Those plots totally unweeded in 1967/8 produced the lowest percentage and the plots with weeds present between April and July 1968 the highest. When the experiment was eventually lifted in July 1969, the unweeded treatment gave a significantly lower fresh weight of bulbs (18%) than the weed-free, and also showed a higher proportion of large, unsplit mother bulbs.

In a second experiment planted in September 1968, the autumn and winter weed population was relatively sparse with the result that differences in weed growth between unweeded plots and those on which only spring weeds were allowed to develop were small. The treatments had no significant effects on shoot emergence, flower production or the weight of tops and bulbs lifted after flowering, or at the beginning of July 1969. However, when yields were assessed in mid-August the weed-free plots produced, on average, 15% greater weight of bulbs than plots totally unweeded or carrying spring weeds only. Removal of winter and/or spring weeds on 9 June prevented any reduction in yield, but plots weeded on 2 July were no better than unweeded plots.

As the evidence suggests that potential competition from weeds is likely to be at its maximum during the period of rapid bulb growth the possibility of herbicide application to narcissus after flowering is being investigated.

Herbicide development

Experiments on herbicide efficiency and crop tolerance were carried out in peas, red beet, swedes, cabbage, strawberries and pot-raised raspberry cuttings. Results will be reported elsewhere. (H. M. Lawson, J. S. Wiseman).

FRUIT CROPS

Raspberries

Results of a preliminary experiment on intra-plant competition have shown that the growth of vegetative cane and the yield of fruiting cane are each depressed by competition from the other. These data came from treatments superimposed on an existing fruiting plantation. In a new experiment planted in 1968 specifically to examine these effects further, the first yield comparisons were possible in 1969. The variety Norfolk Giant yielded 44 cwt/acre in the absence of competition from young cane, compared with only 33 cwt from the controls. Comparable figures for Malling Jewel were 32 and 28 cwt respectively.

Mechanised harvesting will probably necessitate plantations being grown on a hedgerow system at 8 ft. spacing instead of in stooled rows at 6 ft spacing. In the first cropping year of an experiment to compare yields under these two systems, a 15 in. wide unthinned hedgerow of Malling Jewel cropped at 43 cwt/acre, 36% higher than the control stooled treatment. The difference was even greater (60%) in the case of Malling Promise. The differences are likely to be at a maximum in the early fruiting years when cane numbers in the standard treatments are known to be sub-optimal.

Past experiments on row spacing have shown that yields increase with progressive decreases in spacing down to 5.5 ft without a maximum being reached. In 1968 investigation of the potential yield of spacings as close as 3 ft was started. The first crop was harvested in 1969 and this narrow spacing gave almost double the yield per acre of the conventional 6 ft rows. As in the case of the unthinned hedgerow described above, competition effects due to high cane numbers are not expected in the first cropping years.

Results from further experiments on methods of establishing raspberry plantations suggest that the 15 in. 'handle' normally left on planting can suppresses the emergence of new shoots. When the root systems were cut away from the 'handle,' divided into 3 or 4 pieces and planted at optimum depth, these produced nearly twice as many new canes as the conventional method of planting.

For the fourth year in succession, experiments on field control of *Botrytis cinerea* gave no useful results because of the low incidence of infection. Treatments with three different fungicides, applied at different times and pressures had no detectable effects on yield or fruit quality. (M. R. Cormack, P. D. Waister).

Strawberries

The new Institute variety, Montrose (formerly 60BB55), again produced the highest yield (125 cwt/acre) in the second cropping year of a variety trial. Senga Sengana yielded 110 cwt and Cambridge Favourite 108 cwt. The largest favourable responses to defoliation were shown by Senga Sengana and Montrose, while Cambridge Favourite, as usual, yielded less following the treatment.

Prototype mechanical harvesters for strawberries are of two types. The one under development in Britain will pick fruit from rows, and the American machines are designed to comb fruit from matted plantations. Comparisons of yield from rows and matted plots were obtained this year with the varieties Cambridge Favourite, Redgauntlet and Crusader, planted in spring 1966. When yields for the matted plots were calculated as for solid plantings (no beds), all varieties gave similar large yield increases over the row system in the first fruiting year. The crop was earlier and the fruit was appreciably smaller. The mean increase in yield was just over 100% and berry size was decreased by 20%.

As reported above for raspberries, *Botrytis* infection in strawberries was too light to permit assessment of differences between fungicides, sprays

pressures or timing of applications, when yield and quality of harvested fruit were used as criteria. (M. R. Cormack).

Reports of crown death in Cambridge Favourite, apparently following winter injury, prompted a survey of growers' holdings in 1968 and 1969. At the same time the opportunity was taken to collect data which would provide information on factors currently limiting yields in Scotland. The 68 sites on 33 farms which were finally surveyed were chosen to give a wide range of environmental conditions. The total area sampled was 190 acres, representing an estimated 20% of the fruiting acreage of Cambridge Favourite in Scotland.

Crown counts were made in November and December 1968 and samples dissected to assess truss initiation and internal injury to the crowns. Crowns were again counted in April, in pegged areas, and estimates made of the number of crowns that had died during the winter period. On the same areas, inflorescences were recorded in June and fruit was picked in July and August. From the data collected it is possible to estimate fruiting potential in autumn, the extent of winter injury, and the relative contribution to yield of parent plant crowns and runner crowns of varying ages. The oldest crowns showed the greatest degree of winter injury, and there was some evidence to suggest that the damage was cumulative. Yield reduction due to crown death would be much more serious were it not for the now widespread practice of retaining runners in matted rows, rather than cropping spaced plants.

The results of the survey are not yet analysed but there are already indications of the directions future investigations should follow in attempts to improve the average yield in Scotland. Though yields were restricted in many cases by failure to apply known techniques there appeared to be a need for investigation of ways of improving the techniques themselves. This applies particularly to methods of weed control and methods of establishing uniform plantations with high crown numbers. (D. T. Mason, N. Rath).

Vaccinium species

Highbush blueberries planted in 1966 fruited satisfactorily. These bushes were planted in peat-filled holes in normal arable land with a pH greater than 6. In a new experiment, the limitations of high pH are being examined. It will be two more years before yield figures are available but at the end of the season vegetative growth was already showing response to soil treatments, which included applications of sulphur, peat, and sulphate of ammonia. Onset of leaf senescence was earlier the higher the pH.

A variety trial of eight American varieties and four European varieties ofighbush blueberries was planted in 1969 as part of an international assessment organised by a working group of the International Society for Horticultural Science.

Investigation of propagation methods showed that, by selection of shoots in the temporary resting stage, 80% of softwood cuttings taken in July produced roots.

Although all varieties of cranberries (*V. macrocarpon*) planted in peat beds

in 1968 have grown well, only Franklin produced fruit this year. (M. R. Cormack).

VEGETABLE CROPS

Brussels sprouts

Two varieties of contrasting growth habit, Peer Gynt and the larger but later, Roem van Kloosterburen, were used in experiments to assess the variety and density interaction. Both varieties showed a similar degree of tolerance of close spacing down to the minimum of 1 ft x 1 ft. Total yields were little affected by spacings in the range 2 ft x 2 ft to 1 ft x 1 ft, though the proportions in the freezing grade rose from 54% to 84%.

Carrots

An experiment with a Chantenay variety, using seeds of 0.85–1.00 mm and 1.20–1.40 mm sown at depths increasing systematically from 0.25 in. to 3 in. provided evidence of interaction between depth of sowing and seed size. At a sowing depth of 0.4 in., the smaller seeds yielded 25% more roots than the larger but at 1 in. they yielded 20% fewer. Sowing depths exceeding 1.25 in. substantially reduced the plant stand.

Cabbage

There is an increasing demand for summer cabbage for dehydration, and the required raw material must be of high dry matter content, low in fibre, and as green as possible without excessive loose leaf. Experiments this year have shown appreciable differences in dry matter between 23 varieties (11.5% to 4.2% at the same stage of maturity) and have indicated an increase in dry matter with closer spacing. Population studies with a large and a small headed variety showed that for all head sizes in the range 2/3 lb–13 lb higher yields were obtained from the inherently large variety.

Calabrese

Three varieties of differing maturity were each sown on six different dates in an attempt to obtain continuity of harvest over as long a period as possible. Gaps in production occurred as a result of pronounced differences in rates of maturation between consecutive sowings of the same variety. For example when Rex was sown under heated glass on 20 March, and in field seedbeds on 27 March, 9 May and 12 June, the periods to 50% harvest date were 120, 161, 118 and 130 days respectively. While both temperature and daylength are known to influence time of head initiation, the major effect in this experiment appeared to be that of temperature.

A comparison was made of the yield and maturity of crops of the variety Rex direct-drilled on the 6 June and of crops sown at the same time but transplanted at the 1, 3, 5 and 7 true-leaf stages. All plants were spaced at 18 in. square. The 1, 3, and 5-leaf transplants each yielded about 4 tons/acre, the direct-drilled 4.5 tons, and the 7 leaf transplants 3.5 tons. Size of trans-

plant had an appreciable effect on the 50% harvest date, the 7 leaf transplants maturing approximately one month later than the 1 and 3 leaf ones.

Potatoes for canning

Estimates of the optimum population of Maris Peer for production of potatoes for canning were obtained from an experiment which included two set sizes (0.8oz and 4.8oz) at each of four populations (2, 10, 15 and 20 eyes/sq ft), harvested on four occasions (22 July, 14 Aug., 9 and 26 Sept.). The crops were grown on the flat without ridging and weeds were controlled by pre-emergence application of linuron.

The results suggest that at equivalent planting rates, size of mother tuber had no measurable effect on either total yield at the first harvest or the proportion of canning size tubers. At each subsequent harvest, however, for a given planting rate the small sets produced a greater proportion in the canning grade than did the large sets.

Taking account of the cost of seed and the feasibility of planting at high rates, a planting rate of 2½–3 tons/acre appeared to be optimum for the production of canning size tubers. From a planting rate of 2½ tons/acre of small or large sets, total yields for the four harvests, in chronological order, were 7, 15, 18 and 19 tons/acre. Of these total yields the small sets gave 6.5, 10.5, 9.0 and 9.0 tons/acre respectively of canning size tubers; the corresponding values for the large sets were 6.5, 5.0, 4.0 and 4.0 tons/acre.

The new canning variety, Pentland Marble, bred by the Scottish Plant Breeding Station, was grown in a population experiment, and in a trial of 16 varieties carried out in collaboration with the Fruit and Vegetable Preservation Research Association. On the basis of canning yield and quality at maturity it proved superior to any other variety examined.

Peas

In an experiment with Dark Skin Perfection which included five populations (1.4, 2.5, 5.6, 9.5 and 13.6 plants/sq ft) each harvested on seven dates, yield was the same at populations of 9.5 and 13.6 plants/sq ft. At tenderometer values of 100 and 120 the yield from 5.6 plants/sq ft was respectively 85% and 95% of that at 9.5 plants/sq ft (67 and 74 cwt/acre). The corresponding yields from 1.4 plants/sq ft were 32 and 37 cwt/acre. Whilst the analysis is not yet completed, the indications are that compensation in the components of yield in response to increased plant population included reduction in the number of tillers per plant from 1.88 to 0.04, reduction in the number of pods per tiller from 3.12 to 1.13 and in the number of pods per main stem from 7.11 to 3.06, and a reduction in the number of peas per pod originating from the main stem (but not from tillers) from 5.4 to 4.4.

Over the wide range of populations from 2.4 to 13.6 plants/sq ft there were no measurable differences in sieve size distribution of the usable part of the produce.

Protected cropping

The polythene 'bubble' house has now survived for two seasons. At least part of this prolonged life may be attributed to the installation of a wind-switch which activates the larger of the two fans under windy conditions, thus increasing the air pressure within the structure and thereby its stability.

RESULTS FROM OTHER EXPERIMENTS

Results of experimental work in 1969 not reported here are being published in the Bulletin of the Institute Association. These are from variety trials of peas, French beans, Brussels sprouts and sweet corn, an experiment on broad bean varieties and timing of maturity, a variety trial of cucumbers in the plastic bubble house and experiments on once-over strawberry harvesting.

PUBLICATIONS

BLEASDALE, J. K. A.¹ and THOMPSON, R.² (1969). Some effects of plant spacing on potato quality. *Eur. Potato J.* **12**, 173-187.

(Dry matter content of tubers increased as plant population increased, but for a given population small tubers had a lower dry matter content than large. Disintegration of the tubers when cooked was related to their dry matter content. Differences in after cooking-blackening appeared to be related to variation in the K/N ratio of the tubers resulting from differences in population).

HEGARTY, T. W. (1970). The possibility of increasing field establishment by seed hardening. *Hort. Res.* (in press).

(Seed hardening increased the field emergence of two out of five varieties of sweetcorn and also increased the field emergence of one carrot cultivar hardened in different solutions. Under laboratory conditions, reduction in germination of some carrot seed lots due to low temperature could be counteracted by seed hardening).

THOMPSON, R.² (1969). Some factors affecting carrot root shape and size. *Euphytica* **18**, 277-285.

(Changes in root shape with age and as affected by plant population were defined objectively for the varieties Amsterdam Forcing and Autumn King. During early growth the change in root shape from conical towards cylindrical was especially rapid and was promoted by high population. It is concluded that plant density as well as age can influence carrot root shape so much as to make unsuitable a variety normally suited to a particular market requirement).

THOMPSON, R.² and WOOD, J. T.¹ (1969). A semi-automatic direct-recording balance. *Appl. Statist.* **18**, 82-85.

(A system is described for the direct recording on punched paper tape, of weights and other data from vegetable experiments).

WAISTER, P. D. (1969). The ideal canning potato. *The Grower* **72**, 733-734.

¹National Vegetable Research Station, Wellesbourne.

²Reports work done at National Vegetable Research Station, Wellesbourne.

WAISTER, P. D.³ and HUDSON, J. P.⁴ (1970). Effects of soil moisture regimes on leaf water deficit, transpiration and yield of tomatoes. *J. Hort. Sci.* (in press).

(Tomato plants in a glasshouse were subjected to four different water regimes based on soil moisture deficit, which was first estimated from evaporation from a simple evaporimeter and then checked by measurement in evapotranspiration gauges. The sensitivity of this species to small deficits was shown in total yield, fruit size, and incidence of blossom end rot. Though relative turgidity levels showed a relationship with soil moisture deficit this relationship was modified by the stress regimes imposed. Transpiration rates fell with increasing deficit but, under conditions of frequent irrigation, showed good correlation with losses from evaporimeters, which in turn were closely related to incoming solar radiation).

WAISTER, P. D. (1970). Effects of shelter from wind on the growth and yield of raspberries. *J. Hort. Sci.* (in press).

(Shelter screens of 63% permeability, erected at right angles to the prevailing wind, gave increases of 30% and 23% in total length of cane produced in 1967 and 1968 respectively, in the zone 0-3h from the screens. These growth differences were reflected in yield increases of 40% and 16% in the fruiting years 1968 and 1969).

¹Reports work done at National Vegetable Research Station, Wellesbourne.

²National Vegetable Research Station, Wellesbourne.

³Reports work done at University of Nottingham School of Agriculture, Sutton Bonington.

⁴Research Station, Long Ashton, Bristol.

Mycology

R. A. FOX

This has been a year of considerable change and upheaval. In common with the rest of the staff of the Institute we were very sorry when A. R. Wilson left on retirement on 31 October after serving the Institute for nearly 13 years. He first came here as Head of Section when it was in an embryonic stage consisting of only himself and W. R. Jarvis. For the past 4½ years he has also served as Deputy Director. He will be greatly missed and we wish him well in his new capacity as Mine Host at an hotel where, doubtless, he will find his time as well filled as it was here. He continues to serve as Vice-President of the European Association for Potato Research of which he is still the United Kingdom representative.

R. A. Fox went to the University of Ceylon as Royal Society Visiting Professor in Plant Pathology leaving in mid-January and returning in June. During the University vacation in April he visited many research centres in India including the Central Potato Research Institute at Simla; the British Council generously provided a grant towards the subsistence costs of these visits. W. R. Jarvis left in August for a year's secondment to the Plant Diseases Division of the Department of Scientific and Industrial Research in New Zealand primarily to work on the problems of soft fruit preservation. A. R. Wilson attended the Fourth Triennial Conference of the European Association for Potato Research at Brest, France, in September as did M. Pérombelon who read two papers on bacterial soft rot of potatoes and R. A. Fox who read a paper on potato gangrene.

As might be expected some of our activities have been curtailed and others interrupted. Thus reports on work by W. R. Jarvis on grey mould of soft fruit and smoulder of narcissus will be held over until next year. We look forward to a more settled year in 1970 when again we hope to have more glasshouse and field laboratory facilities, the need for both being pressing.

STAMEN BLIGHT OF RASPBERRY

The level of disease in successive years was studied in a number of plantations at different sites from 1965/6 to 1968/9. Apart from the established fact that infection can be introduced with canes brought from diseased plantations, evidence of its introduction by wind-borne spores was obtained for the first time. Seasonal fluctuations in incidence may be very high and it follows that annual fungicidal applications will be required to maintain disease at a low level.

As in previous field trials already reported, captan (75% W.P.) and Elvaron (50% dichlofluanid) significantly reduced the disease in the following year although in 1969 there were no significant differences either between the two fungicides or between the rates at which they had been applied.

Experiments in which diseased and healthy flowers were hand-pollinated with abundant pollen from healthy flowers did not support the idea that fruit malformation is associated with the absence of pollen on diseased flowers where anther infection inhibits pollen release. The results, assessed by both fruit size and drupelet development, suggest that infection interferes directly with the normal process of fruit development.

The co-operation of Mr G. Bruce and Mr A. W. Bruce, Newton Park, Kirriemuir and Mr N. McIntyre, Mansfield, Lethendy in providing suitable sites for the fungicide trials is gratefully acknowledged. (I. G. Montgomerie).

RED CORE OF STRAWBERRY

Experiments on resistance to *Phytophthora fragariae* have shown that the varieties Elista and Senga Sengana are susceptible to all available races of the pathogen. Some varieties and seedlings which have a high level of field resistance do not become infected in low concentrations of zoospore suspensions which, nevertheless, are sufficient to initiate disease in susceptible hosts. Further, high levels of field resistance are associated with slower rates of growth of the fungus within the roots. When assessed for these two factors, increasing resistance to infection with race B66-11 (pathogenic to all varieties) was shown by Redgauntlet, Huxley, Talisman and 53Q13 in that order.

Sterilised vermiculite has proved the best solid medium of those tested for propagating root systems sufficiently uniform for pathogenicity tests. Good results have also been obtained in Sachs' and Hoagland's nutrient solutions with and without aeration.

A large range of natural and synthetic media, used alone or with various supplements and of proven suitability for other *Phytophthora* species, have all failed to induce oospore production with *P. fragariae*. (I. G. Montgomerie, D. M. Kennedy, J. B. Garrie).

In a field trial planted in October 1968 to compare the effectiveness of 6 treatments in controlling red core, growing plants of Merton Princess on 12 in. high ridges resulted in less than half the number of plants becoming infected compared with controls. The number of diseased roots was also significantly lower in ridged plants than in those grown on the flat. The higher yields recorded for ridged plants were not, however, significantly greater than those of other treatments. Dazomet¹ either at 100 lb/acre or 200 lb/acre was ineffective. All three dexion² (0.175% a.i.) treatments—dipping before planting, and dipping prior to planting followed by drenching in spring 1969—were

¹Supplied by Boots Pure Drug Co. Ltd.

²Supplied by Baywood Chemicals Ltd.

phytotoxic. Primary root production was suppressed and the plants were dwarfed, although infection was negligible when dexton was used as a drench after planting. The assistance of Mrs Jean Wood and other members of the A.R.C. Unit of Statistics, Edinburgh, is gratefully acknowledged. (I. G. Montgomerie, M. C. MacNaughtan).

GANGRENE OF POTATO

The expected adverse effect on emergence of heating seed tubers to 45°C for 2 hr just prior to planting has been previously reported but it was noted that haulm senescence was delayed. The incidence of gangrene in the progeny of these tubers was not affected, but levels of skin spot and silver scurf were markedly lower than in the controls. Heating tubers at the beginning of the storage season in 1968 induced more rapid emergence following planting in 1969 in the varieties Majestic and Pentland Dell, but not in King Edward.

The method and timing of haulm destruction and the interval to harvest affect the amount of gangrene in the crop by changing both tuber susceptibility and the inoculum load at harvest. The interactions are evidently complicated, not yet fully understood, and may vary between seasons. Haulm pulling shows the greatest potential for diminishing incidence presumably by removing much of the potential inoculum on stems, stolons and roots. The gradual decrease in tuber susceptibility that occurs during the growing season is followed by a gradual increase during the storage season in all varieties examined. In inoculation experiments on a number of varieties the stems of Golden Wonder, which has highly resistant tubers, proved more susceptible to infection than those of Pentland Falcon whose tubers in contrast are very susceptible.

Plants of Majestic were grown in bins in the glasshouse in soil to which culture macerates of *Phoma exigua* var. *foveata* were added after planting. Infection was confirmed by plating tissue from 10 stems. In 7 which had no overt symptoms the hyaline inter-cellular mycelium, confined to the basal part of the stem below soil level, had spread through the vascular ring but not into the vessels. In the other stems, generally thickened and pigmented mycelium was found to spread inter- and intra-cellularly up to 50 cm above soil level where the outer cortical cells were discoloured brown. In inoculated stems of field grown plants, pycnidia formed in the outer zone of the cortical parenchyma, in the remains of the pith parenchyma, and within the vascular ring where the ostioles were directed towards the vessels. Fluorescent labelled pycnosporangia can be transported upward for 60 cm in 24 hr in actively transpiring stems. Similar natural movement of spores within vessels may account for the many occasions when the presence of the pathogen has been detected by plating, but where no mycelium has been found by microscopy. Because fungi other than *P. exigua* var. *foveata* have been isolated from apparently healthy stems and stolons, fluorescent antibody techniques are being developed to confirm the identity of the mycelium observed, but as yet only relatively low titres have been obtained.

Isolation of *P. exigua* var. *foveata* from a seedling of sugar beet from an area of suspected docking disorder stimulated an investigation into other plants as potential alternative hosts in relation to crop rotation. Under laboratory conditions, usually symptomless and apparently systemic infection has been induced in seedlings and young plants of sugar beet, barley, rape, Brussels sprouts, swede and peas, the last named being the least susceptible. (R. A. Fox, E. P. Dashwood, H. M. Wilson).

BACTERIAL SOFT ROT AND BLACKLEG OF POTATO

Detailed studies both in the field and laboratory with various systems of artificial soil profiles and soil columns, sterilised or not, and subjected to various watering regimes indicated that water movement is important in distributing *Erwinia* spp. through the soil especially in the vertical plane. Random and lateral movement may also be aided by the soil fauna and *E. carotovora* var. *carotovora* and *E. carotovora* var. *atroseptica* were readily isolated from earth worms in potato fields. Farm machinery may also have effected lateral spread where contamination was detected in tubers growing from plants initially derived from stem cuttings that were separated by 6 ft of clean ground from plants grown from seed tubers.

A laboratory study of the interactions of temperature and moisture in sterile and non-sterile soil showed that both varieties of *Erwinia* survived for several months under favourable conditions (low temperature, high moisture, sterile soil) but that their survival was reduced to less than one month in drier, non-sterile soils at higher temperatures. In the field, added populations survived for only one to two weeks if soil temperatures rose above 16°C which they often do for limited periods throughout the summer and into mid-September. Therefore, any observed increases in soil populations and lenticel contamination during this period can be accounted for only by the mass release of bacteria from the rotting mother tuber observed in this as in previous years. In addition, a further source was the numerous small tubers which form, fail to develop and then rot freely towards the end of the growing season.

As in the previous year's experiments the condition of the mother tuber and lenticel contamination levels were examined weekly; in addition soil populations were determined. It is abundantly clear that the main source of contamination is the rotting mother tuber. Under the influence of rainfall, soil populations and lenticel contamination levels both fluctuate markedly, the latter showing a lag compared with the former, with further complications caused by apparent variations in the receptivity of the lenticels to invasion.

From experiments conducted both here and elsewhere there is now little doubt that the two *Erwinia* varieties are unable to survive freely in the soil through a rotation. However, as has been suggested in a previous Report (1967), groundkeepers may be of importance especially in relation to any proposed policy of building up 'clean' stocks of seed tubers from stem cut-

tings. In 1969 groundkeepers were observed in a turnip field last cropped to potatoes in 1966 and followed by two years of barley. In November a proportion of the turnip crop suffered from hollow heart following death of the apex subsequent to treatment with a pre-emergence herbicide and both varieties of *Erwinia* were repeatedly isolated from these lesions. (M. C. M. Pérombelon, R. Lowe).

SEEDLING ESTABLISHMENT STUDIES

Peas

Laboratory tests on 22 different seed lots used in pea crops in East Scotland showed that all the seed was of high vigour. A field survey revealed, however, considerable variation in populations within lots due to local variations in sowing conditions which, although adverse, were not followed by reports of severe emergence failures. There was no close relation between populations and crop yield within varieties.

The effect of premature harvest on vigour was examined by growing four varieties in the glasshouse and harvesting seed on four occasions at weekly intervals. The first harvest was taken when pods began to wrinkle and the moisture content of the seeds was c.60%; all harvests were dried to c.10% moisture content in a forced draught oven at 30°C. Emergence in soil was lower from the first harvest than from the remaining harvests and seedling evaluation and conductivity tests confirmed the low vigour status of the seed. Germination was least affected by early harvesting. Low levels of hollow heart were found in some of the immature seed.

Field emergence from seed of Dark Skinned Perfection stored in sealed containers at 66% R.H. for 11 months at room temperature ($20 \pm 2^\circ\text{C}$) was less than half that from seed stored at 42% R.H. although germination was not affected. The low vigour of the deteriorated seed was clearly shown by the conductivity and seedling evaluation tests. The vigour tests therefore detected low vigour induced both by immature harvesting and storage deterioration. Examination of root tips confirmed that chromosome aberrations were present in seed deteriorated in storage but not in those harvested immature, suggesting that different mechanisms may underlie low vigour.

Sugar beet

Forty-two lots of monogerm sugar beet seed of different cultivars, treated in various ways, were sown on 26 March, 24 April and 21 May. Mean emergence results were 55.9%, 57.1% and 61.3% respectively for the three sowings and mean daily temperatures during the pre-emergence period were 7.1°, 10.2° and 13.3°C. The results suggested that their emergence was less sensitive to soil temperature than that of peas. Emergence from seeds treated with ethylmercury phosphate was 12% better than from those untreated, and emergence of two varieties was 6% better from pelleted than from non-pelleted seed. Correlation coefficients of the relation between germination and field establishment for 6 samples of commercial pelleted seed were erratic being 0.38,

0.77 and -0.41 respectively for the three sowings. (D. A. Perry, J. G. Harrison).

Carrots

A field emergence trial with 13 samples of carrot seed sown on three dates showed that dusting with captan resulted in improved emergence, and that the improvement was greatest when emergence was poorest due to soil moisture stress. The correlation with laboratory germination was better for treated than for untreated seed, particularly when the germination test was done at 10°C instead of 20°C. (D. A. Perry, with T. W. Hegarty, Crops Research).

PUBLICATIONS

FOX, R. A. (1970). A comparison of methods of dispersal, survival, and parasitism in some fungi causing root diseases of tropical plantation crops. *in* Root Diseases and Soil-borne Pathogens. Ed. T. A. Toussoun. Univ. California Press (in press).

(This paper describes comparatively the life cycles of 4 pathogens, *Fomes lignosus*, *Ganoderma pseudoferreum*, *Fomes noxius*, and *Armillaria mellea* on plantation crops established in lowland rain forest areas of the tropics. Although they differ markedly in sporophore and spore production, the degree of success in aerial dissemination, the presence or absence of ectotrophic mycelium on roots and the rate of its growth, they may each cause problems of similar economic importance depending on location. Comparative studies *in vivo* and *in vitro* suggest the novel hypothesis that the ectotrophic habit may be of significance not only for pathogenesis *per se* but as a source of nutrients extraneous to the host tree).

FOX, R. A. and DASHWOOD, E. Patricia (1970). Some aspects of the biology of *Phoma exigua* var. *foveata* in relation to the control of potato gangrene. *European Assoc. Potato Res. Proc. Triennial Conf., 4th, Brest, 1969* (in press).

(Inoculum surviving in the soil may be increased by planting apparently healthy seed tubers from infected stocks. There are further increases during the growing season from infected roots, stolons and stems; the amount from these sources and the susceptibility of the tubers is affected by the timing and method of haulm destruction and the interval to harvest. The pathogen can infect moribund stems of several common weeds and the roots and stems of seedlings of some crop plants).

JARVIS, W. R. (1969). The phenology of flowering in strawberry and raspberry in relation to grey mould control. *Hort. Res.* 9: 8-17.

(The relative rates of flower and fruit development in eight strawberry and five raspberry cultivars were assessed in relation to the terms at present used to describe different stages, and to the design of grey mould control programmes. Whilst such programmes can be based on analyses of the progress of flowering, they must be modified according to cultivar, season, location, climate and economics).

JARVIS, W. R. (1969). Hazards of soft fruit marketing. *The Grower*, 72, 870-871.

(A popular account of post-harvest problems in strawberries and raspberries caused by grey mould and of the potentialities of its control by fumigation).

MONTGOMERIE, Isabel G. (1969). The red core problem. How can we best tackle this red menace to strawberries? *Commercial Grower* No. 3874, 265-266.

(A popular account of cultural methods of control and an assessment of prospects for improving control by cultural, chemical and breeding methods).

MONTGOMERIE, Isabel G. (1969). Control of red core disease of strawberry. *Proc. 5th Br. Insecticide and Fungicide Conf.*, 145-148.

(The incidence and severity of symptoms of red core disease were studied in a field trial of 10 months duration using the following treatments: Bayer 22555 (sodium 4-(dimethylamino)-benzenediazo-sulphonate) used as a plant dip, a soil drench, or as a combination dip and drench; soil applications of a prill formulation of dazomet (methyl isothiocyanate); and growing plants on ridges. Drenching the soil around each runner with Bayer 22555 immediately after planting resulted in the greatest decrease in both the number of infected plants and the percentage of infected roots. This was not accompanied by increased vigour or yield compared with untreated plants due to the reduction in the number of primary roots. Plants grown on ridges had a significantly lower incidence of disease and percentage of infected roots while dazomet (100 lb/acre) resulted in a significant decrease in the number of infected plants but not in the percentage of infected roots. There was no significant difference in yield as a result of any treatment).

PEROMBELON, M. C. M. (1970). A quantal method for estimating population numbers of pectolytic *Erwinia* spp. *Int. News Bul. Soil Biology (UNESCO)* (in press).

(A quantal method, based on the Maximum Likelihood Method, is described for estimating populations of pectolytic *Erwinia* spp. in soil or plant material. The time-consuming procedure of counting individual *Erwinia* colonies, often on plates over-crowded by other organisms, is thereby avoided).

PEROMBELON, M. C. M. (1970). The biology of contamination of the potato tuber by soft rotting *Erwinia* spp. *European Assoc. Potato Res. Proc. Triennial Conf., 4th Brest, 1969*. (in press).

(Field experiments have shown that extensive contamination of daughter tubers at lenticels occurs following the generalised rotting and breakdown of the mother tuber. From then on there is no gradual build up of contamination which tends instead to fluctuate markedly almost from week to week. It appears that movement of the pathogens from the mother tuber to the daughter tuber, and the receptivity of the tubers at lenticels at any one time are related to rainfall distribution).

PEROMBELON, M. C. M. (1970). Preliminary implication for potato growing from recent research on bacterial soft rot/blackleg complex of potatoes. *European Assoc. Potato Res. Proc. Triennial Conf., 4th, Brest, 1969* (in press).

(The marked fluctuation in contamination level of daughter tubers following the breakdown and rotting of the mother tuber suggests the possibility of reducing contamination by harvesting at appropriate times. Since nearly 100% of the tubers in any one crop may be contaminated, irrespective of the presence or absence of blackleg, roguing plants showing symptoms of this disease is most unlikely to lead to a reduction in its incidence, still less its elimination, in the next generation crop. This is best achieved by raising clean stocks from stem cuttings but there is a real risk of contamination from farm machinery and by the persistence of *Erwinia* spp. in ground-keepers).

PERRY, D. A. (1970). The relation of seed vigour to field establishment of garden pea cultivars. *J. agric. Sci., Camb.*, **74**, 343-348.

(The field establishment of 5 different lots each of 2 cultivars planted at 6 sites on 23 sowing dates in Scotland and England correlated better with the seedling evaluation and the conductivity vigour tests than with the germination test. Mean emergence varied but the rank order of the lots remained almost constant. On the basis of the vigour test results, the lots were divided into grades of vigour which conformed with their field emergence).

PERRY, D. A. and HARRISON, J. G. (1970). The deleterious effect of water and low temperature on germination of pea seeds. *J. exp. Bot.*, **21**, 504-512.

(Some seeds were killed or damaged by soaking in water and the damage was aggravated by low temperatures. Low-vigour seed were more sensitive to injury than high-vigour seed and the injury was alleviated by restricting water uptake in osmotic solutions. More electrolytes exuded from dead and low-vigour seed than from high-vigour seed. Death was considered to be caused by a sudden inrush of water disrupting the sub-cellular organisation).

PERRY, D. A. (1970). Seed vigour in vining peas. *Arable Farmer*, **4**, 10-16.

(A popular account of the causes and effects of low vigour in pea seed, and the methods and application of vigour tests).

Plant Breeding

C. NORTH

The untimely death of Greta Priestley was a sad blow to the Plant Breeding Section. She was not only a cheerful and popular colleague, but also a meticulous, thorough and determined worker with a very good knowledge of her plant material. Her failing health slowed up progress on Brassica and bean breeding during the year, though Joyce Walker managed the routine work well. A. J. Redfern, appointed in October to assist Greta Priestley, will continue with the projects in hand. However, since staff changes had to be made an opportunity was taken to re-organise vegetable breeding into a team headed by A. B. Wills.

The year was a fruitful one for the introduction of new varieties. Glamis French bean has been awarded Plant Breeders' Rights and seed of it is now available from commercial sources. Glen Clova raspberry is being multiplied for distribution in 1970. Agreement has been reached on the naming and release of an F_1 winter cabbage now called Celtic, and an F_1 Brussels sprout, Gleneagles (formerly No. 9). Limited quantities of seed of both these cultivars will probably be available from trade sources in 1970. Two new strawberries, Marmion and Montrose (formerly A_{53} and A_{54}), have been released to the Nuclear Stock Association jointly by the Institute and the National Seed Development Organisation and an application for rights has been made.

This listing of new introductions does not imply that all our efforts are being directed to the production of new varieties. Whilst we shall continue to introduce soft fruit cultivars, the trend in our work on Brassica crops is to give more emphasis to the devising of new breeding techniques and the raising of new raw material to be developed by commercial seed firms.

Two encouraging sources of pest and disease resistance have been discovered. Another clone of *Fragaria virginiana* when used as a parent has given strawberry families with a high degree of field resistance to red core, a par with *F. virginiana* clone 1 which is already in use at Auchincruine. *Ribes ussuriense* and three Russian cultivars of *R. nigrum sibiricum* have shown a remarkable degree of resistance to gall mite, apparently through a hypersensitive reaction. The advantage of this material over black currant and gooseberry hybrids is that it gives fertile progeny in crosses with existing black currant varieties.

Our small lily breeding project was given considerable encouragement by a visit of a party from the International Lily Conference which included Mr Jan de Graaf. It may soon be possible to commence bulking up some

the more promising clones with a view to their release in about two years' time.

The new glasshouse block designed for plant breeding work is nearing completion. It will not only give us the glasshouse facilities we have needed for some years, but it also includes useful laboratory space and three large controlled environment rooms which will be mainly deployed to control flowering periods and thus permit more efficient crossing programmes. A much needed packing shed and store has also been erected at the West of Scotland Unit.

Pauline Topham was awarded a Ph.D. degree for a thesis entitled 'A study of factors influencing fruit and seed development in diploid and tetraploid forms of the raspberry *Rubus idaeus L.*' In addition to her work on this topic she has been acting for some years as an unofficial adviser on statistical matters. Recently she has left the Section to become the Institute's statistician, a post in the Crops Research Section. Other staff changes include, in addition to the appointment of A. J. Redfern mentioned above, the appointment of Adrienne Green on the resignation of E. N. Bent, and the appointment of T. G. Adams as an assistant to M. M. Anderson. H. McC. Anderson resigned to take up an appointment at Long Ashton Research Station. Anne Marie Pehrsson, a horticultural student from Sweden, worked with us for a short period during the summer.

I attended the Eucarpia meeting on carrot breeding held in Hannover during September, and one on chicory breeding in Brussels in February. A. B. Wills visited centres for Brassica breeding in Holland and Germany.

BEAN

Five of the 23 white-seeded stocks of dwarf French bean mentioned in the previous Report have been selected for more advanced trials. After further selection at least one of these 5 stocks will be released as an early-maturing white-seeded variety similar to Glamis.

It is planned to continue with the breeding of anthracnose-resistant varieties but no further work on this crop is envisaged once this, and the above project, are concluded. (A. J. Redfern, J. Walker).

BLACKBERRY

The objective in breeding blackberries is to produce forms which combine an erect, suckering and spine-free habit of growth with earliness of ripening. The cross Early Harvest x Spine-free gave a family which segregated 5:1 for non-suckering:suckering seedlings, suggesting that the capacity to sucker is inherited as a simple recessive character as in the raspberry, and that the parent Spine-free is heterozygous for the gene. Seedlings in this family were uniformly late ripening and gave poor quality fruits, but earliness of ripening segregated in a family related to the variety Darrow. Considerable further breeding will be required to combine all these characters together. (D. L. Jennings, B. M. M. Tulloch).

The black currant seedlings planted in 1969 were further selections for mildew and leaf-spot resistance derived from *Ribes nigrum* or *R. dikuscha*. A new group of crosses has now been made to introduce gall mite resistance and combine it with the productivity and disease resistance of earlier selections.

Gall mite

We have already reported (Ann. Rept. 1967) that derivatives of *R. nigrum sibiricum* have shown resistance to gall mite. A screening test in an infestation plot has now shown that mites can infest but not survive in buds of *R. ussuriense* and three varieties of *R. nigrum sibiricum* parentage raised in the Soviet Union—Rus, Narjadnaja and Gornoaltajskaja. Microscopic examination of a random sample of about 1,000 buds from each of these sources showed that a proportion had injury ranging from slight internal necrosis to complete 'blindness,' presumably the result of mite infestations at different stages of bud development. On the control varieties, Boskop Giant and Seabrook's Black, 27% and 19% respectively of primary buds were galled and 13% and 10% of the remaining mite-free buds showed some injury.

Segregation of mite-free and mite-susceptible seedlings in crosses suggests that resistance may be controlled by a single gene.

Biennial cropping

Non-replicated material of 130 seedlings and foreign varieties of black currant was planted at 4 ft x 2 ft in 1968 to assess its suitability for the destructive method of mechanical harvesting. The growth produced was dense; consequently vigorous, erect or semi-erect forms were less productive in 1969 than those with sparse foliage and moderate vigour. Some seedlings were outstanding for their ability to crop over the entire length of the fruiting stems.

Direct-sown seed

Open-pollinated seed of mildew-resistant parents was sown directly in the field in early May. Natural infection with mildew occurred in late June and it was possible to eliminate mildew susceptible seedlings by early September. Irrigation was not applied and growth rarely exceeded 9 in. but for screening purposes the method was effective and labour-saving.

Direct sowing might also be used to provide planting material for commercial crops where destructive harvesting methods are used and where clonal material produced from hardwood cuttings are in short supply. (M. M. Anderson, T. C. Adams).

BRASSICAS

Cabbage

The F₁ cabbage variety, now named Celtic, has continued to give promising results in trials, and so far the National Seed Development Organisation

met with no overriding difficulties in seed production. The percentage of sibs arising from crops of hybrid seed has been very small and even when they occur the sibs usually produce marketable cabbages.

Celtic is essentially a variety of comparable usage to January King, though some trials have indicated that it may be grown for harvesting over a wide period from August into winter. Reports on its hardiness have been somewhat conflicting but in many areas it has proved to be quite as hardy as January King. (A. J. Redfern, J. Walker).

Brussels sprout

It has not proved so difficult to produce seed of No. 9 as had been anticipated earlier. Agreement has therefore been reached for its multiplication by the N.S.D.O. and release under the name Gleneagles, and small quantities of seed may be available from commercial sources in 1970.

Gleneagles is a mid-season F₁ variety. The plants are of medium height with firm thick stems not prone to lodging. The sprouts are small and dark but bright green; they are suitable for processing. (A. J. Redfern, J. Walker).

A co-operative project with the National Vegetable Research Station has been started to find if useful F₁ varieties can be obtained by the combined use of inbred varieties from both stations. Some progress has already been made on the S-allele relationships of these lines and this work will be completed as soon as possible so that a crossing programme can be carried out in 1971. (J. R. T. Hodgkin).

Incompatibility studies

More effort is now being applied to the study of fundamental problems associated with the production of hybrid varieties and special emphasis is given to an understanding of the incompatibility system.

A start has been made on the determination of S-alleles present in all our breeding material of *Brassica oleracea*. Appropriate pollinations have been made and the results analysed by counting pollen-tube penetration using fluorescence microscopy. The rapidity of this technique has made it possible to obtain a great deal of information in a short time. So far 12 lines homozygous for their S-alleles have been isolated and these have been tested against some of the alleles already isolated and described by Dr K. F. Thompson of the Plant Breeding Institute, Cambridge. All types of S-allele action have been found—dominance in pollen and/or style as well as independent action. Most of the lines are still heterozygous for their S-alleles; a situation which will permit a choice of alleles for use in hybrid production. Unfortunately, the duplication of some of the S-alleles in several lines restricts the total number of crosses that can be made; in the 30 lines examined only 14 different S-alleles have been found.

Preliminary studies on S-allele homozygotes have shown that considerable differences exist in partial self-compatibility between lines with common S-alleles, even between sib lines. A high level of end-of-season compatibility was also found in some lines; in one it was so high as to be indistinguishable from the test outcross to an unrelated line.

The germination of pollen on stigmas in incompatible crosses without growth of pollen tubes in the style, previously reported in *B. campestris* (Ann. Rept. 1968), has been shown to occur frequently in *B. oleracea*. In these incompatible crosses the percentage of germinated pollen is greater when one or both of the parents are heterozygous than when both are homozygous for S-alleles. (J. R. T. Hodgkin).

Genetics of *B. oleracea*

Twenty-four phenotypic characters are now included in the gene and linkage analysis; many are known to be under single gene control and some are not yet described in the literature. Several hundred more selfs and crosses were made to identify and combine a number of genes. However, a further generation will be required before any linkages can be determined.

A disadvantage of genetical work with *B. oleracea* is that most forms are biennial and each generation requires two years. To speed up the programme green seeds were extracted 60 days after pollination, germinated on water agar in petri dishes and grown on in soil. One family derived from a cross with calabrese (*B. oleracea italica*) began flowering five months after pollination were made but the majority were biennial types and will flower in the spring.

Karyotype studies

The length of mitotic metaphase chromosomes of *B. oleracea* after pre-treatment with 1-bromonaphthalene ranges from 2.5 to 5.0 μ . A feature of the karyotype is the large number of secondary constrictions but their exact number is difficult to define because conditions for maximum expression have not yet been found. However, one metacentric pair shows secondary constrictions in both arms, at least five pairs have constrictions in one arm and a further pair has a constriction on one arm and a large terminal heterochromatic segment on the other. Of the nine chromosome pairs, six were classified as metacentric or sub-metacentric and three as acrocentric. The possibility of identifying individual chromosomes in aneuploid derivatives of *Raphanus* x *Brassica* hybrids is being explored.

Interspecific hybrids of *Raphanus* and *Brassica*

More interspecific hybrids have been made to study chromosome homologies in these two genera. Seventy hybrids between fodder radish and various horticultural forms of *B. oleracea* flowered in the spring. Meiosis in pollen mother cells is often atypical with almost simultaneous separation of bivalents and univalents, frequently giving two diploid rather than four haploid pollen grains per pollen mother cell. A third of the plants had some stainable pollen (1-82%) with grains twice the volume of those of the parental species. Pollination tests showed this pollen to be capable of germination and tube growth.

Many plants have set a few seeds spontaneously and viable seeds were also produced by hand pollination with *B. oleracea*. Seeds of similar parentage gave triploid seedlings (Ann. Rept. 1968) and it is presumed that atypical

meiosis, like that in pollen mother cells, leads to the production of some viable diploid egg cells.

Although bivalent and higher associations occur in the hybrid diploids by allo- and autosyndesis, meiosis in a triploid showed strong preferential pairing giving 9 bivalents and 9 univalents. Both euploid and heteroploid triploids produced viable pollen intermediate in volume between that of the species parents and the diploid hybrids, and they have set varying proportions of seed. (A. B. Wills, S. Fyfe).

LILY

The original intention of our breeding programme for European lilies was to obtain hybrids of *L. pyrenaicum*—an easily grown species naturalised in some parts of Britain including Scotland. No crosses with this species had previously been reported but confirmed hybrids between it and 8 of the 11 major European and Caucasian species have now been obtained with the aid of embryo culture; the most recent being *L. pyrenaicum* x *chalcedonicum*. Only one of these Euro-Caucasian group hybrids has flowered so far: *L. pyrenaicum* x *pomponium*, which has a growth habit intermediate between the two parents and scarlet flowers similar to those of *L. pomponium*.

Most of the Asiatic group hybrids derived from crosses made in 1967 have flowered and some, especially the yellow-flowered types, appeared to be very promising. Clones selected from these and the earlier batch of Asiatic group seedlings will be planted in a trial with standard commercial varieties in 1971. The best will be selected from this trial for bulking and eventual release as new cultivars. (C. North, E. M. Holmes).

RASPBERRY

The main objective is to breed new cultivars which combine good quality fruit and easy fruit abscission with cane hardiness, resistance to two strains of aphid and escape from cane diseases. Seven selections which possess some of these characters were propagated for inclusion in a new trial at the National Fruit Trials in 1970. New progenies raised in 1969 should segregate for all these characters.

Breeding for high yield

In addition to the above objectives we are now selecting for characters which directly affect yield including number of laterals, fruit size and number of fruits per lateral. Some of this work is based upon Glen Clova whose high yield potential seems due partly to its frequent production of two or more fruiting laterals per node. The presence of a strong secondary bud is required before two laterals can be produced at a node, but this condition alone does not give multi-lateral production because in most genotypes the secondary buds fail to grow. Genetic control of multi-lateral production is a possibility and is being explored.

Several families fruiting for the first time in 1969 were segregating for gene L_1 , which gives large fruit size. Fruits of previous selections carrying this gene have had a rather coarse appearance because of their uneven drupelet size and incomplete set, but four selections made in 1969 showed a big advance in this respect. Two of these had canes with frequent multi-lateral nodes, and since gene L_1 affects most aspects of lateral development its influence on multi-lateral production is being studied further.

Another component of yield is fruit number per lateral and improvement is being sought from two sources: one in selections derived from the American variety Fairview, where there are higher numbers of fruits at basal nodes of the lateral, and the other in selections from crosses with *R. phoenicolasius*, where there are higher numbers of fruit concentrated at the lateral tips. The latter is preferable for hand picking but the former may be satisfactory for machine picking.

Improvements in yielding potential of raspberries must however be combined with adequate winter hardiness of the canes but the problem is that winter conditions which cause cane death do not occur every year. Selection was possible in 1969, however, and the families obtained by crossing with the Canadian variety Carnival were outstandingly hardy. Interestingly, canes from these families had an exceptionally low water content in early November 1969, and there was a highly significant correlation between the water content of new canes at this time and the incidence of cane death earlier in the year. This result supports the idea that cane injury in our plots frequently occurs in early winter because the canes do not harden soon enough. Whatever may be the explanation, water content of canes in early November may provide an indication of hardiness and a useful aid to selection in years when cane death is not prevalent. (D. L. Jennings, B. M. M. Tulloch, E. Carmichael).

Grey mould resistance

Raspberry varieties and seedlings differed in the proportion of their fruits which developed grey mould (*Botrytis cinerea*) when incubated for 48 hr after harvest. Earlier picks had low infection rates and the results of late picks were not always in agreement with earlier ones, but the two or three tests made in mid-season gave consistent results. In a small diallel, progenies of Carnival produced a high proportion of resistant seedlings, especially those from crosses with Glen Clova. One seedling from a cross with Carnival averaged only 13% infected fruits in four tests. The percentage infection was not closely related to the severity of *Botrytis* infection of the canes recorded earlier in the year, and was not correlated with the percentage of soluble sugars in the fruit juice. (P. B. Topham).

Raspberry Beetle resistance

The last Report mentioned that two seedlings derived from crossing with *R. phoenicolasius* showed resistance to *Byturus tomentosus* in 1968. This result was confirmed in 1969, though one of them seemed more resistant than

the other. Work in collaboration with Dr J. T. Martin of Long Ashton Research Station suggested that *R. phoenicolasius* owes at least some of its resistance to a constituent present in an acidic extract of its cuticular wax. However, no differences were found between the chemical composition of the cuticular wax of the two seedlings mentioned and that of two susceptible seedlings from the same family. The possibility remains that the resistance inherited by these seedlings is not associated with this cuticular component of *R. phoenicolasius*. (D. L. Jennings with C. E. Taylor, Zoology).

STRAWBERRY

In view of the shortage of strawberry varieties suitable for British conditions, two selections, formerly A₅₃ and A₅₄, now named Marmion and Montrose respectively, have been released. Both have been given good reports from the National Fruit Trials but we have reservations about their usefulness, largely because their fruit tends to be soft and neither has good all-round processing qualities. However, Montrose is very productive and Marmion promises to have a high degree of field resistance to red core. Trials at Efford suggest that Montrose may be a useful variety for early crops under polythene tunnels.

A test has been devised to compare the capacity of the fruit of different varieties to withstand transportation. Uniformly sized fruit is shaken for a standard period of time in a special device and then assessed for damage some 48 hr later—by which time fungi, such as *Botrytis*, have had an opportunity to develop. The results indicate that flesh firmness is not the only factor involved in carrying quality. Skin toughness, and possibly also tissue resistance to *Botrytis*, may be important.

Marmion and Montrose had inferior carrying quality to Cambridge Favourite but six Auchincruive seedlings were significantly superior to Cambridge Favourite in this respect.

Field resistance to red core

A crossing programme to assess the capacity of various species and inbreds to transmit field resistance to red core has revealed that another clone of *Fragaria virginiana*, in addition to the one already in use (Clone 1), is likely to be a valuable parent. Further crosses with Cambridge Favourite have also confirmed the value of this cultivar as a parent transmitting field resistance to red core; this is remarkable because of its susceptibility to all races of *Phytophthora fragariae*.

The family which has so far shown the most field resistance to red core has *F. virginiana* Clone 1 and a *F. chiloensis* source of resistance in its parentage.

Once-over harvesting

Since all mechanical devices for strawberry harvesting are likely to depend on picking over the plants once only during the season the yields obtained by this method were compared with those from conventional picking over an

extended period. Both standard varieties and unnamed selections were used in the experiment which showed that, for mechanical harvesting, 'holding-capacity' of the fruit is as important a varietal characteristic as a concentrated ripening period. With Cambridge Favourite that had been treated with Elvaron the primary and secondary fruit could be left on the plant without becoming soft and rotten, thus allowing the tertiary fruit to ripen when harvested once-over. Cambridge Favourite, Crusader and an unnamed selection yielded 67, 46 and 55% respectively of the marketable fruit obtained when fruit was picked from the plots as it ripened. Although the unnamed selection had been chosen for its concentrated ripening period, the fruit holding capacity was not as good as that of Cambridge Favourite.

Field testing of seedlings

During the early stages of selection many plants are lost through damage by red core or have to be discarded because of their weak growth. The usual statistical plot designs are therefore inappropriate, because the inclusion of a large number of 'missing plots' during calculation reduces the accuracy of the analyses. A more accurate assessment of the material is obtained from a design using duplicated plots with frequent controls of proven cultivars. Badly diseased plants and others with undesirable features can then be discarded at will with the minimum loss in accuracy of the results.

The A.R.C. Unit of Statistics at Edinburgh has helpfully provided computer-drawn histograms which depict the amounts of fruit in each size grade. This rapid method of presentation of results increases the efficiency of seedling assessment.

To enable comparisons to be made between selections at Auchincruive and Invergowrie, about 400 seedlings from a partial half diallel have been multiplied vegetatively and planted at both centres. Whereas the trial at Auchincruive showed significant genotypic differences in damage by mildew no such differences were recorded at Invergowrie. The plants established less well at Invergowrie, and it is thought that the general lack of vigour there prevented the full development of potential differences in resistance to mildew. (H. J. Gooding, K. C. McConnell, E. N. Bent).

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- GOODING, H. J. (1969). The problems faced by strawberry breeders. *The Grower*, 71, 591 and 594.
- GOODING, H. J. (1969). (Letter to *Nature* referring to article 'Cultivated plants and the Kon-Tiki Theory'). *Nature*, 223, 185.
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- JENNINGS, D. L. and CARMICHAEL, E. (1970). Ethrel not a ready answer to raspberry harvesting problems. *The Grower*, 73, 86-87.
- NORTH, C. (1969). New lily hybrids with the aid of embryo culture. *Lily Yb., Lond.*, 33, 171-173.
- NORTH, C. (1969). Cole Crops by M. Nieuwhof (Book Review). *Hort. Res.*, 9, 157-158.

NORTH, C. and WILLS, A. B. (1969). Inter-specific hybrids of *Lilium lankongense* Franchet produced by embryo-culture. *Euphytica*, 18, 430-434.

(*Lilium lankongense* crossed with some related species of *Lilium* produced seeds without endosperm and with very small embryos which would not germinate in soil. Hybrid plants have been obtained from a number of these crosses by culturing excised embryos on sterile nutrient medium. It is suggested that this technique may prove useful for the production of hybrids from other lily species-combinations which are not normally viable).

TOPHAM, P. B. (1970). The histology of seed development in diploid and tetraploid raspberries (*Rubus idaeus* L.). *Ann. Bot.* 34, 123-135.

(Seed development was studied in crosses made between the diploid forms and auto-tetraploid mutants of two raspberry (*Rubus idaeus* L.) cultivars. Drupelet abortion did not appear to be caused by failure of fertilization; it occurred mainly between the fourth and eighth day after pollination, and manifested itself as simultaneous cessation of growth in all tissues. In healthy drupelets at eight days after pollination, growth appeared to be proceeding at similar rates in all the tissues except that the embryo seemed to be growing faster than the endosperm in the most advanced crosses. Both diploid and tetraploid ovules appeared to be more stimulated by pollen from tetraploid plants. Embryo differentiation differed according to the direction of cross, especially in stunted embryos. Radicles tended to be abnormally large when diploid pollen was used and smaller than usual with haploid pollen).

TOPHAM, P. B. (1970). The histology of seed development following crosses between diploid and autotetraploid raspberries (*Rubus idaeus* L.). *Ann. Bot.* 34, 137-145.

(Ovules of the raspberry, *Rubus idaeus* L., resembled those of other *Rubus* species in being unitegmic, crassinucellate, and antipodal. In one cultivar, M.69/139, both egg cell and embryo were inserted slightly laterally to the micropyle. Of the tetraploid forms, 4n M.69/139 showed a proportion of embryo sacs with delayed differentiation, and 4n M. Jewel some with four antipodal cells. Embryo development showed little uniformity in timing, but followed the Asterad type.

Occasional delayed endosperm development seemed to be a varietal peculiarity of M.69/139. At maturity, the ergastic material in healthy endosperms consisted of oil globules and aleuron grains. The hypostate formed a projecting pedestal below the endosperm at 8 days. The inner epidermal layer of the testa appeared specialized, both in the early stages of seed growth, when it is suggested that it functioned as an endodermis, and at maturity, when it appeared to form an osmotic barrier).

TOPHAM, P. B. (1970). Some effects of gibberellin and synthetic auxins on the development of raspberry fruits and seeds. *Hort. Res.* (in press).

(Gibberellin (GA) either alone or in combination with para-chlorophenoxyacetic acid (CPA) and beta-naphthoxyacetic acid (NOA), induced normal fruit development in a partially sterile raspberry clone at concentrations ranging from 25 to 500 ppm. GA could substitute for pollination in inducing fruit development. Fruit development was more regular when applications were made soon after pollination.

In spite of the considerable increases in fruit growth which could be attained, seed and embryo growth were little affected. The numbers of large seed-containing pyrenes were somewhat reduced by applications at two or eight days after pollination, though not at other times. All the growth substances tended to make the embryo and seed narrower by reducing their width and to reduce seed size; these effects were less with later applications).

WILLS, A. B. (1969). Verification of new lily species hybrids by chromosome examination. *Lily Yb., Lond.*, 33, 174-177.

TWO NEW STRAWBERRY VARIETIES
MARMION AND MONTROSE

The Scottish Horticultural Research Institute and the National Seed Development Organisation Limited, have applied jointly for Plant Breeders' Rights for two new strawberry varieties, Marmion and Montrose, bred at the West of Scotland Unit of the Scottish Horticultural Research Institute.

Virus-tested foundation stocks prepared by East Malling Research Station have been supplied to the Nuclear Stock Association Limited for multiplication and both varieties will be available for planting fruiting crops in summer 1971.

MARMION Breeder's Number: 60BB38.
Number in National Fruit Trials: A53.

Origin Raised from a cross made in 1960 between:
Crusader (Seedling 50X5 x Cambridge Vigour)
x
Redgauntlet (Seedling N.J.1051 x Auchincruive Climax).

Plant Habit Intermediate dense to open, partially upright and rather vigorous. Leaves with a slight upward pose.

Leaf characters Terminal leaflets about as long as broad to sometimes longer than broad with a slightly rounded base. Leaf serrations slightly rounded. Petiole hairs with an outward pose. Dark, glossy leaves, slightly rugose.

Flowers Half hidden to almost totally hidden by foliage.

Fruit Large to medium with size fairly well maintained throughout the season. Primaries conical to globose/conic, medium orange-red with a pinkish-red flesh and a white core. Slightly soft texture. Flavour moderate.

Calyx Medium to small and clasping the fruit. Fairly difficult to remove.

Season Mid.

Diseases Slightly susceptible to mildew (*Sphaerotheca humuli*) and *Botrytis cinerea*; relatively high field resistance to red core disease (*Phytophthora fragariae*).

Yield On red core-infected land, yields have been in excess of Cambridge Favourite and on clean land, yields have been satisfactory except where a degree of barrenness has been observed. Under some conditions the yield of this cultivar is improved by post-harvest defoliation.

MONTROSE Breeder's Number: 60BB55.
Number in National Fruit Trials: A54.

Origin Raised from a cross made in 1960 between:
Crusader (Seedling 50X5 x Cambridge Vigour)
x
Redgauntlet (Seedling N.J.1051 x Auchincruive Climax).

Plant habit Medium dense, intermediate spreading to upright. Fairly vigorous on clean land. Upright leaf pose.

Leaf characters Terminal leaflets rather longer than broad with a slightly rounded to wedge-shaped base. Leaf serrations slightly rounded. Petiole hairs with an outward pose.

Flowers Almost hidden by foliage.

Fruit Usually fairly large, globose or rounded and pale orange-red. Well displayed around the plant. Flesh partly coloured with a white core. Rather soft flesh but first tests have indicated acceptable transit qualities. Flavour good, slightly acid.

Calyx Close to or clasping fruit and fairly difficult to remove.

Season Late to mid.

Diseases Slightly susceptible to mildew (*Sphaerotheca humuli*); susceptible to *Botrytis cinerea* and red core (*Phytophthora fragariae*).

Yield On clean land, yields may be in excess of 10 tons/acre.

Identification These two new varieties are sister seedlings and resemble their parents Redgauntlet and Crusader. Both more closely resemble Crusader than Redgauntlet in the majority of characters, but Marmion is the most like Crusader, especially in vegetative vigour. Neither display the fruit so well as Redgauntlet but the fruit of Montrose, particularly at close intra-row spacing, is well exposed. The fruits of both varieties tend to be soft, often pale and lacking the uniformly good appearance of Redgauntlet. Stipular and petiolar pigmentation is usually absent but occasionally the stipules of Montrose are slightly pink tinged. In red core-infected land Marmion plants gradually tend to become reduced in size, the leaves smaller and the flowers more exposed, particularly following post-harvest defoliation.

Over the large number of characters measured on healthy and diseased plants, mainly two years old, the following tended to be the most useful diagnostically:

	Marmion	Montrose
<i>Base angle of terminal leaflet</i>	Usually 120°-130°.	Usually 95°-105°.
<i>Ratios (length/breadth)</i>		
<i>sepal</i>	Usually less than 2.	Usually more than 2.
<i>episepal</i>	Smallest	Largest.
<i>Number flowers/truss</i>	Average 7, range 5-10.	Average 9, range 5-14.
<i>Number trusses/plant</i>	Average 9, range 5-14.	Average 16, range 13-18.

NEW RASPBERRY VARIETY

GLEN CLOVA

The Scottish Horticultural Research Institute and the National Seed Development Organisation Limited have applied jointly for Plant Breeders' Rights for a new raspberry variety, Glen Clova, bred at the Scottish Horticultural Research Institute.

Stocks are being multiplied by the Scottish Nuclear Stock Association Limited and canes for planting fruiting crops will be available for distribution in autumn 1970.

Breeder's Number: 6051/44.

Number in National Fruit Trials: M9.

Origin Complex; derived from crosses involving Malling Jewel, Malling Exploit, Burnetholm and Malling 69/105.

Malling 69/105 x Malling Exploit Burnetholm x M. Jewel



New canes Numerous or moderately numerous, strong growing, erect or nearly erect, tending to branch when newly established. Scattered, small to medium sized, deep purple spines. Sub-glabrous and moderately glaucous. Secondary buds frequent. Dormant canes medium brown.

Leaf Large, light green with very slight bronzing. Flat with smooth surface or sometimes with veins prominent to give a plicate appearance as in Malling Exploit.

Fruiting laterals Medium long. Frequently two or more present at each node. By contrast with Malling Jewel, buds towards the base of the canes usually produce laterals.

Fruit Medium to long conical and large. Light to medium red. Dull and very slightly downy. Moderately easy to plug, very cohesive drupelets and moderately firm. Good flavour. Medium to large pyrenes which do not become translucent in jam.

Season of ripening Early, very similar to Malling Exploit but has an extended season and continues fruiting longer than mid-season cultivars like Malling Jewel.

Diseases Resistant to cane spot (*Elsinoe veneta*) and moderately resistant to spur blight (*Didymella applanata*). Susceptible to mildew (*Sphaerotheca alchemillae*), particularly on the fruit. Susceptible

to the nematode-borne viruses, raspberry ringspot, tomato black ring and arabis mosaic. Susceptible to some aphid-borne viruses but resistant to others.

Hardiness Slightly more hardy than Malling Jewel but not hardy in all situations.

Identification Glen Clova is identified by its strong growth, its high frequency of nodes bearing more than one lateral and the plicate appearance of its light green leaves.

NEW FRENCH BEAN VARIETY

GLAMIS

The Scottish Horticultural Research Institute and the National Seed Development Organisation Limited have been granted Plant Breeders' Rights jointly for a new variety, Glamis, bred at the Scottish Horticultural Research Institute.

Seed of this variety is already available through trade sources.

Plant Variety Rights Office file reference: AFP 12/9.

Origin Selected from a cross made in 1956 between Fullcrop (now known as Topcrop) and Record.

Dry seed Dark brown mottled buff colour. Ovoid oblong shape. 1,000 seed weight approximately 530 g.

Mature pod Medium length with a slight-medium reverse curve. Apex semi-pointed. Colour pale green with pale purple flecks. Surface, medium matt. No strings.

Habit Medium-large, erect bush. Pods mainly concealed. Leaflet texture medium. Plant suitable for mechanical harvesting.

Flower Colour pale lilac.

General Very early maturing. Acceptable for canning and deep freezing.

Virology

B. D. HARRISON

O. W. Barnett completed his year on the staff and left to take up his appointment at Clemson University, Dr Zlata Štefanac returned to the University of Zagreb and R. A. C. Jones moved to the University of Birmingham, having finished his three years as a research student. A. T. Jones was appointed to study *Rubus* viruses and J. I. Cooper, previously a research student, joined the staff to do work financed by the Potato Marketing Board on soil-borne potato viruses. Aileen A. Crockatt and D. Donald were also appointed.

J. Chambers spent 10 days in France at the joint invitation of the Institut National de la Recherche Agronomique and a commercial raspberry grower, discussing virus problems in raspberry and advising on raspberry propagation methods.

During the year, the radioisotope equipment was commissioned, and four small plant growth chambers purchased and installed.

Most of the main lines of research were continued from last year, but ultrastructural studies of virus-infected tissues, and biochemical work on tobacco rattle virus, were expanded. Raspberry bushy dwarf virus was characterized and a start made to identifying other previously undescribed sap-transmissible raspberry viruses.

INTRACELLULAR BEHAVIOUR OF TOBACCO RATTLE VIRUS

X-bodies in leaf hair cells of *Nicotiana clevelandii*

Further work on the early stages of formation of these X-bodies showed that they were largely composed of abnormal mitochondria. A description of the structure and composition of the X-bodies, with a discussion of the implications that their formation has for the synthesis of tobacco rattle virus, was published (*J. gen. Virol.* 6, 127, 1970). (B. D. Harrison, A. Z. Štefanac, I. M. Roberts).

Intracellular localization of activity

Electron microscope autoradiography was used in an attempt to locate sites of synthesis and/or accumulation of RNA using ³H-uridine as a precursor. No clear cut difference in localization of radioactivity was noted between virus-infected and healthy *Nicotiana clevelandii* leaf tissue, even when actinomycin D was used in an attempt to inhibit host DNA-directed RNA synthesis without affecting virus-directed RNA synthesis. Parallel biochemical

studies showed that actinomycin D substantially inhibited incorporation into RNA in both infected and healthy material. However, incorporation by infected tissue in the presence of actinomycin D was 30-40% greater than that by healthy tissue. Uptake of uridine was however affected by the inhibitor and by the conditions of incubation, as well as by virus infection, probably reflecting changes in uridine pool size, and complicating interpretation of the results.

A different approach is to fractionate tissue, to find which organelle fractions are involved in virus multiplication. Discontinuous Ficoll density gradients were used for rapid and gentle separation of the components of leaf extracts. The fraction accumulating on the step between 10% and 50% Ficoll was predominantly mitochondrial, the nuclei and chloroplasts entering the 50% Ficoll. Differential centrifugation, in combination with centrifugation in Ficoll density gradients, was used for fractionating larger amounts of material. Preparations of nuclei were obtained by breaking tissue open by gentle chopping, and isolating the nuclei from the material sedimenting at 500 g by dissolving plastids and membrane-bound cytoplasmic contaminants with Triton X-100.

The distribution of buffer- or phenol-extractable infectivity in fractions from Ficoll density gradients showed that with strain CAM and strain CAM/DF, respectively, five to ten times more infectivity was obtained from the mitochondrial fraction than from the nuclear/chloroplast fraction. Work is continuing to determine the nature of this association of infectivity with the mitochondrial fraction. (M. A. Mayo).

Nucleic acid synthesis

Studies were begun on the synthesis of infective virus nucleic acid in *N. clevelandii* leaf tissue infected with strain CAM. By extracting nucleic acids with phenol before or after freezing the tissue, the total amount of extractable infective virus nucleic acid and the proportion derived from intact virus particles were determined. From 2 days after inoculation, when virus was first detected, to 7 days, when multiplication had apparently ceased, only 30-40% of the infective virus nucleic acid in the tissue seemed to be in nucleoprotein virus particles, the rest being inactivated by freezing and thawing.

When polyacrylamide gel electrophoresis was used for analyzing leaf RNA according to molecular size, the results were similar to those obtained using rate zonal centrifugation, but resolution and sensitivity were greatly improved. Following standard methods using 2.5% acrylamide gels, and staining with methylene blue after electrophoresis, about 1 µg of RNA was detectable and the major RNA components of plant tissue were resolved. Purified preparations of the CAM strain of tobacco rattle virus gave two RNA bands, and those of the PRN strain three bands, corresponding to the predominant length sizes of the nucleoprotein virus particles. Although virus nucleic acids were not detected as visible bands in gels when nucleic acid preparations from infected plants were used, infectivity was recovered from slices of these gels. (M. A. Mayo).

The threefold increase in number of photographic plates used during the year largely reflects the expansion of thin-section studies of virus-infected cells. A double bell-jar unit for vacuum pumping was constructed and used to provide the larger supply of desiccated plates now needed.

To aid stretching of sections that become compressed during cutting, a 'heat pen' was devised. This stretches sections more efficiently and reliably than conventional methods, which use solvent vapours, and also eliminates the occupational hazards of exposure to potentially toxic materials. (I. M. Roberts).

ULTRASTRUCTURE OF INFECTED CELLS

Ultrastructural effects in relation to virus grouping

There is increasing evidence that similar kinds of ultrastructural effects are produced by viruses that have many other affinities. For example, several viruses allied to potato virus Y are reported to induce 'pin-wheel' structures, which are not known to be induced by other kinds of viruses. Our observations with members of three different groups of viruses extend this idea and also show some of its limitations.

Electron microscopy of thin sections of leaves of coriander (*Coriandrum sativum*) infected with parsnip mosaic virus which, like potato virus Y, has flexuous particles about 750 nm long, revealed bundles, pin-wheels and a few virus particles, all in the cytoplasm. (A. F. Murant, I. M. Roberts).

Pin-wheels were also seen in cells infected with another elongated virus which was transmitted by aphids, caused a mosaic in tobacco and was originally found as a contaminant in a culture of belladonna mottle virus. The interesting feature of this elongated virus is that it has particles about 900 nm long, and so, although in several respects similar, would not normally be grouped with potato virus Y. (B. D. Harrison, I. M. Roberts).

Tissues infected with a range of nepoviruses showed some features induced by several of the viruses and others not shared. In *Chenopodium amaranticolor* or *C. quinoa* plants, arabis mosaic, cherry leaf roll and strawberry latent ringspot viruses all induced the formation, near the nucleus, of X-bodies largely composed of membranous material and ribosomes. Cherry leaf roll, raspberry ringspot and strawberry latent ringspot viruses were each seen as single rows of virus particles in the plasmodesmata. By contrast, the viruses differed in their patterns of aggregation within the cells. Arabis mosaic virus particles aggregated within X-bodies to form concentric ellipsoidal shells up to eight layers thick, whereas particles of strawberry latent ringspot virus occurred in single rows in tubules, which had double walls and an outer sheath. All the particles in the tubules stained like nucleoprotein particles but regions containing structures resembling empty virus protein coats occurred in other parts of the X-bodies. (I. M. Roberts, B. D. Harrison).

Very characteristic changes in the chloroplasts occurred in leaves of *Nicotiana* spp. infected with eggplant mosaic or belladonna mottle virus.

Affected chloroplasts contained marginal vesicles of various sizes and of a kind reported previously only from cells infected with the allied virus, turnip yellow mosaic. None of the other viruses we have studied produced effects of this type. Eggplant mosaic virus also produced crystals, composed of virus particles, in the vacuoles of some cells. (B. D. Harrison, I. M. Roberts).

Carrot mottle virus

In thin sections of necrotic areas of *Nicotiana clevelandii* leaves infected with carrot mottle virus, palisade but not mesophyll cells were extensively damaged; their vacuolar membranes were disrupted and their central areas filled with cytoplasmic material. In areas of leaf showing less severe symptoms, palisade cells remained intact and both in palisade and in mesophyll cells the most remarkable effect was that the plasmodesmata increased in number, became grossly enlarged and formed protrusions into the cytoplasm, surrounded by new cell wall growth. In mesophyll and palisade cells these enlarged plasmodesmata often extended as far as the vacuole and in some palisade cells they extended towards the nucleus, often indenting, though not apparently penetrating, the nuclear membrane. Virus-like particles of 50 nm diameter were seen in the cell vacuoles, in greater number in palisade than in mesophyll cells; in time-sampling experiments there was a close correlation between the number of particles and the infectivity of leaf extracts. It is not clear whether the abnormal plasmodesmata are pathological side-effects of virus infection or whether they have some functional role in virus synthesis or in the movement of virus materials from cell to cell. (A. F. Murant, I. M. Roberts).

VIRUSES OF FLOWER BULBS

Tulip viruses

Of tulip plants whose roots are naturally infected with tobacco necrosis virus under field or glasshouse conditions, most do not develop Augusta disease. Failure of the disease to appear in such plants was not related to the presence or absence of satellite virus. It is possible that only particular strains of tobacco necrosis virus can cause the disease. However when Korneforos tulip leaves were manually inoculated with two strains of tobacco necrosis virus, either singly or in combination, 95% of the inoculated plants developed fully systemic symptoms. In contrast, when these strains were inoculated to roots of the same stock of Korneforos, using vector *Olpidium*, less than 10% of the plants developed the disease although the root systems of 40% were heavily infected with virus. Thus although these strains of tobacco necrosis virus can move readily from one leaf to another there seems to be some barrier to their movement from roots to tops. This suggests that the factors affecting this barrier control disease development. What these factors are is not known but temperature may be important. The non-uniform response of a stock to infection is however puzzling, because such bulbs are genetically uniform and cultural methods are designed to keep physiological differences to a minimum.

We confirmed our earlier finding that Augusta disease can occur as the result of infection by bulb-borne virus, and detected tobacco necrosis virus in all plants of a Gudoshnik stock which showed Augusta disease-like symptoms when grown in sterilized soil. These diseased plants developed from grades of bulbs including those normally used in forcing.

Very different results were obtained with a stock of Andes. When this was forced in sterilized soil, tobacco necrosis virus was detected in only about 5% of the plants that developed leaf necrosis. Another agent, tentatively named tulip halo necrosis virus, was transmitted from about half the remaining diseased plants. It produced necrotic lesions in inoculated leaves of *Chenopodium quinoa*, *Phaseolus vulgaris* and *Nicotiana clevelandii*, and infected the last-named systemically. These isolates could not be maintained under glasshouse conditions but were cultured when the test plants were kept in a growth cabinet at 15°C. Tulip halo necrosis virus is extremely unstable and the infectivity of extracts of *N. clevelandii* leaves, made in water or phosphate buffer (pH 6-8), was lost within 10 min at 20°C. Addition of 2-mercapto-ethanol preserved much of the infectivity for about 1 hr. Such extracts were infective when diluted to 10⁻¹ but not 10⁻² and when heated for 10 min at 40° but not at 45°C. Infectivity survived treatment with diethyl ether and remained in the supernatant fluid after centrifugation for 10 min at 9,000 g. Leaf extracts made using phenol were not infective and the agent does not seem to be a free nucleic acid. (W. P. Mowat).

Narcissus viruses

Of plants of four varieties of narcissus (Carlton, Golden Harvest, Sempro Avanti and Yellow Cheerfulness) grown for two years at an infested site, up to 55% became infected with tomato black ring virus and up to 15% with raspberry ringspot virus. The difference in incidence of the two viruses probably reflects their relative infectivity in the soil, as suggested by the frequency of infection of bait seedlings grown in soil samples in the glasshouse, and not an intrinsic difference in susceptibility of narcissus to the two viruses (W. P. Mowat).

Meristem tip culture

Further attempts were made to free Double White narcissus from virus infection by this method. Several of the meristem-tips began to differentiate and it should soon be possible to test some of the plantlets for virus infection.

Similar work was started with some varieties of bulbous iris and gladiolus that seem to be totally virus infected. (J. Chambers).

RUBUS VIRUSES

Raspberry propagation

About 4,500 virus-free young raspberry plants were supplied to the Scottish Nuclear Stock Association in 1969 and were planted at two sites in Angus. Establishment of the young plants was however uneven. The plantings made

in 1968 grew well throughout their two growing seasons, and a good crop of cane is expected. It is hoped to begin propagating a virus-free stock of the new variety Glen Clova in 1971.

Results of a test on the establishment in the field of young raspberry plants showed that cuttings raised late survived at least as well as early cuttings. However, delaying the planting out of early cuttings can decrease survival. (J. Chambers).

Raspberry bushy dwarf virus

Further studies with raspberry bushy dwarf virus, which occurred in all tested Lloyd George raspberry plants with bushy dwarf disease, and occasionally in plants of some other cultivars, showed that it is not, as previously thought, a filamentous virus related to apple chlorotic leaf spot virus, but has isometric particles about 33 nm in diameter. Preparations were made by twice precipitating the virus at pH 4.8 and resuspending it at pH 7.0, followed by ultracentrifugation and exclusion chromatography in columns of 2% agarose beads. In density gradient and analytical ultracentrifugation, the virus sedimented as two components, with sedimentation coefficients of 111 and 116 S. Only a few particles, all disrupted, were seen in preparations mounted in phosphotungstate but numerous well preserved particles were seen in uranyl formate, provided that they were first dispersed in a salt such as 0.01 M-MgCl₂ instead of distilled water. Serological tests showed that this virus is not related to any of 24 other isometric viruses, nor to apple chlorotic leaf spot or apple stem-grooving viruses. Loganberry degeneration virus is serologically closely related to raspberry bushy dwarf virus. Raspberry plants infected through seed or by manual inoculation did not show symptoms of bushy dwarf disease after 6-12 months, and further work is needed to show what role, if any, the virus plays in the etiology of the disease. (O. W. Barnett, A. F. Murant, R. A. Goold).

Previously undescribed viruses

In addition to raspberry bushy dwarf virus, two other sap-transmissible viruses were obtained from red raspberry. One, from Lloyd George plants, caused systemic vein-clearing and necrotic spots in *Nicotiana clevelandii*, but no symptoms in *Chenopodium quinoa*. The other, obtained from plants of Malling Enterprise, Malling Exploit, Lloyd George and Malling Jewel, caused systemic necrosis in *C. quinoa*, but did not infect *N. clevelandii*. It reached only low concentrations in *C. quinoa*, was difficult to transmit by inoculation of sap and resembled a virus transmitted to *C. quinoa* by inoculation with sap from a *Rubus occidentalis* test plant which had developed leaf curling and stunting symptoms after receiving aphids (*Amphorophora rubi*) taken from a Malling Enterprise raspberry plant. This third virus lost infectivity after dilution to 10⁻¹ to 10⁻², heating for 10 min at 50-55°C or storage for 24 hr at 22°C. Some infectivity remained after *C. quinoa* extracts were clarified with diethyl ether or chloroform, but not with *n*-butanol. A fourth virus was transmitted to *C. quinoa* by inoculation with sap from a

Rubus occidentalis plant previously grafted with tissue from Glen Clova raspberry. It caused systemic chlorotic rings and mottling in *C. quinoa* and *C. amaranticolor*, necrotic local lesions in *C. murale*, and infected *Nicotiana clevelandii* symptomlessly. It is not yet clear whether the third and fourth viruses came from the red raspberry plants or were seed-borne in the *R. occidentalis* test plants; neither resembles black raspberry latent virus, which is known to be carried in seed of *R. occidentalis*. (A. T. Jones, A. F. Murant).

POTATO VIRUSES

Tobacco rattle virus

Spraing caused by tobacco rattle virus was less common in commercial potato crops in 1969 than in 1968. A trial of several advanced selections bred by the Scottish Plant Breeding Station showed that none developed spraing as frequently as Pentland Dell when grown in infested soil. Of two long-established varieties, British Queen was more susceptible to spraing than Pentland Dell, but Epicure was apparently unaffected.

Previous results indicated that weed plants are important hosts of tobacco rattle virus and are probably responsible for its persistence from year to year at infested sites. Potato seems to be infected only incidentally and to be unimportant for survival of the virus. Prevention of weed growth during the life of the crop, by applying linuron, decreased spraing incidence by about a third. Tests of the effect of eliminating overwintering weeds are in progress.

At two sites, patches with a high incidence of spraing were associated with large numbers of stubby root nematodes (*Trichodorus* spp.), the vectors of tobacco rattle virus. The topsoil in these patches was shallow (30 cm) and soil samples from its junction with the subsoil contained more stubby root nematodes than either the topsoil or subsoil. Many soils infested with *Trichodorus* spp. are deficient in copper, cobalt and manganese. Solutions of cupric sulphate (16 ppm Cu) were toxic to *T. pachydermus*, *T. primitivus* and *T. cylindricus* but the number of these nematodes was little affected by applying copper or manganese salts to field soils. Their number was also unaffected when the pH value of field soil was decreased from 6.8 to 4.8 by applying sulphur. (J. I. Cooper, B. D. Harrison).

Plots treated with the nematicide D-D (200 or 400 lb/acre) in spring 1968 were again planted with potatoes to assess the persistence of the control achieved. The incidence of spraing in tubers from the treated plots was 7% (1% in 1968) and that in untreated plots was 64% (92% in 1968). In a new experiment, 56% of the Pentland Dell tubers in untreated plots developed spraing, about 20% in plots treated before planting with either 50 or 100 lb/acre D-D, and negligible numbers in plots treated with 200 or 400 lb/acre. In another trial, Lannate (Dupont 1179; 8 lb/acre) was as effective as D-D in decreasing spraing incidence, Dazomet was less effective and Ciba C14421 (20 lb/acre) was ineffective.

Two species not before recorded from the U.K. were found in Scottish soils. *Trichodorus nanus* occurred at two localities in soil from stabilized sand dunes; the second species seems previously undescribed and has yet to be

named. It occurred with *T. nanus* at one site but had distinctive males. Hand-picked *T. nanus* transmitted tobacco rattle virus to cucumber plants. (J. I. Cooper with P. R. Thomas, Zoology).

Potato mop-top virus

Further work showed that the straight elongated particles found in infective tobacco sap have lengths up to 900 nm, without a clear cut mode. Cross-banding at intervals of 2.5 nm was discerned on the particles, several of which were aggregated side to side and most of whose ends seemed damaged. Most of the infectivity of sap was sedimented by centrifugation at low speed. The slight infectivity of phenol-treated leaf extracts was abolished by pancreatic ribonuclease, indicating that the virus contains ribonucleic acid.

Additional evidence was obtained of the effects of environmental factors on symptom development. Necrotic spots, which later became surrounded by a series of concentric necrotic rings, developed in inoculated tobacco (cv. Xanthi-nc) leaves kept at 14°C in continuous light. The process of lesion formation could however be separated into an initial light-requiring phase and a subsequent low-temperature requiring phase. Infectivity assays showed that little virus accumulated in leaves in darkness, but virus content increased when leaves were transferred from dark to light. Correspondingly, the virus spread very slowly through leaf tissue in the dark at either 14° or 22°C. Spread in the light was about 30 μm/hr at 22°C and 20 μm/hr at 14°C, but the virus reached a higher concentration at 14°C. In naturally infected Arran Pilot tubers at 14°C in the dark, the virus spread at about 10 μm/hr.

Brown arcs (spraing) in naturally infected Arran Pilot tubers did not form in darkness at constant temperatures of 9°, 13°, 18° or 22°C. Pigmented rings were however produced at the boundary of the virus-invaded region a few days after the tubers were transferred from 18° to 13°C or from 18° to 9°C but not when they were moved from 22° to 9°C, or from 22°, first to 18° and then to 9°C. The virus content of the affected, newly invaded, tissue was several fold greater than that of long-infected symptomless tissue. Symptom formation may perhaps be related to changes in carbohydrate metabolism brought about by changes in temperature; the concentration of reducing sugars in healthy tubers reached its lowest point 3 days after transfer from 18° to 13°C, at the time when symptoms first appeared in infected tubers. Non-reducing sugars were little affected. Also, the starch content of cells in the spraing arcs was not exhausted. These results show that potato mop-top virus can spread through partially invaded tubers during storage, but produces spraing only in response to a particular sequence of temperature changes. (B. D. Harrison, R. A. C. Jones).

Applications of a zinc-containing frit to naturally infested soil increased the zinc content of the soil from 3 ppm to 170 ppm and decreased the incidence of spraing in a subsequently grown Arran Pilot crop from 33% of the tubers to nil. The zinc content of the tubers increased from 9 to 12 ppm. Further tests are however needed to examine this possible method of control in more detail. (J. I. Cooper, B. D. Harrison).

Virus from elder

A virus causing chlorotic local lesions in *Chenopodium quinoa* was obtained from American elder (*Sambucus canadensis*) plants imported from the United States by the Crops Research Section, and showing distortion and chlorotic mottling of the leaves. In *C. quinoa* sap, infectivity was lost after dilution to 10^{-4} , or heating for 10 min at 70°C. Infective *C. quinoa* sap contained flexuous particles of about 650 x 15 nm. (A. T. Jones).

Cauliflower mosaic virus

In collaborative work with the Institute of Virology, Glasgow, cauliflower mosaic virus was purified from *Brassica perviridis* with a yield of 10-40 mg/kg leaf. The results obtained at Glasgow indicate that the virus DNA is double-stranded, has a molecular weight of about 5×10^6 and contains 41% guanine + cytosine. Electron microscopy showed two forms of virus DNA, one linear, and the other ring-shaped and folded but not supercoiled. A nearest neighbour analysis of nucleotides gave a pattern for the virus not greatly different from that of the DNA of cauliflower plants. (B. D. Harrison with G. J. Russell, E. A. Follett and J. H. Subak-Sharpe, Glasgow University).

Rubus stunt disease

Mycoplasma-like bodies were found in sieve tubes by electron microscopy of thin sections of leaves from bramble (*Rubus fruticosus*) plants thought to be showing symptoms of rubus stunt, which is caused by a leafhopper-borne agent. Such structures did not occur in leaves from apparently healthy plants. Watering the plants on alternate days for 7 weeks with aureomycin solution (100 ppm) induced apparent remission of the symptoms and caused a sixteen-fold decrease in numbers of mycoplasma-like bodies found in sections, as compared to the number in plants receiving water alone. This disease therefore seems to be caused by a mycoplasma-like agent, and not by a virus. (A. F. Murant, I. M. Roberts).

Radioactive labelling of Longidorus elongatus

L. elongatus became labelled when placed in a solution of D-glucose- ^{14}C for several hours. Some radioactivity was retained during washing and the nematodes remained labelled when kept for several days in wet sand. The level of labelling was sufficient to detect single nematodes using either liquid scintillation or thin end-window counting, and also for detecting nematodes on filter paper strips by X-ray autoradiography. (M. A. Mayo with P. R. Thomas, Zoology).

- GIBBS, A. J.¹ and HARRISON, B. D. (1969). Eggplant mosaic virus, and its relationship to Andean potato latent virus. *Ann. appl. Biol.* **64**, 225-231.
(Eggplant mosaic virus (EMV), obtained from *Solanum melongena* L. from Trinidad, is readily transmitted by inoculation of sap to several solanaceous and a few non-solanaceous plant species. Purified preparations of EMV contain isometric particles 30 nm in diameter, and with sedimentation co-efficients of either 111 or 53S. The particles have thirty-two major morphological subunits. EMV is closely serologically related to Andean potato latent virus and has a similar host range, but is more virulent. Also, whereas EMV accumulates fastest in *Nicotiana clevelandii* leaves at 20-24°C, Andean potato latent virus accumulates fastest at 15°C, and fails to attain a serologically detectable concentration at 24°C. A few symptomatologically or serologically distinguishable strains of EMV were obtained. EMV has properties typical of viruses of the Andean potato latent subgroup of the turnip yellow mosaic group of viruses, and its present cryptogram is */*:*/*:S:S/CI).
- GIBBS, A. J.² and HARRISON, B. D. (1970). Cucumber mosaic virus. *C.M.I./A.A.B. Descriptions of Plant Viruses*, No. 1.
- HARRISON, B. D. (1969). Varietal differences in the reaction of potato to tobacco rattle virus. *Proc. 6th Conf. Czechoslovak Plant Virologists, Olomouc 1967*, 143-144.
(A brief account of work described in more detail elsewhere).
- HARRISON, B. D. (1969). On the transmission of tomato black ring virus by *Longidorus attenuatus* (Nematoda). *Zentralbl. Bakt. Parasitenk.* **123**, 226-229.
(The 'English' form of tomato black ring virus was serially transmitted to cucumber seedlings by individual juvenile *L. attenuatus*. One nematode transmitted five times during a period of more than two weeks and with another more than ten days elapsed between consecutive transmissions. *L. attenuatus* transmitted only slightly less often when the soil temperature was 29°C than when it was 24°C or 20°C).
- HARRISON, B. D. (1970). Tobacco rattle virus. *C.M.I./A.A.B. Descriptions of Plant Viruses*, No. 12.
- HARRISON, B. D. and ROBERTS, I. M. (1969). Association of mycoplasma-like bodies with potato witches' broom disease from Scotland. *Ann. appl. Biol.* **63**, 347-349.
(Mycoplasma-like bodies were found by electron microscopy of sections of sieve tubes, both from shoots and roots of potato (*Solanum tuberosum*) plants affected by Scottish witches' broom disease, and from graft-inoculated tomato shoots. The bodies were bounded by a unit membrane, contained ribosome-like material and mostly measured 200-800 nm in diameter. Most were oval in cross-section but some had lobes or slender protrusions. Some of the bodies were found in the mouths of sieve pores).
- HARRISON, B. D., STEFANAC, A. Z. and ROBERTS, I. M. (1970). Role of mitochondria in the formation of X-bodies in cells of *Nicotiana clevelandii* infected by tobacco rattle viruses. *J. gen. Virol.* **6**, 127-140.
(Non-crystalline inclusions, referred to as X-bodies, developed in leaf-hair cells of *Nicotiana clevelandii* infected with a RNA-producing defective isolate (CAM/DF) of tobacco rattle virus but not in those infected with the nucleoprotein particle-producing strain (CAM) from which CAM/DF was derived. The X-bodies appeared 3 days after inoculation; some persisted for at least 10 weeks. They were digested by pronase and were rich in RNA, which was protected by proteinaceous material from digestion by

¹Australian National University, Canberra.

²Rothamsted Experimental Station.

pancreatic ribonuclease; they did not contain virus coat-protein detectable by fluorescent antibody tests. Electron microscopy of thin sections showed that mitochondria in infected cells developed two abnormalities—peripheral membranous sacs and membrane bounded vacuoles—and then aggregated, together with ribosomes and material containing small darkly staining granules, to form small X-bodies. These fused to form larger X-bodies, in which the mitochondria were further modified and eventually became barely recognisable. Finally, the contents of the X-bodies became increasingly amorphous, and the bodies disintegrated.

X-bodies also developed in leaf-hair cells infected with the virus particle-producing strain PRN, but were less common and mostly persisted for only a few days. These X-bodies were formed in the same way as those produced by CAM/DF, but contained in addition small aggregates of virus particles resembling the aggregates found in the cytoplasm in other parts of the same cells. The frequency of formation, and persistence, of X-bodies induced by these tobacco rattle viruses paralleled the severity and persistence of their macroscopic effects on *N. clevelandii*. The possibility that mitochondria are sites of synthesis of tobacco rattle virus RNA is discussed).

MOWAT, W. P. and STEFANAC, A. Z. (1970). Viruses in lilies. *Lily Yb., Lond.*, 33, 251-253.

(An account of past work, and our current studies, on the identity, spread and control of viruses in lilies).

MURANT, A. F. (1970). Arabis mosaic virus. *C.M.I./A.A.B. Descriptions of Plant Viruses*, No. 16.

MURANT, A. F. (1970). Raspberry ringspot virus. *C.M.I./A.A.B. Descriptions of Plant Viruses*, No. 6.

MURANT, A. F., MUNTHER, T.¹ and GOOLD, R. A. (1970). Parsnip mosaic, a new member of the potato virus Y group. *Ann. appl. Biol.* 65, 127-135.

(Parsonip mosaic virus (PMV) occurs commonly in parsonip in Britain and is transmitted after acquisition access periods of 2 to 5 min by the aphids *Cavariella aegopodii*, *C. theobaldi* and *Myzus persicae*. It was transmitted by manual inoculation of sap, infecting parsonip, chervil, coriander and carrot plants systemically, and causing local lesions without subsequent systemic infection in eight *Chenopodium* spp., *Spinacia oleracea*, *Gomphrena globosa*, and *Torenia fournieri*. It lost infectivity in *Chenopodium quinoa* sap after dilution to 10⁻³–10⁻⁴, heating for 10 min at 55–58°C, or storage at room temperature for 7–10 days. Preparations partially purified by *n*-butanol or chloroform clarification, followed by acid precipitation and/or chromatography in columns of 2% agarose beads, contained filamentous particles, many of which were aggregated or fragmented. Preparations made with chloroform and without acid precipitation contained unaggregated particles of 766 nm normal length, with a sedimentation coefficient of 149S. PMV did not react with antisera to any of 14 other viruses with filamentous particles. The present cryptogram for PMV is */*:*/*:E/E:S/Ap).

MURANT, A. F., TAYLOR, C. E. and CHAMBERS, J. (1969). A strain of raspberry ringspot virus causing yellow blotch disease of Lloyd George raspberry. *Proc. 7th European Symposium on Virus Diseases of Fruit Trees, Aschersleben 1967*, 309-310.

ROBERTS, I. M. and HARRISON, B. D. (1970). Inclusion bodies and tubular structures in *Chenopodium amaranticolor* plants infected with strawberry latent ringspot virus. *J. gen. Virol.* 7, 47-54.

(The first change observed in cells of leaves systemically infected with strawberry latent ringspot virus was the formation of inclusion bodies near the nucleus. The inclusions were largely composed of endoplasmic reticulum, complex membranous structures and ribosomes. Three days later their outer parts contained unbranched, double-walled, slightly flexuous tubules about 50 nm wide and up to at least 2.5 μm long. Each tubule, or occasionally two or three tubules, was enclosed in a membranous sheath 80 to 120 nm in diameter, joined to the endoplasmic reticulum. The tubules contained a single row of up to 100 or more darkly stained virus-like particles. Some tubules ended within the inclusion and some at plasmodesmata, in which virus-like particles occurred. The central, predominantly membranous, regions of the inclusions contained masses of faintly stained, apparently hollow structures resembling empty shells of virus-coat protein).

TAYLOR, C. E., THOMAS, P. R., ROBERTSON, W. M. and ROBERTS, I. M. (1970). An electron microscope study of the oesophageal region of *Longidorus elongatus* (de Man). *Nematologica* 16, 6-12.

(For summary see Zoology Section).

¹Statens Plantevern, Vollebek, Norway.

Zoology

C. E. TAYLOR

The research programme continued virtually unchanged from last year with emphasis on nematode vectors of plant viruses but with entomological interests sustained by work on raspberry beetle and raspberry mite. The finding of sites of virus retention in *Xiphinema diversicaudatum* and *X. index* follows similar results with *Longidorus elongatus* and *Trichodorus pachydermus* reported last year and provides an exciting prelude to work anticipated on an Hitachi HS-8 electron microscope to be installed in the Section by early 1970. A NATO grant was awarded in November to C. E. Taylor and to Dr F. Lamberti and Professor G. Martelli at Bari, Italy, to do co-operative work on the distribution and ecology of *Xiphinema* and *Longidorus*; the grant supports the appointment of Miss Heather Baker as Scientific Assistant from January, 1970.

NEMATOLOGY

Biology

Species of *Longidorus* or *Xiphinema* were present in 73% of the total of 322 soil samples collected to date in Scotland, mostly from the counties of Angus, Perth and Fife. *L. elongatus* occurred in 60% of the samples, *L. goodeyi* in 7%, *L. leptcephalus* in 4% and *X. diversicaudatum* in 9%. Only 8% of the samples containing *L. elongatus* and 10% of those containing *X. diversicaudatum* proved viruliferous when tested with bait plants. Virus transmission occurred in soil samples with as few as 5 *L. elongatus* larvae, or 10 *X. diversicaudatum* larvae, per kg. (P. R. Thomas, C. E. Taylor).

Attempts are being made to find whether movement of *L. elongatus* and *X. diversicaudatum* through soil is a response to the presence of host plants. So far, there is no evidence of any response to root secretions and movement is random. (P. R. Thomas).

L. elongatus immersed for a few hours in D-glucose-¹⁴C took up sufficient to enable single nematodes to be monitored by scintillation counting and thin-end window counting. Labelled nematodes produced individually identifiable images on X-ray film. (P. R. Thomas with M. Mayo, Virology).

Optical brighteners were detected in the alimentary tract of *L. elongatus* and *X. diversicaudatum* from pots of soil in which labelled tomato, clover and ryegrass seedlings were grown. The brightness of the acquired fluorescence was clearly distinguishable from the background autofluorescence which occurred in both species. (P. R. Thomas with H. M. Wilson, Mycology).

Chemical control

In field and laboratory experiments D-D, dazomet and quintozone gave good control of *Longidorus elongatus* and *Xiphinema diversicaudatum* and largely prevented virus transmission. Treatments were equally successful at 7, 145 and 22°C. Methomyl (Du Pont Lannate) prevented virus infection for up to about 12 weeks although it had little effect on the numbers of nematodes. Low concentrations of methomyl caused muscular contraction and continuous protraction of the stylet; after 30 min exposure both *L. elongatus* and *X. diversicaudatum* were alive although they did not transmit virus. (C. E. Taylor, S. C. Gordon).

In a field experiment D-D applied at 400, 200 or 100 lb/acre gave good control of *Trichodorus* spp. and prevented transmission of tobacco rattle virus to potatoes; at 50 lb/acre it was ineffective. In another experiment dazomet compared favourably with D-D in controlling nematodes and virus transmission; methomyl reduced nematode numbers only to about half of those in untreated plots but control of virus spread was as good as in D-D treatments. Treatment with dazomet or D-D almost doubled the yield of potatoes; the reason for this response, which is not related to virus infection or nematode numbers present, is not understood. These experiments are also discussed in the Virology Section (see p. 56).

Populations of *T. nanus*, a species previously unrecorded in Britain, were found in the experimental area; in laboratory experiments the species was shown to transmit tobacco rattle virus. (P. R. Thomas with J. I. Cooper, Virology).

Association of virus and vectors

Longidorus elongatus occurs in many parts of the world and is particularly abundant in England and Scotland. Only in Scotland has the nematode so far been found in association with raspberry ringspot and tomato black ring viruses. In a laboratory experiment, using virus-infected *Chenopodium quinoa* as a host plant, a population of *L. elongatus* from Norfolk, England, transmitted English and Scottish strains of raspberry ringspot virus and a Scottish, but not a German strain, of tomato black ring virus. This parallels the behaviour of Scottish *L. elongatus* (Ann. Rept. 1968). There therefore seems no prima facie reason why outbreaks of these viruses should not develop wherever *L. elongatus* populations occur if the viruses are introduced by means of infected crop plants or weed seeds. (C. E. Taylor, R. R. Crichton).

Electron microscopy

Comparison between transmission of viruses by *Longidorus elongatus* and *Xiphinema* species suggested a mechanical, short-term retention of virus particles by *L. elongatus* but a closer biological association between virus and vector in *Xiphinema*. Evidence for the specific association of raspberry ringspot and tomato black ring viruses with the stylet guiding sheath of *L. elongatus* (Ann. Rept. 1968) provided a reasonable explanation of the mechanism of transmission in that vector. Electron microscopy of thin

sections of viruliferous *X. diversicaudatum* and *X. index* failed to provide any evidence of virus association with cells of the tissues of the oesophageal region but clearly showed that viruses were retained as a monolayer of particles adsorbed on to the cuticle lining the lumina of the odontophore (stylet extension), anterior oesophagus and oesophageal bulb. The cuticular lining becomes detached from the underlying cellular tissue during the moult of the nematode and the partially digested cuticle and virus particles pass posteriorly into the intestine. The virus particles may be inactivated by the moulting fluid or by the digestive processes in the intestine, but in any case cannot be regurgitated into the lumen of the oesophagus because of the 'one-way' action of the oesophago-intestinal valve. This supports the limited experimental evidence which showed that viruses transmitted by *X. diversicaudatum* and *X. index* are not retained through the moult.

In co-operation with Drs Sheila Scott and D. M. Green of the Bacteriology Department, University of Dundee, attempts have so far been unsuccessful in specifically identifying the virus particles in *X. diversicaudatum* by immersing excised oesophagii in virus antiserum, conjugated with fluorescein isothiocyanate. An interesting side-observation was the strong autofluorescence exhibited by the stylet guiding sheath; treatment with 100% cold acetone removed the fluorescence.

As a basis for the investigation of the mechanism of virus transmission, a study is being made of the ultrastructure of the oesophageal region of 10 different *Longidorus* species. (C. E. Taylor, W. M. Robertson).

An examination of the ultrastructure of the conidia of the fungus *Cochliobolus sativus* was undertaken on behalf of Dr K. Old, Department of Biological Sciences, University of Dundee in exchange for time on the University's electron microscope. (W. M. Robertson).

ENTOMOLOGY

Raspberry beetle

Work has continued in collaboration with Dr J. T. Martin, Long Ashton Research Station, on the nature of resistance of *Rubus phoenicolasius* to the raspberry beetle, *Byturus tomentosus*. Feeding tests showed that the beetle was strongly repelled by an acidic fraction obtained by KOH extraction from the cuticle of the leaves and flower buds of *R. phoenicolasius*. However, only low concentrations of this fraction were present in the leaf cuticle of two derivatives of *R. phoenicolasius* x raspberry (see p. 42) which had proved resistant to beetle feeding in bioassays and it is possible that other chemicals in the leaf tissues may confer resistance.

Evidence from field and laboratory tests showed that *R. phoenicolasius* is unacceptable to the raspberry aphid, *Amphorophora rubi* and that this resistance is present to some extent in the *R. phoenicolasius* x raspberry derivatives. Tests showed that the aphids were repelled from raspberry buds coated with the KOH extract from *R. phoenicolasius*. This chemical fraction also repelled *Pieris* larvae from treated cabbage leaves and *Tribolium confusum*

from treated cornflakes. It is planned to investigate further the general nature of the repellency associated with the fatty acids derived from *R. phoenicolasius*. (C. E. Taylor with D. L. Jennings, Plant Breeding).

A new insecticide with low mammalian toxicity (Shell Gardona, 2-chloro-1-(2, 4, 5-trichlorophenyl) vinyl dimethyl phosphate) proved effective in controlling raspberry beetle. Applied at the pink bud stage, infestation of the fruit was less than 0.5% on treated, compared with 21% on untreated plants. (C. E. Taylor, S. C. Gordon).

Raspberry mite

A small scale survey in Angus and Perthshire revealed the widespread occurrence of the raspberry mite (*Eriophyes gracilis*) in commercial raspberry plantations and among wild raspberries. There were, however, generally fewer mites per bud overwintering on wild than on cultivated raspberries. Cultivated raspberries growing in sheltered situations were invariably more heavily infested throughout the year than those that were more exposed. Differences in infestations also varied with the variety; in a replicated experiment, the largest overwintering populations were found on Malling Jewel, with lesser numbers on Norfolk Giant, Malling Promise and Lloyd George and very few on Malling Exploit. Larger populations also developed during the summer on Malling Jewel than on the other varieties.

On experimental plots, mite populations on Malling Jewel were controlled by endosulfan, formothion, endrin or tricyclohexyltin hydroxide (Plictran, Dow Chemical Co.) applied as two sprays, the first in mid-June and the second 3 weeks later. All treatments decreased the mite infestations on the leaves by more than 90%. Moreover, numbers continued to decline to very low levels by late summer, whereas on untreated plants populations eventually rose to about 1,000 mites per leaf. *Phytoseius* sp. predatory mites were numerous throughout the season and, seemingly little affected by the spray treatments, they effectively 'mopped up' most of the raspberry mites on treated plants. Apparently they were not sufficiently numerous to overcome the greater multiplication of mites on untreated plants. Spray treatments were also effective in controlling mite infestation of the fruits, and yields were 15% heavier than from unsprayed plants on which the fruits were generally smaller and many were malformed. (C. E. Taylor, S. C. Gordon).

Potato aphids

As part of a collaborative project for the International Biological Programme, a preliminary investigation was made of the population dynamics of aphids infesting the potato crop, with particular reference to *Myzus persicae*. Populations reached their peak of about 250 per plant on the variety Maris Peer by early August and thereafter declined rapidly as winged forms migrated from the crop. It was estimated that parasites and predators killed less than 4% of the *M. persicae* present on the plants. (C. E. Taylor).

- MURANT, A. F., TAYLOR, C. E. and CHAMBERS, J. (1968). A strain of raspberry ringspot virus causing yellow blotch disease of Lloyd George raspberry. *TagBer. dt. Akad. Landw. Wiss. Berl.* **97**, 309-310.
(For summary see Virology Section).
- OLD, K. M.¹ and ROBERTSON, W. M. (1970). Growth of bacteria within lysing fungal conidia in soil. *Trans. Brit. mycol. Soc.* **53** (in press).
(Electron microscopy of thin sections of conidia of *Cochliobolus sativus* recovered from soil showed bacterium-like organisms associated with lysed areas in the matrix of the fungal cell wall. The outer electron-dense layer of the cell wall was more resistant to lysis than inner fibrillar layers).
- OLD, K. M.¹ and ROBERTSON, W. M. (1970). Effects of lytic enzymes and natural soil on the fine structure of conidia of *Cochliobolus sativus*. *Trans. Brit. mycol. Soc.* **53** (in press).
(Isolates of *Cochliobolus sativus* with pigmented conidia resisted lysis by enzymes and survived for more than two weeks on natural soil. Isolates with hyaline conidia lysed within a few hours in enzyme solution and within a few days on natural soil. The fine structure of pigmented and hyaline conidia were compared by electron microscopy before and after exposure to soil and enzymes; resistance to lysis and enzymes of wild type (pigmented) conidia was associated with a thick, electron-dense surface layer, corresponding to the distribution of pigment in the cell wall).
- TAYLOR, C. E. (1969). Control of *Longidorus* and *Xiphinema*. *Proc. 5th Br. Insectic. Fungic. Conf.*, 1969, 177-184.
(D-D, dazomet and quintozone gave good control of *Longidorus elongatus* and *Xiphinema diversicaudatum* and largely prevented the transmission of viruses in field experiments. Methomyl treatment of the soil had little effect on nematode numbers but prevented virus transmission for up to 2 months after application, probably by preventing the nematodes from feeding. Laboratory experiments showed that the nematicidal treatments were equally effective at 7, 14 or 22°C).
- TAYLOR, C. E. and ROBERTSON, W. M. (1969). The location of raspberry ringspot and tomato black ring viruses in the nematode vector, *Longidorus elongatus* (de Man). *Ann. appl. Biol.* **64**, 233-237.
(Electron microscopy of thin sections of *Longidorus elongatus* fed on plants infected with raspberry ringspot and tomato black ring viruses showed virus-like particles in the space between the odontostyle and its cuticular guiding sheath. The particles are thought to be specifically adsorbed on to the guiding sheath. This association was not seen in nematodes fed on plants containing viruses which it does not normally transmit).
- TAYLOR, C. E. and ROBERTSON, W. M. (1970). Location of tobacco rattle virus in nematode vector, *Trichodorus pachydermus* Seinhorst. *J. gen. Virol.* **6**, 179-182.
(Electron microscopy of transverse and longitudinal sections of *Trichodorus pachydermus* showed tobacco rattle virus particles associated with the cuticle lining the pharynx and the oesophagus. Most particles occurred in the glandular part of the oesophagus where they are possibly protected within a layer of mucus overlying the cuticular lining).
- TAYLOR, C. E., THOMAS, P. R., ROBERTSON, W. M. and ROBERTS, I. M. (1970). An electron microscope study of the oesophageal region of *Longidorus elongatus* (de Man). *Nematologica* **16**, 6-12.
(The fine structure of the digestive tract and its associated musculature and the structure of the body cuticle are described from a series of transverse and longitudinal thin sections).
- THOMAS, P. R. (1969). Population development of *Longidorus elongatus* on strawberry in Scotland with observations on *Xiphinema diversicaudatum* on raspberry. *Nematologica* **15**, 582-590.
(*Longidorus elongatus* populations on strawberry and ryegrass reached their peak in autumn or early winter. The life cycle occupies a year; egg-laying occurs mainly in the period April to July and again in October. *Xiphinema diversicaudatum* reached maximum populations on raspberry in November and most egg-laying occurred about mid-summer).
- THOMAS, P. R. (1970). Host status of some plants for *Xiphinema diversicaudatum* (Micol.) and their susceptibility to viruses transmitted by this species. *Ann. appl. Biol.* **65**, 169-180.
(*Xiphinema diversicaudatum* multiplied on relatively more woody perennials than on herbaceous crop plants or weeds out of a total of 40 plant species tested. Nematode numbers declined on *Chrysanthemum coronarium*. Most plant species became infected with arabis mosaic or strawberry latent ringspot viruses).

¹Department of Biological Sciences, University of Dundee.

Meteorological Records 1969

P. D. WAISTER, J. L. MILNE

MYLNEFIELD

General

During the year the remainder of the meteorological instruments were transferred from the old site in Glasshouse field to the new one in East Loan. Differences in exposure between the two sites are small and are unlikely to introduce ambiguity in comparisons of records between years. In previous Reports, monthly means for various meteorological elements have been related either to long term averages from Dundee Meteorological Station or to means for varying periods at the Institute. Each of these elements has now been recorded for a continuous period of fifteen years (1954-1968) and the means for this period are now being used to calculate deviations each year. A Kipp solarimeter and recording equipment have been in use since October 1967 but instrumentation problems gave rise to doubts about the accuracy of the records prior to 1969.

Wind

Total run of wind for the year was slightly higher than the average for the preceding eight years. For the 3 month period September to November mean wind speed was 30% higher than the average.

Temperature

The first half of the year was appreciably cooler than usual. The number of days of ground frost recorded was the highest since 1962, but there was no measurable loss of soft fruit blossom through frost.

Rainfall

In both January and May the rainfall was more than double the average and the totals for either month were the highest since records began at the Institute in 1954.

Solar radiation

Despite an exceptionally dull May, the total of sunshine hours for the year was 75 hours greater than the average.

AUCHINCUIVE 1969

Month	Temperature °C		Rainfall inches	Sunshine hours	Ground frost days
	Mean of daily maxima	Mean of daily minima			
January	6.9	2.4	3.20	31	18
February	4.0	-1.4	1.09	79	23
March	6.1	-0.6	0.73	94	19
April	10.9	2.6	1.34	187	18
May	13.8	6.0	3.05	164	6
June	17.3	8.7	1.94	229	2
July	18.2	11.3	2.45	186	0
August	18.7	11.7	1.81	177	0
September	16.2	9.3	2.09	116	0
October	15.0	9.5	2.25	88	1
November	7.0	1.3	5.80	55	17
December	6.3	1.8	3.51	40	20
Year	11.7	5.2	29.26	1446	124

MYLNEFIELD 1969

Month	Temperature (Centigrade)				Rainfall		Solar Radiation		Wind Run Miles	
	Mean of daily maxima	Deviation from average*	Mean of daily minima	Deviation from average*	Inches	Deviation from average*	Hours	Deviation from average*		Mean daily radiation, mWh cm-2
January	6.5	+1.4	0.7	+1.2	4.10	+2.13	59	+1	54	5022
February	2.8	-2.8	-2.3	-1.9	1.92	+0.17	80	+5	110	5326
March	5.1	-2.9	0.0	-1.8	1.89	+0.06	88	-12	177	6389
April	10.0	-1.5	2.1	-1.2	2.29	+0.61	158	-2	364	6321
May	12.0	-1.9	6.0	+0.4	5.60	+3.47	125	-63	334	5944
June	17.0	-0.1	8.8	+0.3	2.37	+0.35	225	+49	512	5006
July	19.1	+1.0	10.5	+0.7	1.79	-0.87	201	+36	475	6521
August	19.4	+1.7	11.4	+1.7	2.17	-0.94	176	+30	376	4508
September	16.5	+0.6	9.4	+0.9	1.59	-0.91	140	+23	258	6539
October	15.0	+2.3	8.8	+2.7	1.10	-1.39	94	+1	133	6369
November	6.5	-1.8	-0.4	-2.6	2.13	-0.27	83	+23	73	5808
December	5.6	-0.2	-0.6	-1.0	2.33	-0.57	29	-16	37	4187
Year	11.3	-0.3	4.6	0.0	29.28	+1.84	1458	+75	—	67940

* Recorded at Mylnefield, 1954-1968

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