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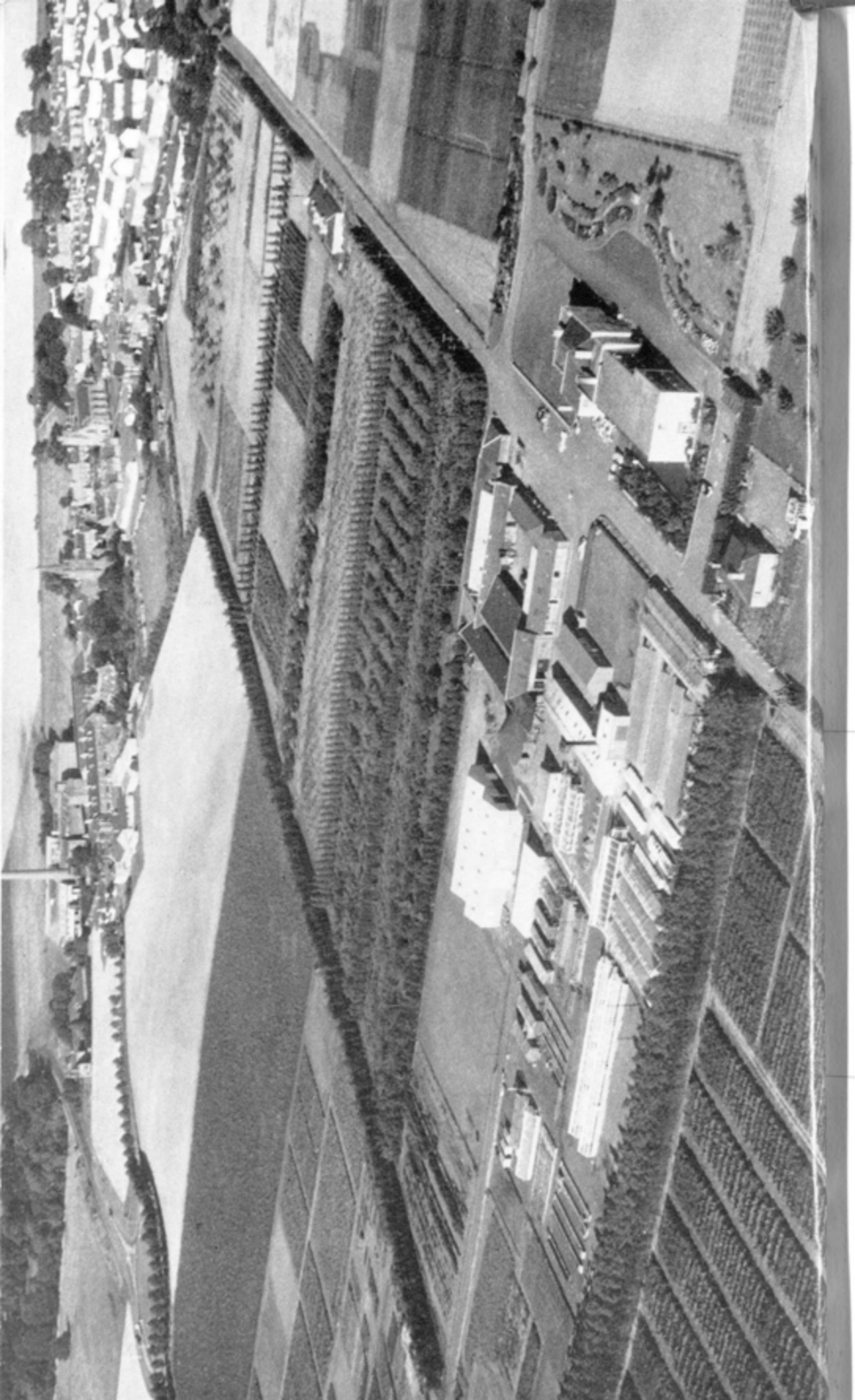
ANNUAL REPORT

THE SCOTTISH HORTICULTURAL RESEARCH INSTITUTE

1968



The Scottish Horticultural Research Institute

15th Annual Report for the year 1968

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Anna K. McGibbon *Appointed* September 1968
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J. H. Raschke *Appointed* September 1968
Mrs. Maureen Robertson
Heather A. Ross *Appointed* June 1968
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Visiting Worker N. Rath

Mycology

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Isobel G. Stockdale

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Morag P. Lindsay

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Wanda K. D. Burza *Appointed* October 1968
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W. Waterson *Resigned* October 1968

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Photographer J. Sunderland

Assistants Maureen I. McMaster, D.A.
S. F. Malecki *Appointed* December 1968

West of Scotland Unit (Auchincruive)

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Assistant Marjorie Campbell *Appointed* August 1968
Mrs. Gillian M. Innocent *Resigned* August 1968
Janet B. Henry

*Honorary Lecturer in the Universities of St. Andrews and Dundee.

General Report

C. H. CADMAN

Being a man of principle, our Chairman had made a private decision that his continued residence south of the Border was incompatible with his continuation in office and was preparing to resign in 1969. His appointment, last October, to the Regius Chair of Botany in the University of Glasgow averted this diaster and we congratulate him on this honour and ourselves in retaining his services. Not all the vacancies left by those who retired from the Governing Body last March have been filled, but we were glad to welcome as new members Dr J. Philp, C.B.E., lately Director of the National Vegetable Research Station, Wellesbourne, and Messrs W. J. Alexander, M. D. Henderson and A. G. Porter and have indeed made use of each of them in various aspects of the Institute's affairs.

The chronicle of this year's events leaves little space for the riding of hobby horses and averts the temptation to steal the meat from the Sectional reports which follow. Two inter-related events do, however, merit distinction; one is the launching of the Scottish Nuclear Stock Association and the other is the release of our first raspberry variety, to be named Glen Clova.

The events which led to the setting up of the S.N.S.A. stem directly from the Institute's decision to cease trading in virus-tested raspberry canes, and its formation is a welcome and long-overdue event. Not only are we thus relieved of the burden of propagating bulk supplies of canes; the raspberry industry will gain a service more efficient than was within the Institute's capacity to provide. Whilst we shall continue to produce virus-free plants of the varieties most in demand, the Association will bulk these up in its own cane nurseries and handle the distribution and sales of cane to its members and the industry. By autumn 1970 the Association should be producing supplies of high grade canes of Malling Jewel which, though possibly short of the demand, will approach it closer than has been possible in the past eight or nine years. Later in the year, joint discussions between the S.N.S.A., the Nuclear Stock Association, London, the National Seed Development Organisation and those agricultural research institutes, including ourselves, which have an interest in soft fruit breeding resulted in agreement that the S.N.S.A. would, in future, handle the propagation and distribution of new raspberry varieties and the Nuclear Stock Association would perform a like service with new strawberry varieties on behalf of the N.S.D.O. Following this agreement, the Institute and the N.S.D.O. jointly applied for plant breeders' rights for Glen Clova and released it to the S.N.S.A. for propagation. Canes are

expected to be available through the Association in autumn 1970. After son 20 years of famine, the release of a new raspberry variety is something of a event. Whilst we should have preferred to make a decision better based o performance trials, the urgency of the need and the evidence of processin quality and cropping capacity left little choice. At worst Glen Clova will fi a gap through being earlier and cropping longer than Malling Jewel and w are confident of having made a sensible decision.

Development scheme

Advance planning, co-ordination between designers and executors, a certai amount of luck and strong nerves seem the main qualifications for piloting major capital scheme through the squalls of government finance. Much ha been accomplished this year and this is due not only to the willingness of ou professional consultants, the contractors–and particularly the site foreman and our own staff but also to the interest and helpfulness of those member of staff of St. Andrews House who are concerned in our affairs.

The extensions to the General Purpose Building which provided ne offices, stores and workshops for the Maintenance Section and new accom modation for the handling and storage of farm crops were occupied in earl summer and it is difficult to imagine how we previously managed withou them. The allocation of capital for the financial year 1968/9, although les than we had hoped for, was spent on the installation of a new boiler, heatin and drainage systems to service the entire development scheme and the wel come provision of steam heating and piped hot water to the main laborator block. Work almost came to a halt before the protracted announcement in October, of a Winter Work Scheme under which sufficient capital wa released to permit of a start on the remainder of Phase 1 of the Developmen Scheme. The new Farm Buildings block is almost completed and provide new accommodation for tractors and implements and the farm workshop as well as adequate stores for tools and spray materials and offices for th farm staff. Sites have been prepared for the new glasshouse blocks and start made on the header house for the Plant Breeding glasshouses. The pre paration of new access roads to the glasshouse site alone involved shiftin nearly all the unheated glasshouses and their attendant services. The incon venience has therefore been difficult to tolerate but the worst now seems ove and the whole scheme is beginning to take shape. Probably a further life saving exercise will be needed if Phase 1 is to make the target completio date of autumn 1969 but optimism still runs high.

Staff

There have been unusually many changes this year, the major one being th disbandment of the Plant Physiology Section with the transfer of C. G Guttridge to the Pomology Section of Long Ashton Research Station. I part a consequence of the A.R.C. Visiting Group's recommendations in 1967 this event had mutual benefits. Whilst the physical loss of a senior membe of staff and his research programme after 15 years is no mean one for

relatively small institute, the environment which Long Ashton can provide for Dr Guttridge's interests may well result in greater benefits to the Agricultural Research Service as a whole than was possible at Mylnefield. As a result, work on hormone physiology ceased in 1968 and the tidying up of loose ends was made easier by the departure of P. B. Goodwin in July to join Professor J. G. Carr's unit at the Australian National University, Canberra, the transfer of D. T. Mason and Maureen Robertson to the Crops Research Section, H. McC. Anderson to the Plant Breeding Section and Aileen Kinninmonth to the Virology Section. J. B. Garrie and J. G. Harrison each competed successfully for appointments in the Mycology Section. Mrs Olfat Gabr returned to the University of Alexandria in August after being awarded the degree of Ph.D. by the University of St. Andrews.

The Virology Section was also faced with a major re-organisation of electron microscope work by the departure of J. Cathro to academic circles to become a senior technician in the Anatomy Department, University of Dundee, after spending 14 years at the Institute, ten of them as electron microscopist. The opportunity was taken to redefine and regrade the post at Scientific Officer level and M. A. Mayo was appointed in October. At the same time the system of running an electron microscopy service was abandoned and users, after instruction, are now expected to do their own work. This has resulted in a striking increase in volume of work done and indeed the pressure on microscope time is such that the acquisition of a second microscope is becoming a dire necessity, baulked only by our inability to find space to house it.

With the blessing of the Department of Agriculture and Fisheries for Scotland and the Agricultural Research Council we were permitted to use vacant posts for the purpose of inviting visiting workers from overseas. Our first experiment in this direction–the appointment for 12 months of O. W. Barnett, a post-doctoral student from the University of Wisconsin to fill the vacancy left by R. M. Lister–has been a great success for he has not only brought new knowledge and techniques to his colleagues in the Virology Section but has made useful progress in work on raspberry viruses.

The Crops Research Section acquired two additional Scientific Officer posts with the disbandment of Plant Physiology. T. W. Hegarty was appointed to one of these to study the effects of environment on seedling establishment. He also took on the supervision of the Institute's share of the International Biological Programme which is being run in conjunction with Professor G. E. Blackman's Department, University of Oxford. The other, reserved for a statistician, is still unfilled. Redistribution of work within the Crops Research Section enabled us to make a convincing case for the employment of a Senior Experimental Officer to take charge of the development programme on vegetable crops and R. Thompson, formerly a member of staff of the National Vegetable Research Station was appointed in October. All four parts of the Section's programme–environment research, work on herbicides and development work on soft fruit and vegetable crops–are now reasonably well supported and are rapidly gaining momentum.

J. R. T. Hodgkin joined the Plant Breeding Section in August with t immediate practical objective of sorting out the genetics of incompatibil in our Brussels sprout material. Like other producers of F_1 hybrid lines, w are aware of the need to adopt new techniques of selecting parental mater to lessen the risks of inbred lines 'breaking down' when their multiplicati on a field scale is attempted.

Custodianship of the Library changed hands in September when Mrs H Barnes resigned to take on domestic commitments; her successor, Kathle McClurg came in January.

Few communities are free from personal tragedies and one that affecte us all was the tragic death, on a fishing expedition in the Tay last June, David Mason of the Crops Research Section at the untimely age of 28.

In September, Mrs A. Z. Štefanac, University of Zagreb, came as a Briti Council scholar to spend nine months working in the Virology Section, an Nicholas Rath, Agricultural Research Institute, Kinsealy, Dublin, joined th Crops Research Section for a year to work with D. T. Mason on the grow and cropping of strawberry. At the invitation of the Royal Society, R. A. Fe left the Mycology Section in January to serve for four months as a Visitin Professor in the University of Ceylon. Midox Ltd. invited H. M. Lawson t visit the Philips-Duphar Laboratories, Wageningen, and the Institute o Phytopathological Research, Wageningen, invited H. M. Wilson to advis on fluorescence microscopy. Aided by travel grants from the Agricultur Research Council, P. D. Waister and M. M. Anderson visited horticultur research centres in Scandinavia and Finland; R. A. Fox discussed work o gangrene and heat-treatment of potato tubers with workers in Holland an Norway; C. North, W. R. Jarvis and W. P. Mowat attended meetings i Italy, Belgium and Denmark respectively and the Director joined a tou organised by the National Farmers' Union to study strawberry growing i Israel.

Public relations

The Institute Association now has a membership of 170 and held its firs Annual General Meeting in May to elect a Committee of Management an its chairman, Mr G. M. Hodge, Blairgowrie. Dr V. D. Arthey, Fruit an Vegetable Preservation Research Association, Chipping Campden, wa invited for the occasion and spoke on the quality requirements of fruit an vegetables for processing. Members' Days were held in July for raspberr growers, in September and November for vegetable growers and in Februar for potato growers and merchants. A second performance of the potato pro gramme, given for the benefit of members of the Agricultural Branches of th National Farmers' Union of Scotland was enthusiastically supported. Th Association's Bulletin, planned as an occasional publication to report wor of interest to growers, seems as if it may usefully fill a gap in communication

The Institute receives a steady flow of visitors from home and overseas augmented this year by delegates to the 1st International Congress of Plan Pathology which was held in London in July and in which many members o

staff participated. We also received visitors from the British Association during its meeting in Dundee in August, and the Horticultural Advisers of the Scottish Agricultural Colleges held their biennial conference at the Institute in October.

Conversely, senior members of staff travelled extensively on study visits to colleagues, to attend scientific meetings or as serving members of committees. All in all, our northerly location protects us from invasion by the less interested and, though travelling is expensive, we are fortunate in being able to maintain close contact with scientific colleagues in Britain and Europe.

Farm and Experimental Crops

W. I. A. JACK

Although, like the rest of Scotland, we could claim to have had a goo summer in 1968 – the second in succession – the season was not a particularl favourable one for most crops in the east of the country and cereal yiel were considerably less than last year. Rain, cold winds and little sunshi distinguished the months of April, May, the first fortnight of July and th whole of September and October. Persistent sea mist hindered the cere harvest, which began later than usual – 25 August – with barley and ended fou weeks later with wheat. Only one-third of the 191 tons of barley harvested wa of malting quality and the bulk of this was from 23 acres of Golden Promis which we grew for the first time this year as an alternative to Ymer. Althoug the wheat suffered most from the weather, it was still of millable quality Yields – 34.4 cwt./acre barley and 46.3 cwt./acre wheat – were some 8 cwt./acr less than last year. In an effort to conserve such eelworm-free land as we have the commercial potato acreage was drastically decreased. An error of judg ment resulted in severe potash deficiency and the yield was only 8.1 ton/acr

Fruit-picking began some ten days later than last year – strawberries o 15 July and raspberries on 23 July – and we found ourselves short of picker towards the end of the season with the result that a small proportion of th raspberry and blackcurrant crops had to be abandoned. Strawberries, fro the same acreage as 1967, yielded 8.7 tons; raspberries, mainly from younge plantations of comparable acreage to 1967, 17.5 tons.

During the winter all the remaining plantations of tree fruits wer grubbed. A new site has been set aside for the 300 varieties of apple chose from the museum collection by the Horticulture Committee of the Scottish Agricultural Improvement Council; the National Trust for Scotland pro vided a new home at Threave Gardens, Castle Douglas, for trees of 19 pea varieties of Scottish origin; trees of Victoria plum were sent to Aberdeen t provide Dr A. M. Paton with material for continuing the work on bacteria canker in which the Institute has co-operated with him and Dr A. E. W. Boyd and the Edinburgh School of Agriculture. The bulk of the 9 tons of apple harvested were sold for processing.

Cabbages, Brussels sprouts, carrots, beetroot, swedes, French beans cauliflowers and sweet corn were all marketed locally as was the crop o calabrese whose reception encourages prospects of its usefulness as a cro for the smaller grower catering for the fresh market.

Much thought has gone into the planning of a system of crop rotatio designed to meet the Institute's needs, and progress made towards realisatio

of the revised system of land usage outlined in the last Report. Choice of rotational cropping systems is restricted both by the need to conserve such potato root eelworm-free land as we have and to avoid the consequences of too much barley growing. Plans for the future are based on a six-year system in which grass, oats and barley are the alternatives to experimental crops. These last fall conveniently into six groups and will move round the farm as part of the rotational system. If this system can be operated successfully it should help to conserve fertility, avoid some of the less desirable consequences of too much cereal growing and make the experimental crops easier to handle. A material aid to this planning has been the help of Mr K. Simpson and his colleagues of the Soil Science Department, Edinburgh School of Agriculture, who have undertaken to survey annually the nutrient status of the Institute's lands and to advise on our needs for fertilisers.

Like many farmers, we found the persistence of B.S.T. during the winter months a hindrance and, but for the long cold and wet spell in February and March, we would have been far behind with winter work because of the reduction in daylight hours of working. However, much has been done to put the estate in good trim by repairing dykes, fences and gates and preparing nearly a mile of surfaced roads which will allow of access to field experiments in all weather conditions.

The completion, in summer 1968, of the extension to the General Purpose building provided welcome extra space for handling and storing farm crops. We look forward to occupation of the new Farm Buildings, due to be completed in a few months' time, which will replace the old steading and provide new accommodation for tractors and implements, herbicides and chemicals, the farm workshop and farm staff.

Glasshouse Section

J. CANTWELL

The Development Scheme disrupted the work of the Section and considerabl more time had to be spent on the day-to-day running of the Section, so tha fewer experimental projects could be undertaken. Advantage is being take of the upheaval to standardise the type of cold glass unit for which there is steady demand in research programmes. Traditional wooden Dutch ligh structures will cater for projects requiring insect-proof facilities whil aluminium-clad houses will become available for more general work. A another move towards standardisation, clay pots used for bench-grow material are being replaced by a square, white, polypropylene pot which ca be autoclaved, is light to handle and economical of both bench and storag space; the pot is also suitable for automatic filling.

Minor refinements in technique of propagating raspberries from roo cuttings were made on the basis of Dr Marston's recent work at Nottingham University. Propagation of strawberries from runners under mist has als been modified as a result of finding that, compared with plain water, plant under nutrient mist produced fewer but thicker roots. The method is particu larly suitable for production of plants used for work on red core by th Mycology Section.

Work was continued on soilless composts with the object of developing on that meets the Institute's specific needs. One peat/sand compost show promise and is based on a formula devised by Bunt at the Glasshouse Crop Research Institute. Experience so far suggests that its use might decrease pes and disease problems, especially during the winter months.

One of the biggest problems associated with year-round production o plants for the Virology Section is the great discrepancy in growth rate between seasons; only in spring and autumn can satisfactory plants be grow without need to modify the light régimes. For this reason a series of trials wa carried out in growth cabinets to find an environment in which *Chenopodium* spp. and tobaccos could be grown. The results provide a basis for designing a simple type of growing room capable of producing the type of plan desired.

Damage to *Chenopodium* spp. and tobacco caused by U.V. emission from high pressure mercury vapour lamps (MBFR/U) was observed in the autumn and a trial comparing these lamps with a horticultural version (HLRG) wa carried out. There were no differences in growth rates and it would appear that to suffer damage from the unmodified lamp, plants have to be irradiated for more than 12 hr. per day. As a result all future lamps will be of the

modified HLRG type and the use of external reflectors will be discontinued.

Investigations of the possibilities of automatic shading on and in glass houses was started, but the equipment at present available needs further development. A tentative figure of maximum total daily radiation for *Chenopodium amaranticolor* was obtained, however, and this will be of great use in the assessment of shading materials.

It is to the credit of the glasshouse foreman, R. D. Taylor and his staff that, despite difficulties, all requests for plant material–amounting to well over 100,000 potted plants–were met. In addition, he assisted in the experimental programme and his help is gratefully acknowledged.

Crops Research

P. D. WAISTER

Further staff appointments made during the year will ultimately result greater cohesion of the Section's fields of investigation. In particular t transfer of D. T. Mason from the Plant Physiology Section and the appoi ment of R. Thompson as Senior Experimental Officer will aid in the integ tion of agronomic activities with studies of crop environment. The fact th this is a transition period will be evident in the report which follows. T. W Hegarty was appointed to a new Scientific Officer post to investigate proble of seed germination and seedling establishment, and J. Q. Neilson joined t Section to conduct the Institute's experimental work under the Internatio Biological Programme.

N. Rath, of the Agricultural Institute of Eire, arrived in September spend a year studying the variability of components of yield in strawberri

P. J. Joy resigned in December to take up a post in Finland. Changes Scientific Assistant staff are indicated in the Institute staff list. The Secti lost a popular member of staff in C. D. Mason who died as a result of accident in June 1968.

Aspects of the Section's work that are of more immediate application commercial production were demonstrated at a number of specialist growe days during the year. H. M. Lawson visited Wageningen and the Agricultu Research Station of Philips-Duphar in Holland, as a guest of Midox Lt and a travel grant from the A.R.C. allowed P. D. Waister to visit resear centres in Scandinavia.

CROP ENVIRONMENT

Crop response to shelter

The yield of both raspberries and strawberries increased in response shelter. In this first cropping year of the experiment planted in spring 19 the mean yield of raspberries increased by 27% for a distance of 70 (7 x the height of the screens), when sheltered from the west wind. Strawber yields increased even more. The plots protected from both east and w yielded 71% more than the exposed controls. Measurements of exposure growers' holdings suggest that the Institute is not atypical of the soft fr producing areas of eastern Scotland.

Irrigation

Raspberry and strawberry experiments planted in 1967 were irrigated for t

first time in 1968, the first cropping season. There were no differences in yield of fruit between non-irrigated plots, plots irrigated whenever soil moisture tension in the root zone reached 30 cm. Hg, and those irrigated only at pink fruit stage. However, cane growth of raspberries in 1968 increased by 12% in the plots that were frequently irrigated.

Light interception by the raspberry crop

Commercially, row spacing is dictated by cultivation techniques and is usually 6 ft. though it is recognised that closer spacings would give greater yields. As part of a new experiment reported below (p. 26), light interception at 6 ft. spacing was measured using 3 ft. tube solarimeters and electrolytic integrators. Interception increased throughout the season as new cane grew out but at its maximum was only 70%.

Growth of tulips

The 'soil shift' experiment, reported last year, showed that in 1967 the rate of increase of tulip bulbs was greater at the Institute than under the climatic conditions of the Nottingham area. The bulbs harvested from the two centres were forced under identical glasshouse conditions at the School of Agriculture, University of Nottingham, Sutton Bonington. No differences in flowering date or flower quality were detected. The only difference between the stocks was in stem length; bulbs harvested at the Institute produced slightly longer stems than those harvested at Sutton Bonington. The experiment was repeated in 1968 but had to be terminated at Sutton Bonington before the bulbs were harvested. (P. D. Waister, P. J. Joy).

Seed germination and seedling establishment

The pattern of field germination and establishment in part controls both the ultimate plant population and crop uniformity, factors which are of overriding importance in the production of certain crops for processing.

Starting with the carrot crop, experiments have been initiated to investigate the influence of environment on establishment, and the possibility of applying pre-sowing treatments to reduce seed and seedling loss and variability in the field. (T. W. Hegarty).

WEED CONTROL

Raspberries

Simazine, bromacil, terbacil, fluometuron, chlorthiamid and dichlobenil were applied at the rates given below to bands, 1 ft. wide, on either side of the row in a 7-year-old raspberry plantation to evaluate crop tolerance.

Herbicide	*Formulation*	*Dosage rate(s)* (lb. a.i./*acre*)		
Simazine	Wettable powder	2.0		
Bromacil	Wettable powder	2.0	4.0	6.0
Terbacil	Wettable powder	2.0	4.0	6.0

Herbicide	*Formulation*	*Dosage rate(s)* (lb. a.i./ac		
Fluometuron	Wettable powder	2.2	4.4	
Chlorthiamid	Granule	8.3	16.5	2
Dichlobenil	Granule	8.3	16.5	2

Treatments were applied in early April 1967 before the new canes emerg None of the newer herbicides, even at the highest dosages, had any adve effect on fruiting canes or their yield. On plots treated with chlorthiamid a dichlobenil the number of suckers produced outside the stool was almost 6 fewer than on plots treated with simazine, and spring growth of new sto cane was retarded. The number of canes produced per stool was not affec and the differences in cane growth had largely disappeared by the end of t growing season, since the number and average height of stool canes availab for tying in did not differ significantly from those on the plots treated w simazine. No further herbicide treatments were applied in 1968. Such growth around the stools and growth of new stool canes were normal in 19 on plots originally treated with chlorthiamid and dichlobenil, indicating th any adverse effect on new growth was not carried over into the followi season. None of the herbicides even at the highest dosage rates had a effect on cane growth or fruit yield in 1968.

Bromacil (2 lb.), terbacil (2 lb.), chlorthiamid (8.25 lb.) and dichlobe (9.75 lb.) (all a.i./acre) were evaluated for efficiency of perennial weed cont in two experiments, run in conjunction with the East of Scotland College Agriculture, on commercial raspberry plantations. The herbicides w applied in early April 1967 before new canes emerged, and the dry spell whi followed may to some extent have accounted for the disappointing perfor ance of bromacil and terbacil. Couch grass (*Agropyron repens*) was only ve temporarily checked by these herbicides, whilst coltsfoot (*Tussilago farfar* creeping thistle (*Cirsium arvense*), dock (*Rumex* spp.) and buttercup (*Ran culus repens*) were unaffected. Chlorthiamid and dichlobenil gave go initial knock-down of couch, but by late summer it was recovering rapidly one site, although more permanently checked at the other. These two her cides eliminated coltsfoot, creeping thistle and docks. None of the herbici treatments gave worthwhile control of hogweed (*Heracleum sphondylium* hedge parsley (*Torilis japonica*), buttercup, or silverweed (*Potentilla anserin* Assessments in 1968 showed that couch (the only weed) at one site had co pletely re-infested the treated plots. At the other, the resistant broad-leav weeds had colonised the space evacuated by those removed by chlorthiam and dichlobenil while couch remained dominant on the other plots. N further herbicide treatments were made in 1968.

The effect of even temporary control of perennial weeds on subsequ cane production was striking. At one site the number of canes tied in in 19 on treated plots ranged from 23-38% more than on control plots. At the s with the mixed weed population, cane numbers were higher only on pl treated with chlorthiamid and dichlobenil. These results give some indicati of the importance of competition from perennial weeds in raspberry plantatio

In an identical experiment laid down in April 1968, under ideal spraying conditions, bromacil and terbacil gave much better control of couch and the infestation on these plots at the end of the growing season was only one-third of the original level, while that on the untreated plots had doubled. Chlorthiamid and dichlobenil again gave excellent initial knock-down of couch, but recovery began in late summer.

Compared with untreated plots, 'furring up' canes immediately after planting in April 1967 did not result in the production of more or longer canes. A repetition of the treatment in April 1968 delayed the emergence of new canes by up to four weeks. However, in 1968 yield per cane was significantly higher on 'furred' than on 'unfurred' plots, but differences in yield per plot were not.

A trial which had received applications of simazine, atrazine, bromacil (all 2 lb. a.i./acre) or chlorthiamid (4 lb. a.i./acre) every spring from 1964-7 inclusive was rotavated in during winter 1967-8 and the area sown with spring barley. This germinated and grew normally until it reached 3-4 in. high when large patches of the crop on plots previously treated with bromacil then turned yellow and died. When the plots were combine-harvested in September, those originally treated with bromacil produced only 52% of the yield of the untreated controls. None of the other treatments depressed yield or produced any visible effect on crop growth.

Strawberries

Simazine, bromacil and terbacil were applied at 0.5, 1 and 2 lb. a.i./acre on 4 July or 15 September to plots of Templar strawberry planted out on 24 April 1967. Apart from slight marginal chlorosis at the 2 lb. rate, no adverse effects of simazine were noted. Bromacil at 1 lb. produced slight chlorosis, while terbacil at 1 lb. and bromacil at 2 lb. caused moderately severe chlorosis. Plants in these plots soon recovered, but terbacil, at 2 lb., severely scorched the leaves and stunted the growth of the crop, a check which persisted in 1968 in terms of smaller plant size. At harvest in 1968 there was no indication of variation between herbicide treatments in terms of numbers of trusses per plant, berry size or yield per plant and no evidence of crop reaction to increasing dosage rates of the three herbicides.

Plots treated with 2 lb. of any herbicide required no weeding from the date of treatment until late November 1968, nor did those treated with 1 lb. terbacil in September 1967. Plots treated at 1 lb. rates were hoed once in June or July 1968 whereas those treated with simazine in July 1967 required hoeing in October 1967 and twice more in 1968. In plots treated with other herbicides at 0.5 lb. rates, weeds had to be removed in June or July 1968 and again in November 1968. There may be a possible place for bromacil and terbacil in strawberries at low dosage rates for annual weed control, and perhaps at the higher rates for spot treatment of perennial weeds.

Vegetables

Further evaluation of C7019 (azoprotryne) on peas, in collaboration with the

Pea Growing Research Organisation, showed that this product compa favourably with prometryne as a pre-emergence treatment, and with dino amine when applied post-emergence, and had no adverse effect on growth yield. The range of weed species controlled by pre-emergence treatme requires further evaluation.

In an experiment on Glamis French bean, dinoseb amine and dino acetate plus monolinuron gave satisfactory weed control without check the crop. Trifluralin and prometryne, while not affecting the crop, failed control the range of weeds present.

Phenmedipham, at 1 lb. a.i./acre, gave excellent weed control in red b grown in 6 in. rows for 'baby' beet production when applied at the cotyled 1st true leaf stage of growth of the crop. Application when the crop around 3 in. high gave good weed control considering the advanced stag the weed growth. Lenacil applied pre-emergence at 2 lb. a.i./acre chec early weed growth, but resistant weeds, particularly fat hen (*Chenopod album*) and fumitory (*Fumaria officinalis*) grew above the crop and shad the foliage on these plots. Plots left unweeded and those treated with lena or phenmedipham at the 3 in. stage respectively yielded 86, 59 and 20% l than the weed-free plots whose total yield of roots was 12.5 tons/acre. Yie from the earlier phenmedipham application were comparable with those the weed-free plots.

With cabbage direct-seeded, trifluralin at 1 lb. a.i./acre again contro weeds more effectively than propachlor at 3.9 lb. a.i./acre. However, wh resistant weeds growing between the crop rows were burned off with shield applications of paraquat/diquat just before singling, and those growing the rows chopped out during singling, subsequent weed growth on eit residual herbicide treatment was minimal. Where hoeing was used a supplementary treatment instead of paraquat/diquat, plots originally trea with propachlor had to be re-hoed six weeks later. Those treated origina with trifluralin required no further hoeing.

Weed competition

From a better understanding of the competitive effects of weeds throughou crop's history, it should be possible to design improved techniques herbicide usage. The results of experiments with spring cabbage, peas a narcissus illustrate the range of effects of weed competition.

In plots of spring cabbage, planted out on 28 August 1967, the ini weed population was removed by hand-weeding at intervals through winter and early spring 1968 and the plots kept weed-free thereafter. T major weed species were annual meadow grass (*Poa annua*) and chickwe (*Stellaria media*). Weed growth increased very rapidly in spring, and chickweed had grown level with or over the top of the crop on unweed plots by late April. Where the autumn and winter weed growth was remo at any date up to 15 April, total weights of saleable cabbage (all lea harvested on 25 May were comparable with those on plots kept weed-f throughout. Totally unweeded plots yielded 35% less than clean plots, w

those weeded on 10 May yielded 28% less. Average size per cabbage marketed was 20-25% lower on unweeded plots and 15% lower on plots weeded in May than on weed-free plots.

A pea experiment, sown in April 1968 was serially harvested throughout the growing season, and weed and crop growth analysed. The cold spring weather produced slow growth for many weeks. When conditions improved the crop grew away very rapidly and completely smothered the weeds. No adverse effects of early weed competition were found when crop data from unweeded plots were compared with those from weed-free control plots. On one treatment the natural weed population was allowed to grow in the absence of a crop. Comparison of weed yield data from cropped and uncropped plots clearly demonstrated the strong competitive ability of the crop in this situation.

Plots of Carlton narcissus were planted out in 28 in. ridged rows on 28 August 1967. The initial weed infestation was removed in mid-November or in mid-March and the plots were kept weed-free thereafter. There were no significant differences in size of bulbs lifted in August 1968 between plots weeded in November, March or kept weed-free throughout. Totally unweeded plots showed no reduction in bulb yield when lifted immediately post-flowering on 29 April, but showed a 24% reduction in bulb yield compared with weed-free plots at a harvest on 7 August. On plots weeded in November or March where the spring weed flush was allowed to develop, bulb yields in August were only slightly reduced relative to plots kept clean. Removal of the spring weed flush on 8 July had no effect on final yield, although the crop foliage was still green and healthy at that time and was heavily shaded by hempnettle (*Galeopsis tetrahit*). Weed removal accelerated foliage senescence. (H. M. Lawson, J. S. Wiseman).

FIELD EXPERIMENTATION

VEGETABLE CROPS

Potatoes

Assessments by the Fruit and Vegetable Preservation Research Association, of tuber samples from last year's experiments (Report 1967 p. 25) showed that none of the treatments affected colour or flavour of King Edward. Furthermore, maturity was the only factor which influenced texture; the more mature the tubers the greater their disintegration upon processing. Maris Peer, Sutton's Foremost and Aura retained cooking quality with increasing maturity. The textural quality of all other varieties declined with age by amounts which varied with variety. Canned samples of tubers of the several varieties grown on moor peat in Aberdeenshire were of similar quality to those grown on the mineral soil at Mylnefield. However, tubers of the same varieties grown on fen peat in Aberdeenshire were of consistently better texture than those grown on moor peat.

In 1968 the effects of planting rate and harvest date on the yield and size

of tubers were examined with crops of Maris Peer grown on a coastal sa soil in conventional 28 in. ridges and in 14 in. rows in beds without ridgin

Seed of 1.5–2.25 in. grade was planted at 2.1, 2.9 and 4.4 tons/acre ridges, and at 2.8, 3.9 and 5.9 tons/acre in beds on 29 April. The ridged cr was sampled for assessment of yield, size grade and canning quality 22 July, 5 August, 13 September and 18 October. Because of their slo bulking rate, samples were taken on only the last three of these dates fr the beds.

Planting rate, either in ridges or in beds, had little effect on total yiel any one harvest date; the yield from the highest planting rate never exceed that of the lowest by more than 1.5 tons/acre. Total yields, averaged o planting rates for harvest dates in chronological order, were 5.6, 9.6, 11.2 a 16.5 tons/acre from ridges and 8.3, 8.8 and 11.8 tons/acre from beds. T corresponding yields of 0.75–1.5 in. grade (canning size) were 4.9, 5.9, and 9.3 tons/acre for ridges and 6.9, 6.9 and 10.0 tons/acre for beds. ridges, the proportion of tubers of canning size increased with increas planting rate. The greatest effect was at the last harvest when, for the 2.1 a 4.4 tons/acre planting rates, 54% and 64% respectively of the total yield w of canning size. There was no comparable effect of planting rate on the cr from beds. At the final harvest about 85% of the total yield was of cann size irrespective of the planting rates.

Peas

Using a lower range of plant densities than in 1967 (5, 10 and 15 plants/sq.f it has again been found that yields and size grade distribution of shelled p of Dark Skin Perfection and Kelvedon Wonder were unaffected by pla density. By contrast to 1967, plant density had no effect on the rate of mat ation between the freezing and canning stages.

In a replicated trial sown on 10 April, 19 varieties, each of which has be shown elsewhere to fulfil the basic requirements of quality, were assessed f yield. Each of the varieties conformed to its normally accepted time maturity. Dates of maturity for the large dark-seeded group of varieties T100 ranged from 11 July to 14 August and for the small, pale-seeded gro at T120 from 1 August to 15 August. Yields this year, as elsewhere, w comparatively low; the dark-seeded group ranged from 44 cwt./acre 67 cwt./acre at T100, and the pale-seed edgroup at T120 from 53 cwt./acre 81 cwt./acre. There has been little consistency in performance or ranking varieties between years and it is at present impossible to define the causes such variation in yield. Studies of the relative importance of the plant pa contributing to yield will be made, and these may indicate where either ag nomic experimentation or plant breeding effort should be directed.

Brussels sprouts

Comparisons of performance were made of Peer Gynt and Thor precisi sown at 3, 6 and 12 in. spacings in rows 18 in. apart without thinning, dir drilled and thinned to 18 x 18 in., and transplanted at 18 x 18 in. The int

row spacings resulting from the three precision-sown treatments were on average, 6, 12 and 24 in. respectively. Seed for each treatment was sown on 26 March, and whole plants were harvested from Peer Gynt on 24 October and 9 December and from Thor on 11 November and 13 January.

The highest total marketable yield of Peer Gynt in October, 8.1 tons/acre, was from the 3 in. spacing, and in December, 11.8 tons/acre, from the 6 in. spacing. Yields from transplanted Peer Gynt were equal to the highest from precision sowing. As plant spacing increased, the proportion of the total marketable yield of sprouts in the freezing grade decreased at the first harvest from 51% to 41%; for the closest and widest spacings respectively the corresponding values for the second harvest were 43% and 36%. By the December harvest, these differences had disappeared; about 37% of sprouts from each treatment were of freezing size.

With the later maturing variety Thor, yields from the transplanted crop were lower than from any of the precision-sown treatments. The heaviest total marketable yield in November, 6.7 tons/acre (39% freezing grade), was from the 3 in. spacing. In January, total marketable yields from this spacing had risen to 8.6 tons/acre (44% freezing grade). Direct drilling produced a high proportion of plants with bent stems, which would make mechanical stripping difficult. Close spacing delayed maturity and reduced the amount of rotting.

Examination of the yield of varieties grown at different spacings showed that the variety x density interaction is of considerable importance in assessing the yield potential of cultivars. In a second spacing experiment, in which growth rates of two hybrids were compared, no differential interaction with spacing was recorded but differences in efficiency of partition of dry matter were apparent. At all spacings Peer Gynt outyielded Thor, though at the two narrowest spacings (1.5 ft. square, and 1 ft. square) the total above-ground dry matter production of Thor was the higher. In both spacing experiments, varieties, on average, matured about one month earlier at 2 ft. square spacing than at 1 ft. square.

Calabrese

The yield of primary heads from the variety Rex, precision-sown on 6 June at a variety of spacings with 200, 400 or 600 units N per acre, was unaffected by nitrogen treatment. Over a six-week harvest period in August and September yield increased from 3.5 tons/acre (7 oz. heads) at the widest spacing of 24 in. x 15 in. to about 5 tons/acre (3.5 oz. heads) at the closest spacing of 12 in. x 7.5 in.

Beetroot

Yield and quality, as influenced by spacing, were examined at sowing rates of 5, 10, 20 and 40 lb./acre in rows 6 in. and 14 in. apart and in a precision-sown treatment of 1 in. spacing in 14 in. rows. The relationship between plant density and total yield was little affected by either row spacings or precision sowing. Total yield fell from 17 tons/acre at 4 plants/sq. ft. to 8 tons/acre at

26 plants/sq. ft., while yield of 0.75–1.5 in. diam. roots rose from a minimum o
1 ton at 4 plants/sq. ft. to a constant 5 tons/acre at and above 14 plants/sq. f

Protected cropping

As in 1967, sweet corn (cv. Seneca Daybreak) cropped satisfactorily whe
direct sown in a furrow and covered with clear polythene, which was late
cut to allow emergence of the seedling plants. The yield was 30% higher tha
from the transplanted crop. Neither the unprotected, direct-sown seed no
the plants raised under black polythene produced a crop.

A variety of crops including cucumbers, tomatoes and aubergines wer
grown successfully in a polythene bubble house erected in April. This hous
with a solid wooden gable end has now survived several severe gales witho
damage.

Variety trials

Details of the performance of varieties of the following crops during 1968 wi
be given in the next issue of the Institute Association's Bulletin: beetroo
broad bean, French bean, celery, calabrese, cauliflower, and spring, autum
and winter cabbage. (R. Thompson, H. Taylor).

FRUIT CROPS

Raspberries

Studies on intra-plant competition were extended by the planting of a
experiment in which growth of cane can be compared with and without th
competition from fruiting cane, and yields can be compared with and with-
out the presence of new cane growth. In the preliminary experiment reporte
in 1967, the comparison of fruit yields is only possible every second year. I
1968 the non-fruiting plots showed excessive development of new cane, and
a thinning treatment was superimposed on half of the experiment. In th
absence of support from mature cane, the young growth had to be tied in
whether thinned or not.

The initial results of attempts to establish raspberry plantations direc
from root cuttings in the field have been encouraging and suggest tha
economies in planting material may be possible.

Rates of cane increase are often low in the establishment years of th
variety Malling Jewel. Cane numbers were increased in 1967 in plots estab-
lished from pot plants grown from root cuttings, compared with stool cane
but the vigour of individual canes was poorer. Cutting back of first year cane
did not produce the expected increase in cane numbers in 1968.

Mechanical harvesting of raspberries will require adjustments in row
spacing and training methods. The effect of this on yield is to be examined in
an experiment planted in spring 1968. The varieties Malling Jewel and Mall-
ing Promise are being compared in standard stooled rows 6 ft. apart and in
15. in. wide 'hedgerows,' 8 ft. apart, thinned or unthinned. Wide spacing may
reduce yield even when cane numbers per row are increased. Past experiments

at the Institute have shown increasing yield with decreasing row spacing,
without an indication of fall-off. The point of inflexion on the yield/row
spacing curve is being determined by using a range of row spacings down to
3 ft., at which spacing the canopy should be near to closed when the new cane
has grown out.

Investigations on field control of *Botrytis cinerea* again showed no
advantage of high pressure (300 lb./sq. in.) over low pressure (50 lb./sq. in.)
spraying. A new systemic fungicide, benomyl, was included this season, and,
like captan and dichlofluanid, the treatment gave an increased yield over
unsprayed controls. The response was small in this year of low incidence of
infection in the controls.

Strawberries

In the trial of nine varieties and seedlings planted in spring 1967, the highest
yield, 245 cwt./acre, was recorded in the Auchincruive seedling, 60BB55.
This was followed by 60BB14 with 181 cwt./acre, Crusader with 150, 57Q20
with 132, Cambridge Favourite with 116, 60BB15 with 114, Templar with
100, Senga Sengana with 84 and Redgauntlet with 81 cwt./acre. Cambridge
Favourite produced the least (4%) and 60BB55 the highest proportion
(18.4%) of damaged fruit, largely caused by *Botrytis*.

In anticipation of the development of mechanised harvesting techniques,
a pilot trial of seven strawberry varieties was planted in 1967. Cambridge
Favourite, Crusader, Redgauntlet, Talisman, Templar and the seedlings
57Q20 and 60BB55 were grown as single and matted rows. The single rows
were planted 9 in. apart, half the normal distance, to encourage trusses to
grow only to the outsides of the row and not into the inaccessible area
between plants. Three picking treatments were applied, two once-over picks
on dates one week apart and a normal picked-over treatment. Templar and
60BB55 produced fruit in well-defined bands when grown in single rows.
Yield was slightly lower than in matted rows but individual berry size was
greater. Varieties which hang well when ripe yielded the same weight of ripe
fruit whether picked once or by the normal successive harvests. The yields
from conventional, single-row plantings of Cambridge Favourite, Redgaunt-
let and Crusader are being compared with those from a complete ground cover
to determine the plasticity of yield components of varieties of differing habit.

A collection of cultivars has been started using 4-plant units, with the
object of screening new varieties from abroad for their performance under
Scottish conditions.

As in the case of raspberries, high pressure spraying showed no
superiority over low pressure for field control of *Botrytis cinerea*, despite the
fact that fluorescent tracer techniques showed better coverage of flowers by
the high pressure spray. As with raspberries the level of infection in unsprayed
controls was light. Benomyl, dichlofluanid and captan treatments all gave
higher yields than the unsprayed controls. (M. R. Cormack).

Experiments with Cambridge Favourite, Crusader, Talisman and Tem-
plar confirmed last year's results with Redgauntlet and showed that green

fruit ripened at all temperatures between 16 and 24°C. Fruit of Crusade ripened the quickest and that of Talisman the slowest. Fruit ripened satisfactorily in darkness but slightly more rapidly when illuminated continuously with fluorescent light. Exposure to 0.2% ethylene for 24 hr. did not accelerate ripening, and fruit stored in atmospheres entirely without oxygen (carbon dioxide, ethylene, nitrogen) did not ripen at all. (D. T. Mason with W. R. Jarvis, Mycology).

In recent years, Cambridge Favourite, the most widely-grown cultivar in eastern Scotland, has suffered from a condition leading to death of up to 50% of the crowns in some plantations. The symptoms – varying degrees of browning of the pith of the crown leading to its eventual death – are similar to those reported for low temperature injury in the U.S.A. Over 60 plantations between Perth and Elgin were examined for pith necrosis during November and December 1968. It appeared to be more severe in inland compared with coastal sites, and its severity increased with the age of the plantations. Further samples from the same plantations will be examined after winter frosting to measure any increase in damage. This study forms part of a larger investigation of the variation in the components of yield in strawberry plantations (D. T. Mason, N. Rath).

Top fruit

The trial of North American apple varieties on four Malling/Merton rootstocks again cropped satisfactorily. As it appears that rootstocks behave here much as they do in the south of England, and as there is no indication of a possible revival of commercial dessert fruit production in Scotland, the trial has now been terminated.

Miscellaneous

Of the highbush blueberry cultivars planted out from pots in 1966, Bluecrop gave the highest yield. About 300 seedlings from the U.S.D.A. were planted in observation plots. Cranberry cultivars, mainly from N. American sources, have been established in peat beds. (M. R. Cormack).

PUBLICATIONS

LAWSON, H. M. (1968). Weed control in transplanted and direct sown *Brassica* crops. *Proc. 9th Brit. Weed Control Conf.*, 312-317.

LAWSON, H. M. (1968). Experiments with herbicides in peas and French beans – a progress report. *Proc. 9th Brit. Weed Control Conf.*, 420-425.

LAWSON, H. M. (1968). Experiments on weed control in red beet grown for bottling as small whole beet. *Proc. 9th Brit. Weed Control Conf.*, 455-460.

LAWSON, H. M. and WAISTER, P. D. (1968). An evaluation of four herbicides for routine weed control in a minimal cultivation management programme for raspberries. *Proc. 9th Brit. Weed Control Conf.*, 916-921.

LAWSON, H. M. (1968). Making effective use of contact herbicides in vegetable crops. *S.H.R.I. Asscn. Bulletin*, **1**, 20-23.

WAISTER, P. D. (1968). Selecting a system for Brussels sprout production. *S.H.R.I. Asscn. Bulletin*, **1**, 17-19.

Mycology

A. R. WILSON

As will be seen from the staff list, there have been a number of changes in the personnel of the Section during the year. We were particularly sorry to part company with Dorothy Spencer who left on the termination of a Potato Marketing Board grant in December to take up full-time domestic duties. Her work has made a considerable contribution not only to our knowledge of potato black scurf but also to our understanding of other soil-borne tuber diseases.

In May, W. R. Jarvis took part in a meeting of specialist workers on strawberry grey mould at the Research Centre, Gorsem, Belgium, after which he visited the Institute of Phytopathological Research (I.P.O.) and the Agricultural University at Wageningen. R. A. Fox visited the Netherlands and Norway in November. In Wageningen he visited the Research and Advisory Institute for Field Crop and Grassland Husbandry, the Plant Protection Service and the I.P.O., and in Vollebekk he discussed recent developments in the control of potato tuber diseases by heat therapy with Mr E. Førsund and co-workers. Both of these visits were made possible by travel grants awarded by the A.R.C.

At the beginning of January, A. R. Wilson resigned after a five-year term as joint-editor of the European Potato Journal and, in May, attended his last Editors' meeting in Wageningen. In September, he attended a meeting of the Council of the European Association for Potato Research in Brest. In October, H. M. Wilson was seconded for a week to the I.P.O. in Wageningen, to assist Dr K. Verhoeff in the commissioning of a new fluorescence microscope and the application of associated tracer techniques to work in progress.

The Section, *en masse*, attended the First International Congress of Plant Pathology in London in July. Papers were read by W. R. Jarvis and R. A. Fox and a demonstration mounted of the potato work in progress. Following the Congress we were glad to receive visits from a number of our overseas colleagues.

Steady progress has been made during the year on most of the Section's projects. With the reduction of W. R. Jarvis's programme on grey mould of soft fruit it will be seen that he has extended his interests to narcissus smoulder, on which he is co-operating with the Glasshouse Crops Research Institute. Now that the investigation of raspberry stamen blight is nearing completion, Isabel Montgomerie is stepping up her programme on strawberry red core; in particular on factors involved in field resistance. As indicated earlier, work on potato black scurf has been terminated and the results will shortly be published.

The Section is looking forward to the provision in 1969 of the new and extensive glasshouse and field laboratory facilities which have become increasingly necessary over the past few years.

As usual, I should like to acknowledge our debt to Dr T. H. Nicolson and his staff at the Botany Department, University of Dundee, for their contribution to our programme of joint seminars during the year. I also wish to thank the many people who gave facilities and assistance to the Section or who supplied samples of fungicides, seeds and other materials. It is unfortunately impossible to mention more than a few of these by name in this Report.

GREY MOULD OF SOFT FRUIT

Effect of fungicides on strawberry and raspberry pollen

Although captan, dichlofluanid, benomyl and Daconil 2787 (tetrachlorisophthalonitrile) applied at various rates and pressures to plants in the field also reduced the germination *in vitro* of pollen collected 2 hours to 2 weeks after spraying, they had no effect on seed set and berry size. (W. R. Jarvis with M. R. Cormack, Crops Research).

GREY MOULD OF TOMATO

The intake of spores into the cut ends of vessels following deleafing has been previously demonstrated (this Report 1961-62 *et seq.*). When plants previously inoculated with spore suspension were placed in a saturated atmosphere, the exudate from petiole stubs contained few spores. When inoculation had been with dry spores, however, many were recovered from the exudate, presumably washed from the cut surface. It is still uncertain whether spores in the vessels lie continuously in water, or in air, or in alternating conditions, but *in vitro*, spores remained viable at 10° to 25°C. for periods of 2-12 months under 9-36 mm. of water or 0.001M solutions of various phenols (1-naphthol was toxic).

The suberisation which occurs at the cut surface of the petiole after severance of the lamina did not prevent infection when inoculations were made with spore suspensions up to 14 days after deleafing. Repeated inoculations (i.e. 'wave infection') were no more effective than single inoculations. Spore concentration in the inoculum within wide limits was of little importance. (W. R. Jarvis).

SMOULDER OF NARCISSUS

Epidemiology and control

Field plots have been established and work begun on the biology and control of *Botrytis narcissicola*. In culture, the mycelium of the fungus tolerated the vapour phase of tecnazene, quintozene and dibromotetrachloroethane[1] when 10 mg. amounts were deposited in petri-dish lids; it also tolerated dichlofluanid at a concentration of 10^{-3}M, captan and thiram at 10^{-4}, dicloran at 10^{-5} and benomyl[2] at 10^{-6}M, in a nutrient medium. Benomyl was also an effective fungicide *in vitro* in combination with heat treatment, though it has not yet been tried on bulbs. The fungus utilised a variety of carbohydrates and polyphenols (not 1-naphthol) and in many cases culture filtrates had considerable macerating activity on potato tuber discs, though cellulase activity was low. (W. R. Jarvis).

[1]Supplied by Crown Zellerbach Corp. Inc.

STAMEN BLIGHT OF RASPBERRY

The collection of spores 12 ft. from the nearest diseased inflorescence indicated that a separation greater than this would be required to ensure that clean stocks were not infected by rain splash from diseased plantations.

In a field trial to compare the effect of captan (75%WP) and Elvaron (50% dichlofluanid) in controlling infection, all spray treatments resulted in significantly less disease the following year when compared with control plots. Captan, at a concentration of 2 lb./100 gal., was superior to captan (1 lb./100 gal.), Elvaron (3 lb./100 gal.) and Elvaron (1.5 lb./100 gal.). Probably because of climatic conditions in 1967, the disease was much less prevalent in 1968.

The results of inoculation experiments suggest that the main factors in successful infection of axillary buds are spore concentration and humidity. In one experiment with Malling Jewel over 60% of inflorescences, developing from axillary buds inoculated in 1967, were diseased. (I. G. Montgomerie).

RED CORE OF STRAWBERRY

Collaborative work is being done with the Plant Breeding Section (p. 42) to help identify factors important in the field resistance of strawberry cultivars to infection by red core (*Phytophthora fragariae*). The results of a field experiment with seven cultivars, duplicated on clean land at Mylnefield and infected land at Auchincruive, showed that they differed in the number of roots they produced. The ranking was the same at each site but cultivars on infected land produced more roots than those on clean land. Temperatures at Auchincruive were higher (71% of days above 5°C. compared with 57%) and this may account for the difference, but it is possible that infection by *P. fragariae* stimulates the production of roots by some cultivars; this is being looked into.

In pathogenicity tests with a number of physiologic races, Merton Herald was susceptible to all of them.

Acknowledgment is made of the co-operation of Mr G. Bruce and Mr A. W. Bruce of Pathhead Farm, Kirriemuir, where the fungicide trial was sited,

[2]Benlate supplied by Du Pont (U.K.) Ltd.,
(1-(butylcarbamoyl)-2-benzimidazole carbamic acid, methyl ester).

and of the advice of the A.R.C. Unit of Statistics, Edinburgh, on the analysis of results. (I. G. Montgomerie, C. M. MacNaughtan).

COLD STORAGE OF STRAWBERRY RUNNERS

Only 3% of untreated Cambridge Favourite runners survived nine months' storage at just below 0°C. Those plants inoculated with pure cultures of *Gnomonia fructicola* or *Botrytis cinerea* survived equally badly. By contrast, the addition of *Cylindrocarpon radicicola* resulted in a significantly higher number of survivors. Of the fungicides tested, thiram (0.16% a.i.), captan (0.15% a.i.) and Wepsyn 155 liquid (0.25%), only thiram effectively increased the number of survivors. (I. G. Montgomerie with C. G. Guttridge, Plant Physiology).

GANGRENE OF POTATO

The results of examining more than 250 stocks in the surveys initiated in 1966 and concluded in 1968, show that nearly all gangrene in Scotland may be attributed to *Phoma exigua* var. *foveata*. All isolates of this fungus tested were killed by exposure to 33°C. for 1 week or 45°C. for 2 hr. Experiments have shown that the erratic results obtained in heating artificially infected tubers at 45°C. in 1967 cannot be explained by potato tissue inducing heat tolerance in the fungus, a phenomenon which can occur when certain heat resistant and heat susceptible organisms are grown together. Increasing rates of air flow in the apparatus used and checking tuber temperatures with adequate numbers of thermocouples ensures uniform heating in current experiments. Heating seed tubers just before planting had the anticipated effect of depressing emergence but the haulm remained green longer compared with the controls.

Inoculating the haulm had no effect on the subsequent incidence of gangrene in tubers of the very resistant cultivar Golden Wonder. In King Edward (resistant) and Pentland Dell (intermediate) the incidences were low but nevertheless many times greater than those obtained from check plots. The higher figures for Majestic (susceptible) and Pentland Falcon (very susceptible) were only a few times greater than the incidences from their check plots.

In 1967 haulm of the cultivar Majestic was destroyed by acid or cutting on three dates and the crop was harvested at three intervals after each date of treatment. The tubers were wounded in January 1968 and assessed for disease 10 weeks later. The early and late treatments had little effect on disease incidence which increased with increasing interval between treatment and harvesting at rates similar to those found in the check plots, but there was a marked increase with the longest interval before harvest (six weeks) following the mid-season treatments. In contrast, acid treatment in 1966 enhanced resistance to artificial inoculation to which tubers from check plots generally became more resistant as the season progressed. In 1967, however, there was a progressive increase in the incidence of natural infection in tubers from

check plots, in which the haulm was still green at the final harvest. Although haulm infection has been shown to be important, pycnidia develop only when the stems become senescent. The foregoing results suggest that inoculum in the soil increases through the season.

Observations in late August 1968 showed that 1 root in 6 was infected by *P. exigua* var. *foveata* in field grown plants of Majestic. (R. A. Fox, E. P. Dashwood).

BLACK SCURF OF POTATO[1]

The haulm of plants grown from scurf-infected seed was destroyed, or not, with sulphuric acid at five dates, from early August to mid-September. Root-infection in acid, but not check plots, increased, often significantly, in the first week from haulm destruction and little thereafter. A similar though less marked rise occurred on stolons. *In vitro* studies suggested that sclerotial initials could form and mature on the mycelial investment on decaying plant parts within a few days. The time necessary for their maturation coincided with the observed time of onset of a marked increase in the number of tubers bearing scurf. No similar rise occurred in check plants which lacked dying roots and stolons.

Spread of infection occurred between tubers stored at 4°C. for eight weeks in both dry and wet environments. Tubers damaged at harvest, inoculated with barley seed infested by *R. solani*, and similarly stored, could act as a further source of infection. Occasionally lesions developed within tubers to produce a dry rot.

A survey of isolates examined in 1967 and 1968 for their cultural characteristics and pathogenicity to different parts of the potato plant, revealed no reliable technique for rapidly assessing the potential pathogenicity of an isolate to sprouts. Further there was no evident relationship between black scurf incidence – which was apparently fortuitous – and ability to infect sprouts which was a pathogenic attribute of a given isolate.

Cytological examination of almost 300 isolates from potato tubers and a few from infected sprouts and stems showed them all to be multinucleate. The isolates represented seed stocks from a wide range of soil types and regions in Scotland. Isolates from sharp eyespot on both wheat and barley were binucleate. The perfect states for the two groups have been shown by American workers to belong to different genera.

Field grown tubers were removed at haulm destruction and two and four weeks later; some were scored for the frequency and depth of penetration of *R. solani* and the remainder placed in store at 4°C. for eight weeks. In general the longer tubers remained in the soil after haulm death, the greater was the incidence and depth of penetration of internal infection. Further increases occurred in storage. Invasion of the cortex, rare in tubers from the field, was more frequent after storage. Visual assessment used in current phytosanitary

[1]This work was supported by a 3-year research grant from the Potato Marketing Board.

inspections must be suspect because of the presence of internal infecti
which would probably escape eradication by fungicidal dips. (D. Spencer).

BACTERIAL SOFT ROT AND BLACKLEG OF POTATO

Previous work has shown that with the exception of some V.T. stock raise
from stem cuttings and still in the early stages of build up, nearly 100% o
tubers of all stocks are contaminated by *Erwinia* (*Pectobacterium*) spp. (th
Report 1967). The quantitative determination of the extent of lenticel co
tamination of stocks first carried out in 1967 was repeated and expanded
November 1968 on 29 stocks representing 18 cultivars grown in Kincardin
shire, Angus and Perthshire, and selected on the basis of their harvesti
dates, from late August to early November. Results previously obtained we
confirmed. Thus the level of lenticel contamination in crops lifted befo
mid-September was relatively lower than in those harvested later. Howeve
in stocks which were lifted in late October and November, the level of lentic
contamination tended to fall off. The critical period for contamination seem
to be late September and early October. Though the contamination le
during this period tends to be high, it varies considerably from one stock
another.

The fact that soft rotting *Erwinia* spp. were found not to overwinter fre
in the soil suggests that the mother tuber is the source of contamination
the daughter tubers. In a field experiment carried out in 1968, the pattern
lenticel contamination of the daughter tubers was studied in detail throug
out the growing season. At the same time, the conditions of the mother tub
(rotting or not rotting) was noted. Daughter tuber contamination could n
be detected up to mid-August. Even when subjected to condition favourab
to rotting, the tubers either did not rot or else, if they rotted, no *Erwinia* is
lates could be obtained from them. Contamination occurred later, apparen
coincident with widespread break-down of the mother tubers in the lat
half of August. From then on there was no gradual build up of contamin
tion, which fluctuated markedly from week to week and eventually fell to
very low level in October and November.

Since daughter tubers are generally located above the mother tuber, a
upward movement of the pathogen in the soil profile must take place.
1968, the fluctuation in the level of contamination appeared to be related
the occurrence of a series of alternating wet and dry spells in September. A
the same time, depending on the amount of soil moisture present, tub
lenticels underwent cycles of active proliferation followed by destructio
suberization and sloughing off of the proliferated cells. Thus, at any one tim
lenticels may or may not be receptive to contamination and to its retentio
(M. Pérombelon).

SUGAR CONTENT OF POTATO TUBERS

The second year's (1967) results while substantially confirming the correlati
between latitude and sugar content did not show the previously obser

correlation between latitude and size of haulm at tuber initiation. The suggested causal relationship between this last and sugar accumulation in the tubers does not, therefore, appear to be valid. Nevertheless, the effect of 'ageing' the seed tubers, as suggested in our previous report, has been investigated.

Half the seed for planting in 1968 was 'aged' by storing at 20°C. for approximately four months (29 Nov. 1967 to 21 Mar. 1968), the remainder being held for the same period at 2°C. Extremes were taken deliberately in order to produce the maximum difference in effect. The number of centres was reduced to 10 but the north-south range covered was the same. On average, plants from aged seed formed tubers 15 days earlier than those from cool-stored seed and, in fact, at 8 of the 10 centres tubers were initiated before emergence. Haulm size in plants from aged seed was much reduced not only at tuber initiation but throughout the growing period. Associated with this there was a marked reduction in the total sugar content of the tubers during the first half of the season but by the mid point of growth this effect was lost. The content of both total and reducing sugars at maturity did not differ appreciably from that found in plants grown from the cool-stored seed.

No evidence was obtained during trials with the 1966 and 1967 crops from the various centres that the latitude where the crop is grown has any significant effect on the storage behaviour of Record or on its reaction to conditioning at high temperature (c. 20°C.).

It should be noted that in all three years of our experiments the content of reducing sugars in mature Scottish-grown Records at lifting, although higher than that of crops grown further south, was, nevertheless, well below 0.25% (f.w.b.), the figure which has been suggested as the upper limit for crisp manufacture. Despite this, certain factories have not regarded Scottish-grown Records as generally acceptable during these three years. We are, therefore, forced to the conclusion that, in fact, a lower upper limit is being operated, possibly about 0.15%. If this is so, it is unlikely that Scottish-grown Records will ever prove generally acceptable for crisping and a substitute will have to be found. Three years of trials in Scotland have shown that the Dutch cultivar Woudster has a reducing sugar content consistently much lower than that of Record and should it prove suitable on other grounds it may provide at least a temporary solution to the present difficulties.

Sincere thanks are due to the Edinburgh and East of Scotland College of Agriculture, the North of Scotland College of Agriculture, the N.A.A.S., and the numerous growers involved, for the facilities provided over the three years of trials. (A. R. Wilson, W. G. Burton[1]).

[1]A.R.C. Food Research Institute, Colney Lane, Norwich.

Seed vigour test

Emergence trials of five different seed lots each of Lincoln and Kelvedon Wonder, sown on several dates at six centres[2] in England and Scotland including Invergowrie, provided 27 different sowing treatments in good and poor soil conditions. Although mean emergence between treatments varied the rank order of the 10 lots remained almost constant. The results of the conductivity and seedling evaluation tests for seed vigour correlated well with mean field emergence. In individual sowing treatments, neither test was clearly superior to the other, but both were better than the germination test as indicators of emergence ability. Seed lots were divided into grades of high, medium, low and very low vigour based on results of the laboratory tests. Only high vigour seed emerged well in the early sowings, medium vigour seed was satisfactory for mid and late season sowings, whilst low vigour seed emerged well only when soil conditions were very favourable.

The co-operation of the collaborators in these trials is gratefully acknowledged.

Electrolyte exudation

Studies on electrolyte release during the soaking of pea seed showed that the rate of release at 20°C. was high for the first 12 hr. and decreased thereafter. Total exudation after 48 hr. was least at 20° and 30°C. and increased progressively at 10°, 6° and 1°C. Similarly, differences in the amount of exudation between high and low vigour samples were greater at the lower temperatures. Increased electrolyte release at low temperature was associated with a drop in germination percentage. Measurements on individual seeds showed that the greater exudation from low vigour samples was due mostly to the occurrence of seeds killed during imbibition, and that the further increase at low temperature resulted from a higher death rate. Germination after soaking at 30°C. was also depressed compared with that at 20°C. but there was no increase in electrolyte release.

Effect of vigour on crop yield

Similar populations of plants from high and low vigour lots of Kelvedon Wonder and Lincoln in plots measuring 75 sq. ft. were obtained by adjusting sowing rates and thinning where necessary after emergence. Yields of shelled peas from high vigour seed were 30% and 54% more, respectively, than those from low vigour seed. Seed vigour did not affect the tenderometer reading and differences in total plant weight per plot were not as great as those of shelled peas. (D. A. Perry, J. G. Harrison).

[2]Official Seed Testing Station, Cambridge.
Department of Agriculture and Fisheries for Scotland, East Craigs, Edinburgh.
Pea Growing Research Organisation, Thornhaugh, Peterborough.
Unilever Research Laboratory, Colworth House, Sharnbrook, Bedford.
School of Agriculture, University of Nottingham, Sutton Bonington, Loughborough.

Phoma idaei on raspberry

A pycnidial fungus, identified by the Commonwealth Mycological Institute as *Phoma idaei* Oud., was associated with firm brown-black lesions on the receptacles of several cultivars, notably Malling Exploit. No great damage was apparently caused to the crop in 1968, though further work on pathogenicity has still to be done. (W. R. Jarvis).

PUBLICATIONS

JARVIS, W. R. (1968). Controlling post-harvest grey mould in soft fruit. *S.H.R.I. Assen. Bulletin*, **1**, 14-16.

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

(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. While such programmes can be based with greater accuracy on analyses of the progress of flowering, they must be modified according to cultivar, season, location, climate and economics).

PERRY, D. A. (1969). Seed vigour in peas (*Pisum sativum* L.). *Proc. Int. Seed Test. Cong.* 1968, *New Zealand* **9**, 8-17.

(Low vigour seed fails in the field partly because it is more susceptible to soil-borne pathogens and partly because its germination is more sensitive to low temperature and anaerobiosis than high vigour seed. Low vigour is a phenotypic character in peas which probably develops before, or during, rather than after harvest. It has been induced experimentally by harvesting immature seed. Vigour tests are described and the application of their results to field conditions is discussed).

PERRY, D. A. (1969). A vigour test for peas based on seedling evaluation. *Proc. Int. Seed Test. Cong.* 1968, *New Zealand* (in press).

(A practical description of the seedling evaluation method of testing for seed vigour).

Plant Breeding

C. NORTH

The decision to release a new raspberry variety is our main item of interes
Work on this project can be said to date back to 1952 when the first cross
were made. However, raspberry breeding did not attain the status of a ma
project until D. L. Jennings was appointed in 1958 with the sole responsibi
for this work. Plant breeding is a long-term occupation and we are pleased th
Glen Clova, the first of our new varieties, has been produced within sixte
years. Pressure from the industry for an alternative to Malling Jewel h
induced us to come forward with a new variety after rather less field test
than we would have liked under more normal circumstances. However Gl
Clova commences to ripen its fruit earlier in the season than Malling Jew
and is likely to fill a gap in the repertoire of varieties quite apart from
probable acceptance in its own right as a productive variety with go
quality fruit.

Our strawberry breeding has always been based on producing varie
which will thrive in red core-infested soil, yet the nature of field resistance
the disease has remained an enigma. Work by H. J. Gooding in co-operati
with Isabel Montgomerie of the Mycology Section has now indicated h
the plant's reaction to infection may help it to combat disease. We are hope
that a development of this work will provide a basis for screening for fie
resistance at Invergowrie when strawberry breeding is transferred fro
Auchincruive. The results may also help us to devise a more reliable test th
is possible under the present system of selecting survivors from plants expos
to infection in the field at Auchincruive.

The main problem for breeders of horticultural *Brassica* crops is t
'break-down' in the production of 'hybrid' varieties leading to a high pr
portion of inbred plants when seed is produced on a commercial scale. O
use of 'glossy' markers helps to detect and then discard the unwanted 'inbre
so that seed of hybrid varieties containing a relatively high proportion
them may still be used for commercial crops. However it is highly desirab
that the 'break-down' should be prevented and J. R. T. Hodgkin was appo
ted to start work in August on some aspects of this problem. We are grate
to Dr G. D. H. Bell for allowing him to work for three months with Dr K.
Thompson at the Plant Breeding Institute, Cambridge mainly to study t
incompatibility system of *Brassica oleracea*.

Other staff changes occurred; D. Bruce resigned in June and his pla
with certain modifications in the duties, was taken by H. McC. Anders
from the Plant Physiology Section. Mrs Gillian M. Innocent resigned

August and Marjorie A. Campbell was appointed to take her place.

I attended the Vth Congress of Eucarpia in Milan and took on the duties of Chairman of the Horticultural Section. H. J. Gooding and D. L. Jennings attended meetings of the N.F.U. Soft Fruit Working Group and Sub-Committees of the National Fruit Trials. H. J. Gooding was also elected to the Committee of the Horticultural Educational Association, Scottish Branch.

We are pleased to see progress in the erection of the Section's new glasshouses. These will provide facilities which we have needed for some years.

BEAN

Twenty-three white-seeded selections of dwarf French bean, derived from crosses made in 1965 between Fullcrop x Record (the parents of Glamis), and the varieties Prelude and Slenderwhite were compared with Glamis in a replicated yield trial. These lines, now in the F_5 generation, were uniform and all had white seeds and stringless pods. Some, which equalled or excelled Glamis for earliness, productivity, pod quality, and habit, will be further line-bred and tested with a view to the release of a new variety from this material. (W. G. Priestley, J. Walker).

BLACK-CURRANT

Cuttings of a number of clones selected for their productivity, large fruit size and erect habit have been sent to Luddington Experimental Horticulture Station. They will be propagated with a view to their inclusion in trials there and at the National Fruit Trials, Brogdale, with special attention given to their suitability for harvesting by the N.I.A.E. prototype black currant harvester. The material includes a Consort (*Ribes ussuriense* derivative) cross and hybrids with the Scandinavian varieties Janslunda and Brödtorp.

Resistance to leaf spot and American gooseberry mildew

Further crosses were made to combine known sources of resistance to these diseases. The parents included *R. dikuscha* seedlings, derivatives from both *R. ussuriense* and *R. bracteosum* and blackcurrant varieties.

A surprisingly high degree of resistance to both diseases was found in a selfed family of *R. nigrum reticulatum*. The bushes were of erect habit, but fruit size and productivity were poor and all showed varying degrees of variegation. Outstanding resistance also occurred in more productive crosses between Anger von Oeffelt x Sztahanovka Altaja, Invincible Giant Prolific x Öjebyn, and a family derived from (Consort x Magnus) x (Brödtorp x Janslunda). (M. M. Anderson).

BRUSSELS SPROUT

Although the F_1 variety No. 9 seems to merit introduction on the basis of its quality and performance, it is still not known whether it can be maintained

on a commercial scale. The decision to release it as a new variety has therefore been withheld at least until the end of 1969. By this time more will also be known about its value for processing, for which it seems best suited.

The F_1 variety No. 13, which incorporates a glossy marker gene to detect inbreds, has not performed in trials as well as had been anticipated. We have better material derived from glossy parents and it has therefore been decided to withdraw No. 13. (W. G. Priestley, J. Walker).

LILY

The last Report stated that embryo culture had been used to obtain hybrid plants from some crosses between *Lilium* species that normally fail to produce mature viable seeds. This technique has been further exploited and the following apparently unrecorded hybrids have now been produced: *L. pyrenaicum* crossed with *L. pomponium*, *L. carniolicum*, *L. ciliatum* (both FS 831 and ACH 50 collections) and *L. monadelphum*; *L. szovitzianum* crossed *L. canadense*; *L. lankongense* crossed with *L. duchartrei*, *L. davidii Maxwill*, L.26 (derivative of *L. tigrinum flaviflorum*), L. x Edith Cecelia (derivative of *L. cernuum*), and *L.* x *maxbile* (*L. maximowizii* x *amabile*). Examination of the karyotypes at mitosis has shown that these are true hybrids. Some of the *L. lankongense* hybrids flowered twelve months after excision of the embryos; they produced honey-coloured, pale mauve or white flowers with the scent of the mother parent though less pronounced.

Using the same technique, a few triploid plants of the Asiatic group hybrids have also been produced. (C. North, A. B. Wills, E. M. Holmes).

RASPBERRY

The early ripening selection known as M9 again yielded well in 1968 both at the Institute and in trials elsewhere. The decision was therefore taken to release the seedling as a new cultivar, named Glen Clova. The performance of the other two advanced selections of this group was disappointing, however, and they have been discarded. Many of the more recent selections under test are derived from back-crosses of an F_1 red raspberry/black raspberry hybrid to the red raspberry. This material is particularly interesting for its high fruit quality and ease of fruit abscission but, with one exception, M14, the winter hardiness of the canes in the second backcross generation was inadequate. This one seedling appeared to have adequate hardiness and gave a high yield of excellent quality fruits, and it and other selections from the third backcross generation are being propagated for further trial. (D. L. Jennings, B. M. M. Tulloch, P. B. Topham).

Resistance to diseases and pests

The results of our collaborative study with Dr H. A. Daubeny, Canada Department of Agriculture, of the inheritance of resistance to mildew in raspberries were published. In this study, analyses based upon a model of continuous variation of mildew resistance were compared with others based upon a model of discontinuous variation caused by segregation of three major genes. Resistance was assessed by scoring the severity of the disease on leaves, and a synopsis of the conclusions is given at the end of this Report. Although new observations in 1968 confirmed the ratings of parents as sources of resistance, it was disconcerting to find no correlation between the behaviour of seedlings in successive years or between mildew infection of the leaves and infection of the fruit, either green or ripe. Resistance in the fruit occurred most frequently in seedlings whose fruit had a shiny skin appearance. This possible relationship is being studied further. (D. L. Jennings, B. M. M. Tulloch, P. B. Topham).

Mention was made in the 1966 Report (p. 70) of attempts to transfer resistance to the raspberry beetle (*Byturus urbanus*) from *Rubus phoenicolasius* to the raspberry. F_1 hybrids between *R. phoenicolasius* and the raspberry were susceptible, as were hybrids obtained by backcrossing to the raspberry, but tests in 1968 revealed two apparently resistant seedlings in a progeny obtained by selfing one of the latter. Further tests will be necessary to confirm this result but crosses with both seedlings are being made in an attempt to combine beetle-resistance with improved fruit quality. (D. L. Jennings with C. E. Taylor, Zoology).

Fertility studies

Further attempts were made to improve the success of sub-fertile crosses by treatment of the developing fruits with growth substances. The crosses studied included crosses between distantly related parents and others where the parents differed in ploidy. In most cases druplet set was improved when an aqueous solution containing 100 p.p.m. gibberellin, 50 p.p.m. beta-napthoxyacetic acid and 50 p.p.m. *para*-chlorophenoxyacetic acid was applied 4 or 6 days after pollination, though for some crosses the set was no better than when gibberellin was used alone. However, from gibberellin-treated fruits a smaller proportion of the pyrenes contained seed and the average size of seed and embryo was slightly decreased. The success of the treatments must therefore be assessed from the numbers of seedlings obtained when germination is complete. (P. B. Topham, D. L. Jennings, B. M. M. Tulloch, E. Carmichael).

Mechanical harvesting

The last Report mentioned experiments done in collaboration with the National Institute of Agricultural Engineering with a test rig simulating the action of an American picking machine. In general the results in 1968 supported those of 1967. Weather conditions during the picking season were again favourable and fruit could be left to an advanced stage of ripeness without much deterioration. At this stage good fruit samples were shaken from Malling Jewel and Burnetholm. At a less advanced stage, Burnetholm was harvested more successfully than Malling Jewel; fruit of Malling Seedling M tended to crumble at any stage. To study the effects on the plants a record

was made on high speed film. Interpretation of this is incomplete but a preliminary scan suggests that the most effective action for removing fruit is one which causes the pedicels and fruit to swing in a pendulum-like motion out of phase with the motion of the fruiting laterals. This situation tended to occur when the canes were first engaged by the shaking action, the shake becoming less effective as the movement of fruits and laterals came into phase with each other. (D. L. Jennings).

STRAWBERRY

Three of the nine seedling selections (progenies of Crusader x Redgauntlet) sent to the National Fruit Trials in 1964 have been recommended by the N.F.T. Sub-Committee for Strawberries to be considered for release by the Institute. Although only one of them continues to show promise of field resistance to red core the results of regional trials are awaited with interest, not so much for information on yield, which appears adequate, as for assessments of fruit quality, particularly firmness and carrying quality. All three seedlings are being virus-tested at East Malling to shorten the delay in their release once a decision has been made. Several more seedling selections from crosses made in 1961 and 1963, including some firm-fruited selections, have been sent to the N.F.T. for testing.

Because of the need to incorporate greater fruit firmness in our seedlings, the search is being continued for genetic sources of this character. Several unnamed seedlings from the U.S.A. which have very firm fruits are being used as parents in the breeding programme. Attempts are being made to devise a laboratory test for carrying quality, and indirectly for firmness, by shaking the fruits in a standard device and assessing the condition of the fruit some hours later.

Breeding survey

A partial survey of Mr Reid's crossing programme was made, involving 400 progenies derived from crosses among 70 parents, of which 41 were cultivars. The results show that new varieties were selected from small families that had a higher than average percentage of good seedlings. This suggests that successful breeding is likely to be the outcome of large numbers of crosses with probably no more than 200 seedlings per family, rather than the production of large families of relatively few crosses.

Field resistance to red core

Considerable effort has been put into an attempt to elucidate the nature of field resistance. A co-operative field experiment with Dr Montgomerie has indicated that plant vigour, as measured by scoring the above-ground parts of the plant grown in red core-infected soil, is usually correlated with percentage length of diseased root. Thus measurement of diseased roots may give an assessment of field resistance, and further evidence for this is being sought in a long-term field experiment. The experiment also confirms previous

observations that 53Q13, a selection derived from crossing with *Fragaria virginiana*, is our most resistant genotype. Auchincruive No. 6 in these trials ranked next in resistance to 53Q13 and also merits further testing as a parent.

A glasshouse experiment with 10 selections, all susceptible to a single race of the pathogen (B66-11 isolate 74), showed that these varied greatly in the extent to which their roots became diseased. The highly resistant seedling, 53Q13, had the least amount of diseased roots. However, some of the most severely diseased clones, such as Talisman, were apparently able to survive by producing a large number of new roots in the presence of the fungus; a capacity which might well explain their 'field resistance.' It will be interesting to discover whether Cambridge Favourite also has this capacity, since it is susceptible to all known races and yet has the ability to survive in all except the worst field conditions for red core infection.

These experiments have been devised primarily to study the nature of field resistance, but they may lead to the design of an efficient screening test for use on a laboratory scale, alternative or supplementary to the assessments made by exposure to red core-infected soil in the field.

Since there is a delay in the testing of new seedlings if it is necessary to wait for them to produce runner material for a red core test, an attempt was made to root isolated leaves for this purpose. This proved highly successful and the technique will be exploited further.

Breeding studies

Data from the progenies of 18 parents were analysed by the method of fitting constants to estimate the additive contribution of each parent to the field resistance of their progenies to red core. The analysis of variance showed that most of the variation could be attributed to these additive effects, though there were also significant interactions between parents, indicating specific combining ability effects.

A seedling from the cross Siletz x Talisman and a 53Q13 derivative had very high 'parental values,' reflected in their phenotypic behaviour, while Cambridge Favourite ranked higher as a parent than Crusader, Redgauntlet or Gorella. With the exception of 53Q13, which has *F. virginiana* in its pedigree, most of the other parents with high values for field resistance have Etter's seedlings in their pedigree and may therefore owe their resistance to *F. chiloensis* ancestry. (H. J. Gooding, K. C. McConnell, E. N. Bent, G. M. Innocent).

GENETICAL AND CYTOLOGICAL STUDIES

Genetics of Brassica oleracea

To obtain further markers for gene linkage studies, seedlings and mature flowering plants in lines derived from selfing commercial varieties and lines from irradiated seed were examined. Particular attention was given to seedlings, since seedling markers allow early scoring and may prove valuable in F_1 hybrid programmes if the character can be easily observed.

A mutant form isolated from Cambridge Special had funnel-shaped cotyledons, fused along the outer edges, and was easily distinguished from normal forms. Hairy first leaf in kale (described by Thompson) shows poor penetrance and expression when heterozygous in hybrids with other *B. oleracea* types. However, similar phenotypes have been isolated from three other sources and in one line of winter cauliflower the character is strongly expressed over the whole growing period. Nine glossy foliage mutants have now been collected; six recessives, at least four of which are at independent loci, two dominants of unknown relationship, and another as yet untested.

Mature plant characters so far isolated affect mainly flower morphology and colour. Forms with strongly reflexed petals occurred in derivatives of Winter Pride cabbage and others with petal margins rolled upwards along the long axis were isolated from several lines, including Cambridge Special Brussels sprout. A line from irradiated seed gave a form resembling *crinkly petal* with petals crumpled and folded outwards in the bud. In addition to the three flower colours, white, cream and yellow already described in the literature, a fourth type with pale yellow flowers was frequently isolated, especially from irradiated lines. Interestingly, cream petal was also found in some of the same irradiated lines. The base of the petal lamina in some yellow and pale yellow-flowered lines was of much paler shade than the remainder of the lamina.

There are few easily scored vegetative characters in *B. oleracea*. However, segregation for long and short internodes has been identified in glasshouse-grown progeny from Shetland cabbage, and forms of Brussels sprout without axillary buds have been collected from two different sources.

Raphano-Brassica hybrids

Studies of interspecific and intergeneric hybrids offer a possible means of analysing intragenomic homologies. Previous attempts to produce hybrids between *Raphanus sativus* (culinary radish) and *Brassica oleracea* proved unsuccessful but diploid hybrids between French fodder radish and thousand-head kale were supplied for cytological examination by Dr I. H. McNaughton, Scottish Plant Breeding Station. Analysis of pachytene and subsequent stages of meiosis indicated the occurrence of both allo- and autosyndesis. Bivalents, trivalents and quadrivalents were observed together with an association of five chromosomes. The range of bivalent number at metaphase was usually from one to three, although PMCs showed from one to nine segments with chromomere correspondence varying from those with only minor resemblance to others with apparently complete homology.

The hybrids were quite sterile except for one plant on which seeds were formed at the end of the season. Ten seeds were sown and all germinated to give seedlings of obvious hybrid appearance and with a range of chromosome number from 23 to 30, including a few euploids with 27. This plant has been propagated by cuttings and will be used in an attempt to produce new combinations in controlled pollinations.

Hybrids between fodder radish and several forms of *B. oleracea* were produced and are expected to flower in the spring of 1969.

Incompatibility in B. campestris

Self compatibility in yellow sarson (*B. campestris*) has been reputed to be associated with chromosome inversion. Because the genetic control of fertility in *Brassica* species is important in relation to problems of hybrid breeding, cytogenetic and incompatibility studies have been extended to forms of *B. campestris*. Fluorescence microscopy has confirmed complete germination of self pollen on mature stigmas of yellow sarson with large numbers of tubes growing in the style. By contrast no pollen germinated in selfed brown sarson, while Burma sarson was unusual in that most pollen grains germinated and some developed lengthy tubes but these did not penetrate the stigmatic papillae. (A. B. Wills, S. Fyfe).

PUBLICATIONS

DAUBENY, H. A., TOPHAM, P. B. and JENNINGS, D. L. (1968). A comparison of methods for analysing inheritance data for resistance to red raspberry powdery mildew. *Can. J. Genet. Cytol.*, **10**, 341-350.

(Analysis based on a model for discontinuous variation supported the hypothesis that segregation was controlled by two additive genes for resistance and one epistatic gene for susceptibility. Analysis based on a model for continuous variation indicated that inheritance was predominantly additive with significant genetic interactions. The latter analysis took account of different gene viabilities, of modifying genes and of environmental influences on the expression of disease, and estimates obtained of parental contributions to their progenies were therefore more widely based).

JENNINGS, D. L. and CORMACK, M. R. (1969). Factors affecting the water content and dormancy of overwintering raspberry canes. *Hort. Res.* (in press).

(Application of nitrogenous fertilizer or premature autumn defoliation prevented the water content of raspberry canes from dropping to the low levels of untreated plants in mid winter, and this effect was correlated with a delay in response to spring conditions. These results are discussed in relation to possible variation in the time when the canes became dormant.

Changes and fluctuations in water content from early to late winter are compared for canes of the cultivars Malling Promise, Lloyd George and Norfolk Giant).

WILLS, A. B. (1969). Chromosome behaviour in *Lilium* cultivar 'Redbird,' a complex species hybrid. *Caryologia* (in press).

(*Lilium* x 'Redbird' is a complex hybrid involving *L. concolor*, *L. dauricum*, *L. tigrinum* (diploid) and *L. bulbiforum* var. *croceum*. The karyotype shows numerous differences between chromosome pairs, and irregularities at meiosis include a complex bridge with four centromeres from an inversion-duplication multivalent. These result in reduced pollen fertility. Evidence of extensive homologies between complements in species crosses suggests that cultural techniques to overcome embryo-endosperm incompatibilities should allow the synthesis of a wider range of hybrids in the genus).

Virology

B. D. HARRISON

The Section lost one member and gained several others. In April, J. Cathro left after having spent fourteen years at the Institute, the last ten doing electron microscopy in the Virology Section. In September, O. W. Barnett, from the University of Wisconsin, joined the staff for a year to work on raspberry viruses, and in October M. A. Mayo took up his appointment to study mechanisms of virus infection. Mrs A. Zlata Štefanac arrived from the University of Zagreb to spend a year with us at the expense of the British Council. Aileen M. Kinninmonth was transferred from the former Plant Physiology Section, and Linda Kermath was appointed.

H. S. Abu Salih was awarded the degree of Doctor of Philosophy of the University of St. Andrews, and returned to the Sudan. I. M. Roberts obtained a Higher National Certificate. I gave an invited lecture at the University of Strasbourg. W. P. Mowat read a paper at the Second Symposium on Virus Diseases of Ornamental Plants, held at Lyngby, Denmark, and was supported by a travel grant from the Agricultural Research Council. Several members of the Section attended the First International Congress of Plant Pathology in London, and contributed to the exhibit of the Institute's work. The Director and I organised the symposia on plant viruses and virus diseases; A. F. Murant, R. A. C. Jones and I read papers. Both before and after the Congress we were glad to receive visits from many plant virologists from overseas.

In October, the Siemens electron microscope was moved to more convenient and much improved accommodation in the main laboratory block. Equipment grants for the year enabled several major additions to be made to our apparatus. The new ultra-microtome, analytical ultracentrifuge and microdensitometer are in use and four small plant growth chambers are about to be installed.

Although its emphasis may have changed somewhat, most of the research described below, as last year, concerns viruses of *Rubus*, potato, umbelliferous plants and bulbous ornamentals. Among the new lines of work described are the detection of viruses in lilies, the first record for Britain of a plant disease associated with a mycoplasma-like agent, and the first indications of how environmental factors determine the development of symptoms of virus infection in potato tubers.

ELECTRON MICROSCOPY

The move of the electron microscope to its new accommodation in the main laboratory block provided the chance to introduce a more functional layout of facilities and equipment, using little extra floor space. In addition to the specimen-preparation laboratory and air-conditioned microscope room, two small dark rooms for photographic developing and printing were constructed, plus two cubicles which respectively house the ultramicrotome and provide an office. The increase in pressure on microscope time can be seen from the 90% increase in numbers of photographic plates used by the Section during the year. (I. M. Roberts).

INTRACELLULAR BEHAVIOUR OF TOBACCO RATTLE VIRUS

Location of virus particles

Last year we reported the association of the longer particles of strain CAM with mitochondria in the cells of young systemically infected *Nicotiana clevelandii* leaves; the shorter particles were found in the cytoplasm. Further work showed that the distribution of virus within cells depends on many factors. When individual systemically infected leaves increase in age, their total content of infective virus changes little but the number of virus particles associated with mitochondria decreases, and the particles that remain associated are heterogeneous in length. In inoculated leaves, relatively little virus is associated with the mitochondria at any time. Also, in young leaves systemically infected with a second strain of the virus, the virus particles were found in the cytoplasm, unassociated with the mitochondria. These observations do not show whether the mitochondria are sites of virus assembly or sites where already formed virus particles become adsorbed. However, the discovery of cells in which five or more mitochondria were linked by large numbers of the longer virus particles shows that both ends of the particles can be involved and makes adsorption the more plausible explanation. (B. D. Harrison, I. M. Roberts).

A different approach is needed to solve this problem, and with this aim a start was made in linking tissue fractionation studies with direct electron microscopy. When intact infected tissue was centrifuged, virus particles remained attached to mitochondria, even when these were moved to another part of the cell. These observations and those of isolated mitochondrial fractions suggest that the association between virus particles and mitochondria is not easily disrupted. (M. A. Mayo).

X-bodies produced by defective isolates

The amorphous inclusion bodies known as 'X-bodies' can develop in cells infected with any one of several viruses, and may be sites of synthesis of virus protein. However, a defective isolate of tobacco rattle virus, unable to produce virus coat protein, was found to cause the formation of X-bodies, whereas its parent non-defective strain did not. These structures can be digested with pronase, and fluoresce red when treated with acridine orange and examined by fluorescence microscopy. Pre-treatment with ribonuclease does not abolish the red fluorescence unless itself preceded by exposure to

dilute pronase solution. The X-bodies therefore seem to contain large amounts of RNA, which is protected from ribonuclease by proteinaceous material. Ultra-thin sections examined with the electron microscope show that these X-bodies contain complex membraneous vesicles of characteristic appearance. (B. D. Harrison, A. Z. Štefanac, I. M. Roberts).

NEMATODE-BORNE VIRUSES

Strawberry latent ringspot virus

The virus was found to be seed-transmitted in raspberry (75%), *Stellaria media* (97%), *Senecio vulgaris* (20%), *Lamium amplexicaule* (73%) and *Capsella bursa-pastoris* (4%). It therefore seems to resemble other NEPO viruses in being transmitted through the seed of many of its host plants (A. F. Murant, R. A. Goold).

In graft-transmission tests, the virus infected the raspberry cultivars Malling Enterprise, Malling Exploit, Malling Jewel and Malling Promise but not Cuthbert, Burnetholm, Malling Landmark, Lloyd George and Seedling M. This pattern of susceptibility among raspberry cultivars is the same as that shown to the common Scottish strain of raspberry ringspot virus, suggesting that the same gene or genes may be involved in its determination (J. Chambers, A. F. Murant).

NEPO viruses in narcissus

When four narcissus cultivars were grown at sites infested with raspberry ringspot and tomato black ring viruses, some plants of Carlton were infected with raspberry ringspot virus after a year, but no infection was detected in Golden Harvest, Sempre Avanti or Yellow Cheerfulness.

In earlier tests these viruses were readily detected in narcissus by inoculation of leaf sap to *Chenopodium quinoa* or by serological precipitation tests of flower sap in agarose gel. However, the finding of raspberry ringspot, tomato black ring and arabis mosaic viruses in individual plants of Double White narcissus that seemed free from them in the previous year, plus other observations, suggest that these viruses may be slow to establish complete systemic infections. (W. P. Mowat).

Tobacco rattle virus in potato

The spraing disease caused by tobacco rattle virus was much commoner in commercial crops in 1968 than in 1967, and at some outbreaks more than 90% of the tubers were affected. Outbreaks were commonest on soils derived from fluvioglacial and river terrace sands, or from raised beach deposits; they were found on nine soil associations of these types. Outbreaks occurred less commonly on till soils, and were found on four such soil associations. Soils liable to infestation with tobacco rattle virus therefore comprise one-fifth of Scotland's arable acreage. The vector nematode *Trichodorus primitivus* occurred at all tobacco rattle virus outbreaks; *T. pachydermus* also occurred at those on very sandy soils (less than 14% clay).

When moist soil containing virus-carrying *Trichodorus* was kept fallow in the glasshouse, the nematodes ceased to transmit tobacco rattle virus after six weeks, although some were still active. In the field such nematode populations presumably reacquire the virus from plant hosts, which include weeds (e.g. *Stellaria media*) in which it is occasionally seed-borne. Infected weed seeds may thus be a source of over-wintering virus. However, plants of *Stellaria media* may also survive all but the most severe winters, and at one site 80% of those collected in January were systemically infected.

In preliminary tests made in collaboration with P. R. Thomas (Zoology), spraing developed in only 1% of tubers from plots on a sandy soil previously treated with the nematicide D-D at 200 or 400 lb./acre, as compared with 92% in untreated plots. These treatments also greatly decreased the amount of infection of cucumber seedlings grown in the glasshouse in soil samples collected from the plots.

Attempts were made to find the basis of field-immunity to tobacco rattle virus in potato cultivars such as Arran Pilot. Leaves and roots of these cultivars were infected with the virus by inoculating them with infective sap. The inoculated leaves developed more discrete, darker brown lesions than did leaves of spraing-susceptible cultivars. Nucleoprotein particles of tobacco rattle virus were more numerous in sap from leaves of spraing-susceptible than of field-immune cultivars, and larger amounts of infective material were extractable, either with the aid of phenol or in buffer, from the susceptible varieties. With both kinds of variety, the infectivity of extracts made using phenol exceeded that of buffer extracts. No difference was found between field-immune and susceptible cultivars in ability to support populations of *Trichodorus* spp. in pot experiments (but *Stellaria media* was superior to any of the six potato varieties tested). Field-immunity therefore seems to depend on some facet of the interaction of virus-carrying *Trichodorus* spp. with potato tubers, or on failure of the virus to move from the initially infected cells into the surrounding tissue. Spraing was induced in tubers of Pentland Dell, Alpha and King Edward (but not Arran Pilot) by inoculating them with purified preparations of tobacco rattle virus; spraing did not develop, however, when the nucleic acid of a defective isolate of the virus was used as inoculum. (J. I. Cooper, B. D. Harrison).

OTHER VIRUSES IN FLOWER BULBS

Lily viruses

A study was begun to find which viruses are involved in the well-known decline in performance of stocks of lily. Cucumber mosaic virus was obtained from Asiatic lily hybrids, and separate sources of two elongated viruses, about 650 nm. and 780 nm. long respectively, were found in *Lilium formosanum*. Both viruses were transmitted in a non-persistent manner by aphids, the 780 nm. virus by *Myzus persicae* and *Macrosiphum euphorbiae*, and the 650 nm. virus by *M. persicae*. When transmitted by aphids to Asiatic lily hybrids, the 780 nm. virus caused a mottle in one clone but veinal necrosis,

usually followed by complete necrotic collapse, in another. This suggests tha these hybrids contain sources of tolerance useful to plant breeders. No hos outside the Liliaceae was found for either of the two elongated viruses (A. Z. Štefanac, W. P. Mowat).

Double White narcissus

Flower blindness seems to occur in all stocks of this cultivar and up to 70% of plants may be affected. Its cause is unknown and attempts to implicate virus were unsuccessful. Trials over the past four years showed that th disease did not always recur in a given plant in successive years, and tha production of normal flowers was affected by the time when the bulbs wer lifted, and the length of the period before they were replanted. Thus in on trial a delay of three weeks, in lifting or replanting, considerably decrease the number of plants that emerged in the first year and the number of flower produced by these plants. Also, both Nemafos and hot water treatmen improved emergence and flower production, although there was no evidenc that these effects were caused by control of stem and bulb eelworm. (W. P Mowat with D. H. Turner, East of Scotland College of Agriculture).

Meristem-tip culture was used in an attempt to produce virus-free plant of this cultivar. The meristem tips were supplied with a variety of nutrien media, and many of them survived and grew. However, after a year there wa still little evidence of differentiation. Narcissus (Double White) seems mor difficult to culture than some other bulbous ornamental species. (J. Chambers).

RUBUS VIRUSES

Raspberry propagation

During the year the Scottish Nuclear Stock Association was formed. Th functions of this body include the propagation of stocks of plants raised b the Institute, and we shall therefore be relieved of much of the routine wor involved in multiplying virus-tested stocks of raspberry for distribution t growers. In 1968 all our cane nurseries obtained Special Stock Cane certifi cates, and almost 80,000 canes were made available to the S.N.S.A. Most o these were Malling Jewel (39,000) and Malling Promise (28,000). In the la spring of 1968, 5,000 young plants were also handed over to the S.N.S.A. fo field propagation at two sites, one in Angus and the other in East Perthshir The plants established well at both sites and should produce a good crop o cane.

In tests to find whether poor production of shoots by root cuttings caused by unusually mild winter weather, boxes of root cuttings were store at either —1°C. or +4°C. There was no difference between treatments in th numbers of shoots produced, but the onset of shoot production was delaye by eight days, and the period of shoot production similarly shortened, at th lower temperature. (J. Chambers).

Raspberry bushy dwarf virus

An isolate of this virus from Lloyd George raspberry infected 47 species in eleven plant families, most of them symptomlessly. It differed considerably in its effect on many species from apple chlorotic leafspot virus (isolate C-8 of Lister, Bancroft & Nadakavukaren, 1964) and apple stem grooving virus (isolate E-36 of Sequeira, 1967). *Atriplex hortensis*, *Celosia plumosa*, *Chenopodium amaranticolor*, *C. botrys*, *C. quinoa* and *Cucumis sativus* developed systemic mottling. *C. quinoa* seems the most suitable plant for propagating the virus, and *Vigna cylindrica*, which produces minute necrotic lesions, for assaying infectivity. *C. quinoa* sap became non-infective when stored between 72 and 96 hr. at 22°C., when heated for 10 min. at between 60°C. and 65°C. or when diluted to 10^{-4} but not to 10^{-3}. Infectivity survived at least 3 months at −15°C. At 20°C., infectivity decreased less rapidly in the presence of 0.002 M 2-mercaptoethanol but more rapidly in the presence of sodium diethyl dithiocarbamate. Much infectivity was lost on treatment with ether or chloroform, but all remained after addition of bentonite (2 mg./ml.). All infective material was precipitated by protamine sulphate. (O. W. Barnett, A. F. Murant).

POTATO MOP-TOP VIRUS

In a further small-scale survey of commercial crops, the incidence of infection resembled that found in 1967. Many stocks of Arran Pilot and Red Craig's Royal contained diseased plants but in few was their incidence more than 5%. Massive infection from the soil seems uncommon, probably because few fields are heavily infested. Results of testing soils taken from ten farms showed that where the virus occurred, several neighbouring fields were likely to be infested. Soil was infested throughout the ploughed layer but the intensity of infestation can range from nil to heavy in different parts of a field. Heavy infestation occurred particularly at points where clamps were sited in previous years. Some fields were still infested eleven years after having grown potatoes.

Potato mop-top virus can persist for long periods in dormant spore balls of its fungus vector, *Spongospora subterranea*. However, it seemed possible that in the field both fungus and virus might also survive by infecting plants other than potato. Following exposure to spore balls in glasshouse conditions, zoosporangia indistinguishable from those of *S. subterranea* were produced in the roots of 68 species in 19 families of flowering plants, and also in the gymnosperm *Picea sitchensis*. Species differed greatly in susceptibility to *S. subterranea*. Members of the Solanaceae, Chenopodiaceae and Cruciferae were good or moderate hosts. Other families contained some good and some poor hosts or, as with the Gramineae, contained only poor hosts and uninfected species. The better hosts occurring on arable land include sugar beet and several common weed species. Of these plants, only sugar beet and *Solanum nigrum* became infected (slightly) with the virus when exposed to virus-carrying spore balls. Further tests are needed to find whether the virus can be retained by *S. subterranea* when colonizing virus-immune plants.

The virus was transmitted to rooted potato sprout cuttings by exposi them to virus-carrying spore balls of *S. subterranea*. Primary spraing dev oped in Arran Pilot tubers exposed to such inocula, but secondary spra centred on the stolon, was produced in tubers from cuttings inoculated bef tuber initiation had begun. When infected tubers were grown on, the sho developed yellow mottling, chlorotic chevrons and mop-top symptoms.

The symptoms produced by potato mop-top virus in inoculated toba leaves depend on the environmental conditions. In leaves of plants kept natural light, a virulent isolate of the virus produced necrotic spots at 14 rings at 18°C. and no symptoms at 22°C. When plants were transferred fr 22°C. to 14°C., necrotic rings developed whose diameter increased w increasing time at 22°C. At 14°C., lesions did not develop in continu darkness, but rings appeared when the plants were transferred to light (8 h day). The reaction of tubers to infection with potato mop-top virus in p parallels that of leaves. Naturally infected tubers at the soil surface develop obvious spraing whereas those from greater depths were almost symptomle at harvest. The almost symptomless tubers produced pigmented rings af storage in darkness, first at 18°C. and then at 13°C. No symptoms appea in tubers kept only at one or other of these temperatures. Second and th rings were produced by further cycles of storage at 18°C. and 13°C. T necrotic reaction in leaves therefore needs light but that in tubers does n neither reaction prevents the virus from spreading. Necrosis seems to oc only at the boundary of the virus-invaded zone, and then only in cert conditions. (R. A. C. Jones, B. D. Harrison).

POTATO WITCHES' BROOM DISEASE

In 1967, Japanese workers found mycoplasma-like bodies in plants affect by various yellows and witches' broom and yellows-type diseases, previou thought to be caused by viruses. We have found similar bodies in pot plants affected by witches' broom, a disease that occurs sporadically in t best stocks of Scottish seed potatoes. These bodies were found in ultra-t sections of phloem sieve tubes from affected potato shoots and root, but n in healthy plants. They are pleomorphic, 200-800 nm. in diameter, bound only by a unit membrane and have ribosome-like contents. They were a found in graft-infected tomato plants. (B. D. Harrison, I. M. Roberts).

CARROT AND PARSNIP VIRUSES

Work with carrot mottle virus showed further similarities to some lip containing viruses of vertebrates. The virus loses its infectivity when expos to ether, chloroform or sodium deoxycholate. Also, like other envelop viruses, it loses infectivity rapidly at –15°C., but is protected by 10% dimet sulphoxide against damage caused by repeated freezing and thawing.

An improved method was developed of purifying parsnip mosaic vir which has flexuous particles with a modal length of 750 nm. Like ot viruses in the potato virus Y group, it readily aggregates during purificati

Preparations made from inoculated leaves of *Chenopodium quinoa*, using 8.5% butanol, contain in addition to the virus many isometric particles of 10 nm. diameter, thought to be phytoferritin. These sediment heterogeneously in rate zonal sucrose density gradients. Exclusion chromatography on columns of 2% agarose beads (Sepharose 2B) proved to be a convenient way of separating the virus from these contaminants. (A. F. Murant, R. A. Goold).

PUBLICATIONS

ABU SALIH, H. S. (1968). Sensitive serological tests and their use in studies on the accumulation of parsnip yellow fleck virus in *Spinacia oleracea* L. Ph.D. Thesis, University of St. Andrews.

ABU SALIH, H. S., MURANT, A. F. and DAFT, M. J.[1] (1968). The use of antibody-sensitized latex particles to detect plant viruses. *J. gen. Virol.*, 3, 299-302.

(Antibody-sensitized latex particles or tanned red blood cells were compared for detecting arabis mosaic, narcissus mosaic, parsnip yellow fleck, raspberry ringspot, tobacco rattle and turnip yellow mosaic viruses. Sensitized red cells were 8-40 times more sensitive than latex particles for detecting the viruses but, except when maximum sensitivity was needed, the latex test was preferred because sensitized latex particles were easier to prepare and used less antibody. The latex test, slightly modified from the procedure described by Bercks (1967), was 12-100 times more sensitive than the tube-precipitin test, worked with purified virus preparations and with infective sap, and could be read after 10 minutes).

GIBBS, A. J.[2] and HARRISON, B. D. (1968). Realistic approach to virus classification and nomenclature. *Nature, Lond.*, **218**, 927-929.

(Types of virus classification, and their use as a basis for naming of viruses, are discussed. It is argued that the most useful classifications will be those based on many characters. Computers can be used to handle the mass of relevant data needed to make such a classification. However, relatively few viruses are yet studied in enough detail to be classified in this manner, though all must be named. The solution suggested is to use a designation made up of two functionally different parts, one of the vernacular name which would be a convenient and unchanging label for use in conversation, etc., and the other an internationally agreed code or cryptogram such as that previously proposed, which would be added to convey information on several properties of the virus. The merits of this system are discussed and criticisms answered).

HARRISON, B. D. and ROBERTS, I. M. (1968). Association of tobacco rattle virus with mitochondria. *J. gen. Virol*, 3, 121-124.

(In ultra-thin sections of young leaves of *Nicotiana clevelandii* systemically infected with the CAM strain of tobacco rattle virus, the 190 nm. long virus particles were associated with mitochondria and not found free in the cytoplasm. The particles were arranged so that their long axes were perpendicular to the outer mitochondrial membrane with one end closely appressed to it. Many individual mitochondria had 100-500 associated virus particles. The 52 nm. long virus particles were found in the cytoplasm but not associated with mitochondria. Possible explanations of these phenomena are indicated).

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[1]University of Dundee.
[2]Australian National University, Canberra.

JONES, R. A. C. and HARRISON, B. D. (1969). The behaviour of potato mop-to virus in soil, and evidence for its transmission by *Spongospora subterranea* (Wal Lagerh. *Ann. appl. Biol.*, **63**, 1-17.

(Potato mop-top virus (PMTV) was best detected in field soils by air-drying them more than a week before remoistening and growing seedlings of *Nicotiana tabacum* *N. debneyi* for a 6-10 week period. Infection of *N. tabacum* was assessed by inoculat sap from roots and shoots to *Chenopodium amaranticolor*. Similar inoculations fr *N. debneyi* were far less convenient for detecting PMTV than recording leaf sympto but slightly more efficient.

Air-dry soil retained PMTV infectivity for 9 months, when passed through a 50 μ sieve and when diluted with 10^3 but not 10^4 parts of steamed soil. Tobacco seedli were not infected when their roots were steeped in PMTV-containing tobacco s Infective soils contained *Spongospora subterranea*, spore balls of which resisted drying for more than a year and passed a 50 μm sieve. Roots of susceptible seedli were infected with PMTV when exposed to spore balls of *S. subterranea* taken fr powdery scabs on PMTV-infected potato tubers, or to suspensions obtained steeping, in nutrient solution, roots infected with virus-carrying cultures of *S. su terranea*. Plants in several families were hosts of *S. subterranea*, but probabilities infection when exposed to spore balls differed greatly between families and s species of Solanaceae were good hosts. The ten species infected with PMTV wh grown in infective soil or when exposed to spore balls of *S. subterranea* taken fr PMTV-infected potato tubers are all members of this family. PMTV seems to carried internally in *S. subterranea* spore balls and survived in them for at least a ye

PMTV was transmitted by *S. subterranea* to 'Arran Pilot' potato, causing yell blotches in some leaves and spraing in many tubers. However, when newly infec with PMTV in the field, not all 'Arran Pilot' tubers developed spraing. Also, altho many spraing-affected or symptomless but PMTV-infected tubers carried PM containing spore balls of *S. subterranea*, powdery scabs were rarely found near centres of the rings of primary spraing. PMTV became established in virus-free s when PMTV-infected tubers carrying *S. subterranea* were planted as 'seed' but when virus-free tubers bearing powdery scabs were used. *S. subterranea* seems main, and possibly the only, vector of PMTV in the soils examined. *S. subterranea* not transmit potato aucuba mosaic virus from potato to *N. debneyi* or *Capsic annuum*).

MURANT, A. F. and GOOLD, R. A. (1968). Purification, properties and transmiss of parsnip yellow fleck, a semi-persistent, aphid-borne virus. *Ann. appl. Biol.*, 6 123-137.

(Parsnip yellow fleck virus (PYFV) is the commonest cause of virus-like symptoms parsnip plants in Britain; it is sap-transmissible but systemically infects few spec outside the Umbelliferae. It has isometric particles 29-31 nm. in diameter, a sedimen tion coefficient of 167S, and loses infectivity in sap after dilution to 10^{-3}–10^{-4}, heati for 10 min. at 57.5-65°C., or storage at room temperature for 4-7 days. Two isolat from parsnip and *Anthriscus sylvestris* respectively, are only distantly serologica related.

The aphid *Cavariella aegopodii* transmits PYFV in a semi-persistent manner fr *A. sylvestris* but not from parsnip. Transmission by aphids apparently depends the presence in *A. sylvestris* or other source plants of a second virus, anthriscus yell (AYV), which is persistent in the vector and not manually transmissible. PYFV w therefore not transmitted by aphids from manually inoculated plants or from pars or other plants immune to AYV. In controlled experiments, *C. aegopodii* transmit PYFV (both *A. sylvestris* and parsnip isolates) from chervil plants inoculated separat with PYFV and AYV, but not from plants inoculated only with PYFV).

MURANT, A. F., GOOLD, R. A., ROBERTS, I. M. and CATHRO, J. (1969). Carrot Mottle–a persistent aphid-borne virus with unusual properties and particles. *J. gen. Virol.*, **4**, 329-341.

(Carrot mottle, a persistent aphid-borne virus transmissible by inoculation of sap, lost infectivity when *Nicotiana clevelandii* sap was diluted to 10^{-3}, heated for 10 min. at 70°, or stored at room temperature for 9 to 24 hr. Leaf extracts made using phenol contained infective RNA. Infectivity was abolished from leaf extracts by treatment with di-ethyl ether, chloroform or other organic solvents. Partially purified preparations, made by clarification with bentonite, followed by chromatography on calcium phosphate (brushite) columns and sucrose density gradient centrifugation, contained approximately spherical particles about 50 nm. in diameter. After equilibrium sedimentation in caesium chloride gradients, infectivity was found in fractions of density 1.14 to 1.17 g./ml., with a maximum at 1.154 g./ml. Ultra-thin sections of infected *N. clevelandii* leaves revealed approximately spherical particles about 50 nm. in diameter in the cell vacuoles associated with the tonoplast. Some particles seemed in process of budding from the membrane. The particles seem unique among known plant viruses but resemble those of some viruses of vertebrates; they probably contain lipid. The cryptogram for carrot mottle virus is therefore R/*:*/*:S/(S):S/Ap.)

TAYLOR, C. E. and CHAMBERS, J. (1969). Effects of insecticide treatments on aphid populations and on spread of latent viruses in raspberry cane nurseries. *Hort. Res.*, 9, 37-43.

(For summary see Zoology Section).

TAYLOR, C. E. and MURANT, A. F. (1968). Chemical control of raspberry ringspot and tomato black ring viruses in strawberry. *Pl. Path.*, **17**, 171-178.

(For summary see Zoology Section).

TAYLOR, C. E. and MURANT, A. F. (1969). Transmission of strains of raspberry ringspot and tomato black ring viruses by *Longidorus elongatus* (de Man). *Ann. appl. Biol.*, **64** (in press).

(For summary see Zoology Section).

Zoology

C. E. TAYLOR

The biology of nematode vectors of plant viruses continues as the majo research interest of the Section but entomological interests are maintained t a limited extent by the work on raspberry mite and raspberry beetle. Th nematode vector survey of Scotland continues to add many new records o *Longidorus elongatus*, as well as occasional records of other *Longidoru* species, and the most northerly record of *Xiphinema diversicaudatum* is no in northern Fife on the banks of the river Tay. The ultra-thin sectioning an electron microscopy of nematode vectors has made much and exciting pro gress, despite lamentably insufficient time on the microscope because of th pressure of work by other users.

Jane Bowes left in September to study at the College of Education an Wanda Burza and R. Crichton were appointed as Scientific Assistants i October and November respectively. S. C. Gordon was promoted to Assis ant Experimental Officer in September.

In July, C. E. Taylor and P. R. Thomas read papers at the First Inter national Congress of Plant Pathology at London and in October, C. E Taylor contributed a paper to the World Health Organisation Conference o the Health of Agricultural Workers, held at the University of Dunde W. M. Robertson attended a course on electron microscopy organised by th Royal Microscopical Society at the University of Bristol, in July.

ECOLOGY

In Scotland, *Longidorus elongatus* is widely distributed in loam soils used fo arable cropping. In pot tests, *L. elongatus* multiplied well on strawberry grasses and clovers and on several common weed species, but less well o crop plants such as potato, sugar beet and onion. *Xiphinema diversicaudatum* has so far been found to a limited extent in Scotland, usually on heavier soi types than those in which *L. elongatus* are found. In pot tests, *X. diversi caudatum* multiplied on relatively more woody perennials than on herbaceou crop or weed plants. but within each group species varied widely in accept ability. Viruses transmitted by both nematode species infected many kinds o plants used in the host range tests, but infection was not always correlate with the suitability of the plant as a host for the nematode.

Populations of *L. elongatus* under strawberry at several sites and o *X. diversicaudatum* in a raspberry plantation were sampled periodicall to study seasonal fluctuations and features of their life cycles in the fiel

L. elongatus laid eggs in May and successive juvenile stages developed to reach mature females by the next oviposition period, indicating an annual life cycle. In *X. diversicaudatum* there was no comparable increase in each post-embryonic stage. Peak oviposition occurred about mid-summer; populations reached their maxima in November and declined rapidly during the winter.

Crop damage caused by *Trichodorus* spp. is usually more prevalent on sandy soils than on loam or clay soils. Two crops of sugar beet grown on sandy soil near Carnoustie, Angus, had patches of stunted plants which were similar in appearance to the condition known as 'docking disorder.' There were more *Trichodorus* in the affected patches than in the healthy part of the crop. (P. R. Thomas).

Chemical control

Small, non-replicated plots in Angus, Perthshire and Fife were treated with D-D and Temik in an attempt to control *Trichodorus* nematodes and to prevent the transmission of tobacco rattle virus to potatoes. Within each plot the distribution and numbers of *Trichodorus* varied widely, but nevertheless D-D at 400 lb./acre clearly gave good nematode control at all of the sites and was better than D-D at 200 lb./acre. Temik, at 40 lb./acre, also gave good control but applications at 5, 10 or 20 lb./acre were ineffective. The extent of virus infection in the potato crops planted after the soil treatment is reported elsewhere (p.49). (P. R. Thomas with J. I. Cooper, Virology).

An infestation of *Xiphinema diversicaudatum* associated with an outbreak of strawberry latent ringspot virus in Malling Jewel at Cupar, Fife, was the site of a replicated control experiment, using D-D, quintozene, lannate, dazomet and mocap in autumn and spring soil treatments. Preliminary data from soil sampling already indicates that autumn applications of D-D at 400 lb./acre or dazomet at 300 lb./acre are effective in reducing *X. diversicaudatum* populations to low levels. (C. E. Taylor, P. R. Thomas, S. C. Gordon).

Association of virus and vectors

In Scotland, raspberry ringspot and tomato black ring viruses are transmitted by *Longidorus elongatus*, but in England different strains of these viruses are transmitted by *L. macrosoma* and *L. attenuatus* respectively. In laboratory experiments, English strains of raspberry ringspot virus were transmitted by *L. elongatus* almost as efficiently as the Scottish strain. On the other hand, *L. elongatus* transmitted English and German strains of tomato black ring virus only infrequently in comparison with efficient transmission of Scottish isolates of the virus. Thus the specific association of virus strains with their vectors observed in the field is supported by experimental evidence for tomato black ring virus, but the frequency of transmission of English forms of raspberry ringspot by *L. elongatus* makes it difficult to explain why they have not been associated in the field with this nematode, which is widespread throughout Britain. The explanation may lie in some combination of ecological factors, involving the suitability of weed and crop hosts for each virus strain or isolate. (C. E. Taylor with A. F. Murant, Virology).

Electron microscopy

Several methods of processing nematode virus vectors have been investigated and a standardised procedure has now been adopted. This consists of gluteraldehyde fixation at 4°C. followed by post-fixation in 1% osmium tetroxide, dehydration in a graded ethanol series and embedding in araldite. sections are stained on the grids with uranyl acetate and lead citrate.

A study of the anatomy of the nematode vectors forms an important part of the work on the mechanism of virus transmission, besides being of interest and importance for its own sake. The oesophageal region of *Longidorus elongatus* has been the subject of detailed investigation and several new features have come to light. For example, the discovery of a band of muscle extending posteriorly from about mid-way along the anterior oesophagus to the cuticle in the region of the oesophageal bulb provides an explanation of stylet retraction in a nematode which is apparently without the usual retractor muscles as observed in *Xiphinema* species. The cytoplasmic structure of the oesophagus of *L. elongatus* differs fundamentally from that in *Xiphinema diversicaudatum* and *X. index*, and this may be associated with the differences in virus transmission observed between the two genera.

Using a method whereby individual infective nematodes can be identified, longitudinal sections of *L. elongatus* have revealed that the mucous lining of the stylet guiding sheath is probably the main site of accumulation and retention of particles of raspberry ringspot and tomato black ring viruses. Other viruses, such as arabis mosaic, which can be ingested but not transmitted by the nematode, do not appear to become associated with the guiding sheath. Thus there may be a specific attachment of virus particles, which is supported by experimental evidence of specific transmission of viruses by nematodes. In *X. index* fed on plants infected with grape fanleaf virus, no virus particles have been found attached to the stylet guiding sheath. Particles have been found in the lumen of the oesophageal bulb, and complex lattice structures associated with the endoplasmic reticulum of the gland cells of the bulb may be indicative of virus infection.

Particles of tobacco rattle virus have been located in the lumen of the pharnyx and of the oesophagus of *Trichodorus pachydermus*. (C. E. Taylor, W. M. Robertson).

ENTOMOLOGY

The raspberry mite (*Eriophyes gracilis*) was prevalent in several raspberry plantations in the summer, possibly because July 1968 was unusually dry. Succeeding over-wintering populations were also relatively large and as many as 1,200 hibernating females were recorded from the base of a single bud on Malling Jewel raspberry. The mites were distributed among the buds from the base to the tip of the canes but there were more in the buds at 3 to 5 ft. from soil level than elsewhere on the cane. Using this information to devise a method of sampling, comparisons of mite infestation have been made between raspberry cultivars, sheltered and exposed crops, and wild raspberry remote from commercial crops.

The testing of selections of *Rubus phoenicolasius* crosses with raspberry cultivars against the raspberry beetle is reported in the Plant Breeding Section. (C. E. Taylor, S. C. Gordon).

PUBLICATIONS

OLD, K. M.[1] and ROBERTSON, W. M. (1969). Examination of conidia of *Cochliobolus sativus* recovered from natural soil using transmission and scanning electron microscopy. *Trans. Brit. Mycol. Soc.*, **52** (in press).

(The occurrence of minute holes in the spore wall of *Cochliobolus sativus* exposed in natural soil are described).

TAYLOR, C. E. (1968). A multiple Baermann Funnel rack made from standard components. *Nematologica*, **14**, 596.

(Instructions are given for the construction of a rack to hold 36 funnels, and ancillary items for nematode extraction are listed).

TAYLOR, C. E. and CADMAN, C. H. (1969). Nematode vectors. *In* Virus, Vectors and Vegetation (ed. K. Maramorosch). New York: John Wiley and Sons (in press).

(A review of nematodes as vectors of plant viruses).

TAYLOR, C. E. and CHAMBERS, J. (1969). Effects of insecticide treatments on aphid populations and on spread of latent viruses in raspberry cane nurseries. *Hort. Res.*, **9**, 237-243.

(Dimethoate sprays applied at 3-weekly intervals, from early June to late September, largely prevented the infestation of newly established raspberry plants by *Amphorophora rubi* but only decreased infection with latent viruses from 56% to 22%. Fewer such sprays, or the application of granules of either disulfoton or ethoate-methyl, were less effective in preventing aphid infestation).

TAYLOR, C. E. and MURANT, A. F. (1968). Chemical control of raspberry ringspot and tomato black ring viruses in strawberry. *Pl. Path.*, **17**, 171-178.

(Treatment of the soil in the autumn with 20% quintozene at 300 lb./acre or D-D at 400 lb./acre successfully controlled the nematode, *Longidorus elongatus*, and largely prevented transmission of virus to Redgauntlet strawberry planted in the following spring. Fruit yields were increased four- to six-fold in the first fruiting year and nine-to twelve-fold in the second compared with untreated plots. Applications of the herbicide chloroxuron did not affect *L. elongatus* numbers but delayed infection of the strawberry plants by controlling weed sources of the virus).

TAYLOR, C. E. and MURANT, A. F. (1969). Transmission of strains of raspberry ringspot and tomato black ring viruses by *Longidorus elongatus* (de Man). *Ann. appl. Biol.*, **64** (in press).

(In laboratory experiments *Longidorus elongatus* transmitted English isolates of raspberry ringspot virus almost as efficiently as the Scottish isolates but it transmitted English and German isolates of tomato black ring virus only occasionally).

TAYLOR, C. E. and THOMAS, P. R. (1968). The association of *Xiphinema diversicaudatum* (Micoletzky) with strawberry latent ringspot and arabis mosaic viruses in a raspberry plantation. *Ann. appl. Biol.*, **62**, 147-157.

(An outbreak of strawberry latent ringspot virus in a plantation of Malling Jewel raspberry coincided with the greatest abundance of the nematode vector, *Xiphinema*

[1] Botany Department, University of Dundee.

diversicaudatum. Arabis mosaic virus was not detected in the crop but was, together with strawberry latent ringspot virus, in many weed species present. Both viruses were transmitted through the seed of some weed hosts. Soil sampling revealed that peak populations of the nematode occurred in late autumn following oviposition during April to July. All stages of *X. diversicaudatum* transmitted the viruses which were retained in starving nematodes for several months).

THOMAS, P. R. (1969). Crop and weed plants compared as hosts of viruliferous *Longidorus elongatus* (de Man). *Pl. Path.*, **18**, 23-28.

(In pot tests, strawberry, grasses and clovers were the most favourable hosts for *Longidorus elongatus* amongst the crop plants tested, whereas most were poor or non-hosts; several weed species were good hosts. Raspberry ringspot and/or tomato black ring viruses were detected more frequently in the weeds than in the crop plants).

THOMAS, P. R. and TAYLOR, C. E. (1968). Plant nematology in Africa South of the Sahara. Tech. Commn. 39, Commonwealth Bureau of Helminthology. Farnham Royal: Commonwealth Agric. Bureau. 83 pp.

(A comprehensive survey of the literature on plant nematodes in Africa contained in 569 annotations, arranged in alphabetical order of the author, with indices for nematode species, subjects and co-authors).

Meteorological Records 1968

P. D. WAISTER, J. L. MILNE

MYLNEFIELD

General

A new anemograph has been installed, incorporating wind velocity and direction transmitters and chart recorders, and an integrator to give daily wind run. The equipment has been erected on a new site to which the remainder of the meteorological instruments are being transferred, to avoid interference from building developments. The range of equipment now covers the requirements for a Class A agro-meteorological station.

Wind

Total run of wind was below the average for the previous seven years, attributable mainly to a low wind-run in February. During the storm of 14-15 January the anemograph trace was blurred but average wind speed appeared to be approximately 80 m.p.h. for a 5 hr. period. Maximum velocity recorded at Leuchars exceeded 100 m.p.h.

Temperature

May was appreciably cooler than normal, both in mean air temperatures and in the number of ground frosts recorded. However, the severity of frost during the critical blossom period for raspberries was not as great as in 1967 and no crop loss was recorded at the Institute.

Rainfall

The rainfall in May, the highest for that month since 1954, was more than double the 10-year average, and the October figure was also appreciably higher then normal.

Solar radiation

The total hours of sunshine was 74 hr. less than average due mainly to the low figures in May and July.

AUCHINCRUIVE

Sunshine was well above average, June and August being exceptionally sunny. Rainfall during October was almost double the average.

AUCHINCRUIVE 1968

Month	Temperature °C[1] Mean of daily maxima		Mean of daily minima		Rainfall inches	Sunshine hours	Ground frost days
January	7.2	**45.0**	1.9	**35.6**	3.79	35.4	13
February	4.7	**40.4**	−1.5	**29.2**	1.60	98.7	23
March	8.4	**47.2**	2.2	**35.9**	3.73	94.0	16
April	11.6	**52.9**	3.8	**38.8**	1.21	140.7	15
May	12.3	**54.2**	5.0	**41.0**	2.90	166.1	7
June	17.7	**63.9**	9.0	**48.2**	1.72	218.4	1
July	16.9	**62.5**	9.3	**48.8**	4.53	179.8	0
August	18.5	**65.4**	9.7	**49.4**	2.72	190.0	0
September	15.9	**60.7**	9.0	**48.3**	4.95	123.9	0
October	13.8	**56.8**	8.8	**47.8**	5.18	64.7	0
November	8.2	**46.8**	2.8	**37.0**	2.96	70.0	12
December	5.8	**42.4**	0.3	**32.6**	1.38	46.5	18
Year	11.7	**53.2**	5.1	**41.1**	35.67	1,428.2	105

[1] Fahrenheit equivalents shown in bold figures

MYLNEFIELD 1968

Temperature °C Fahrenheit equivalents shown in bold type

Month	Mean of daily maxima		Deviation from average[1] °C	Mean of daily minima		Deviation from average[1] °C	Accumulated Temperature Above 5.6°C	Accumulated Temperature Below 5.6°C	Highest Max. Temp.	Highest Max. Date	Lowest Min. Temp.	Lowest Min. Date	Soil Temperature at 1 ft Depth Mean	Soil Temperature at 1 ft Depth Deviation from average[2]	Ground frost days	Rainfall Inches	Rainfall Deviation from average[3]	Sunshine Hours	Sunshine Deviation from average[3]	Run of Wind Miles
January	5.8	**42.5**	0.0	0.1	**32.2**	−0.2	21	101	11.4	19, 26	−6.9	4	1.5	−0.5	23	1.77	−0.25	53	− 7	5659
February	4.1	**39.4**	−2.3	−1.3	**29.6**	+0.4	1	123	7.8	19	−6.7	26	1.7	−0.4	26	1.43	−0.29	83	+ 8	3512
March	9.1	**48.4**	+0.5	2.0	**35.6**	+0.2	47	46	13.9	28	−2.2	21	4.0	−0.3	17	1.15	−0.73	110	+10	7513
April	10.9	**51.7**	−0.1	2.9	**37.3**	−0.3	82	40	18.3	26	−4.4	2	7.1	−0.2	13	2.61	+0.99	179	+20	5185
May	11.1	**52.0**	−2.9	4.2	**39.5**	−1.1	81	17	18.3	28	−0.5	12	9.3	−0.9	10	4.59	+2.64	141	−50	4247
June	17.3	**63.2**	−0.4	8.4	**47.2**	+0.2	217	0	22.7	18	3.1	24, 25, 28	13.8	+0.2	0	1.18	−0.90	206	+30	4394
July	15.8	**60.4**	−3.6	10.3	**50.6**	−0.4	254	0	21.1	1	6.7	19	14.7	−0.6	0	2.92	+0.30	111	−51	4102
August	18.1	**64.7**	−0.6	10.4	**50.7**	+0.2	259	1	23.3	22	2.8	19	15.3	+0.5	0	1.61	−2.61	183	+40	3775
September	15.6	**60.1**	−0.8	9.0	**48.1**	+0.9	202	2	20.0	6	3.9	22	13.1	+0.2	0	2.61	+1.10	98	−21	3970
October	13.8	**56.9**	+1.2	7.7	**45.8**	+2.4	164	4	16.7	2, 22	0.0	18	10.7	+1.0	1	4.42	+2.07	80	−14	4446
November	7.9	**46.3**	−0.6	3.1	**37.1**	+0.6	32	38	12.8	25	−3.3	5	5.7	−0.2	13	2.56	+0.17	37	−24	5061
December	5.5	**41.9**	−1.2	0.8	**33.2**	−0.4	7	87	9.4	4, 5	−5.0	14	3.5	−0.2	21	1.93	−1.04	31	−15	4643
Year	11.3	**52.3**	−0.8	4.8	**40.6**	0.0	1,366	458	—	—	—	—	8.4	−0.1	124	28.78	+1.45	1,312	−74	56507

[1] Recorded at official Dundee Meteorological Station 1921-1950 [2] and [3] Recorded at Mylnefield, 1954-1961 and 1954-1967 respectively

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