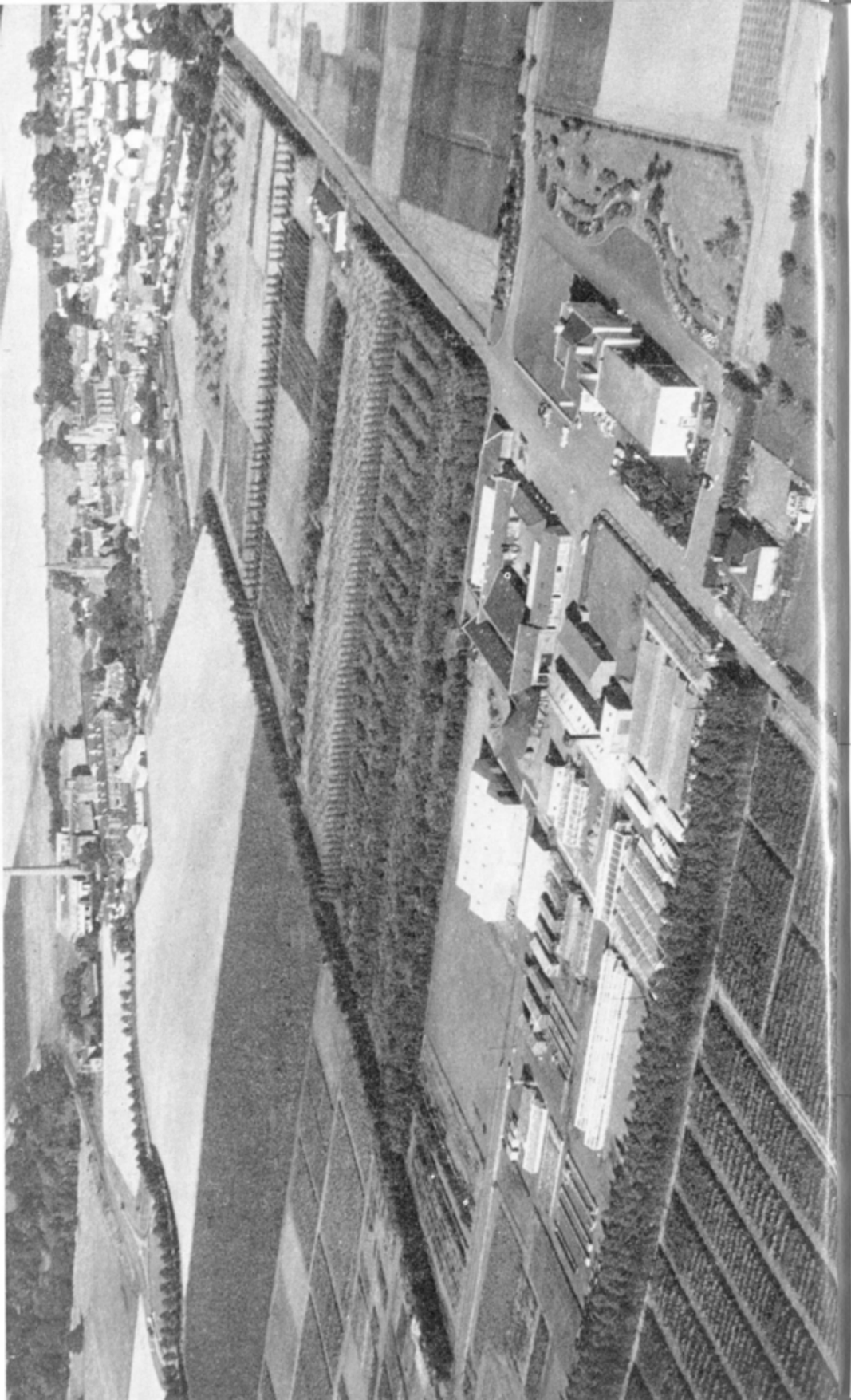

The Scottish Horticultural Research Institute

14th Annual Report for the year 1967

The Scottish Horticultural Research Institute
Invergowrie, Dundee *Telephone* INVERGOWRIE 441

West of Scotland Unit
Auchincruive, Ayr *Telephone* ANNBANK 293

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Susanne A. Dodd *Resigned* April 1967
Janet B. Henry *Appointed* April 1967

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

General Report

C. H. CADMAN

This year we are losing the services of no fewer than six members of the Governing Body. The retirement of Mr J. Gilchrist, Mr D. L. Storrie, Dr M. A. H. Tincker and Professor S. J. Watson breaks a link with the past for which one cannot help feeling some nostalgia. All four were closely associated with the conception of the Institute before its foundation and since then have served first on the Committee of Management and subsequently on the Governing Body since its inception in 1953. These were formative years when the Governing Body had a much more onerous task than it now has and the Institute owes much to the counsel and expertise which these four gentlemen have generously given over the years. We shall miss them greatly. Mr A. T. Bryden and Mr J. Brown are also retiring and we should like to record our gratitude to them for the contribution they have made to the work of the Governing Body.

It was our turn this year, to receive a Visiting Group from the Agricultural Research Council. On 5-7 June we were pleased to welcome Sir Gordon Cox, Secretary of the Agricultural Research Council, other members of the Council's secretariat and representatives of the Department of Agriculture and Fisheries for Scotland who accompanied a distinguished group of visitors headed by Professor P. W. Brian and including the Hon J. Addington, Dr R. Markham, and Professors J. H. Western, C. P. Whittingham and Watkin Williams. We thank these gentlemen for giving up the time to examine our affairs and for their advice and criticism. In large measure our plans for the next five-year period met with approval and the occasion provided a useful opportunity for frank discussion of many of the Institute's problems.

Development Scheme

One of the encouraging results of this visitation was the Group's support for the need to remodel and develop the Institute's laboratories, offices and research facilities on the basis of plans which had been submitted to the Department of Agriculture and Fisheries for Scotland and which subsequently received Treasury approval in principle. Since 1960–the last date at which any new building was done at the Institute–growth in staff and research activities have led to acute problems of overcrowding and congestion of services. Plans for redevelopment aim to solve these by redesigning the glasshouse area and services, erecting new farm buildings so that the old steading and outhouses can be demolished and the site used for new laboratories, and by adding an east wing to the existing laboratory and office block.

They aim also to provide a logical basis for any future developments and are phased so as to interfere as little as possible with the work of the Institute and, we trust, to fit with fluctuations in allocations of capital.

Unfortunately for us, fluctuations in our financial fortunes have been of much greater dimensions than we bargained for and although a start on the scheme has been made it has, as yet, a tenuous existence. Through the efforts of our architects and consultants, to whom we are particularly grateful, planning was in an advanced stage by late summer 1967 and we were therefore able to take advantage of capital released under the Government's Winter Work Scheme. One set of farm buildings, which includes a new crop handling bay, farm store, stores for soft fruit and potatoes and a new block of offices, stores and workshops for the Maintenance Section is virtually completed. Work is now going forward on the drainage and heating services which form part of the major scheme.

Staff

Among the changes in the assistant staff there is one that deserves special mention–the resignation in April of Miss Susanne Dodd from the Auchincruive staff. In her twelve years as secretary of the West of Scotland Unit she had become an indispensable member of staff and she left with mutual regrets: she is succeeded by Miss Janet Henry. At Mylnefield, R. G. Watson of the Maintenance Section left to become an instructor in joinery and was succeeded by A. Low.

The only change in senior staff was the resignation of L. S. Gray in June to become area representative of the Agricultural, Horticultural and Forestry Training Board, the first such appointment to be made in Scotland. After 14 years as Farm Manager to the Institute the change was a major one, both for him and us: we hope the experience here has been useful and wish him well in his new tasks. Opportunity was taken to make some changes in organisation. The post of Farm Manager and the division between plantations and farm were abolished. W. I. A. Jack was transferred from the Auchincruive staff to fill a new post of Field Experiments Officer; F. Ritchie was promoted to the post of foreman, with R. W. Reid as his assistant, whilst oversight of the farm workshop and vehicle fleet in charge of W. R. S. Batchelor was delegated to the Deputy Director.

Although he left the Institute in 1965, it was a shock to his colleagues here and elsewhere to learn of the untimely death of Dr Gordon Haskell, formerly head of the Genetics Department of this Institute and subsequently of the Department of Biological Sciences, Portsmouth College of Technology. Our sympathies go to his widow and family.

Visiting workers to the Institute this year included Dr H. A. Daubeny, Research Branch, Canada Department of Agriculture, Agassiz, British Columbia, who came in July to spend nine months with the Plant Breeding Section; Mr D. J. Engelbrecht, Department of Agriculture Technical Services, Fruit and Food Technology Research Institute, Stellenbosch, S. Africa,

who arrived in September to spend a year in the Virology Section; and Dr M. A. Hall, previously working in the University of California, Riverside, U.S.A. who was awarded a Rehabilitation Research Fellowship by the Science Research Council to enable him to work for a year in the Plant Physiology Section. Mrs Abdel-Galil, a postgraduate research student from the University of Alexandria was appointed to a temporary post to enable her to complete her studies for the degree of Ph.D. Vacation student helpers this year came from as far afield as the U.S.A., Holland and Switzerland as well as other parts of Britain.

Travel grants from the Agricultural Research Council enabled various members of the staff to attend conferences or make study tours abroad. C. North and P. D. Waister visited laboratories in the Netherlands; A. F. Murant and B. D. Harrison attended meetings on plant viruses and visited laboratories in Germany and Czechoslovakia respectively; C. E. Taylor and P. R. Thomas went to the conference of European Nematologists in Warsaw and C. G. Guttridge to a symposium on plant growth substances in Liège.

The granting, by Her Majesty the Queen, of a royal charter to the University of Dundee and the appointment, subsequently, of senior members of the Institute's staff to honorary lectureships in the new University means that the Institute is able to offer facilities to postgraduate students who wish to register for higher degrees in the Universities of either Dundee or St. Andrews. We already have close informal connections with several departments in the new University and we hope that these will encourage new graduates to avail themselves of the research opportunities which the Institute offers.

Public Relations

We are not alone in consciousness of the need to 'sell' agricultural research both as an attraction to the best brains and, more importantly in the eyes of the industry, as a worthwhile investment. One could write at length on either aspect but the second is particularly relevant to this Report. Gauged by opinion in the commercial press, the general attitude is that hidden assets are all very well but investments should pay dividends in the form of results which the average grower can understand, and most Annual Reports, our own included, offer little satisfaction. Scientific research is not this kind of slot machine nor can progress always be interpreted simply. Indeed the art of 'popularising' research results–to use a condescending term, is greatly underrated; but, equally, to so dress up the entire output of a research institute would be tantamount to perjury.

The mainspring of this goose that can occasionally lay golden eggs is a desire to bring order out of the unknown, to predict a course of events and thus in effect to control, in however small a way, the environment in which we live. Prediction might stop short at the levels which have 'grower appeal'–say, the conditions needed to produce maximum yields, the composts which will give predictable performance of container-grown plants and so forth–but technology of this order can only be the handmaiden of more basic research.

Those who would opt for institutes of technology rather than research need reminding that salaries account for 75% of research expenditure and that investment of this order demands a commensurate 'pay off.' This is not to deny the place or the value of technology nor to suggest that this week's problems necessarily require less ingenuity for their solution than the next decade's. But the fact remains that the best brains are attracted to the most worthwhile problems. This is as it should be for the health of agricultural research, even though the results, for the most part, find their way into scientific journals rather than the popular press. What is needed is a correct balance between technology and basic research in programmes that take adequate account of industrial needs.

Annual reports are very much what directors make of them. Technically, ours is a report to the members of the Governing Body and we have chosen to honour this obligation and to use the Report as a means of communication with fellow workers both in this country and overseas. We see no reason to depart from this practice. Not only does it give individuals opportunity to publicise their work; the writing is a salutary exercise compelling them to summarise their efforts for the information of others.

Having thus disposed of the form and content of the Annual Report it would be vexing to find the Institute accused of an exclusive attitude. This is far from the truth. It has a creditable record this year of meetings held either to interest growers in specific parts of its work or to promote relations with the advisory service and with other scientists. In May we held a meeting to explore problems of rose growing, which was attended by nearly all the major rose growers in Scotland and which would not have been possible without the aid of Mr A. Cocker, Aberdeen, Mr J. L. Harkness, Hertford, Dr M. E. Marston, School of Agriculture, University of Nottingham and Messrs A. R. Carter and J. W. Ewan of the N.A.A.S. for whose help we are grateful. The senior horticultural advisers of the Scottish Agricultural Colleges met twice here during the year and, under the auspices of the East of Scotland College of Agriculture, bulb growers visited the field experiments on narcissus and tulip run jointly by the College and the Institute, and fruitgrowers saw the Institute's field experiments on herbicides. We ourselves held open days for pea growers and fruitgrowers in July and two well-attended days for vegetable growers in September and November. In July, the Institute was host to a symposium organised by D. L. Jennings, at the request of the International Society for Horticultural Science, on 'Problems of raspberry culture in Europe' which was attended by delegates from nearly all the major raspberry-growing countries on either side of the Atlantic. In addition, the Institute received many individual visitors and visiting parties.

So anxious are we to interest growers in the work of the Institute and to provide them with opportunities both to understand its objectives and to help in keeping us in touch with the needs of the horticultural industry that a membership scheme–the S.H.R.I. Association–was launched at the fruit-growers' meeting on 26 July. The response has been encouraging and the membership already stands at 150. The Association's affairs are to be run by

a chairman and committee of management elected by the members and the privileges of membership include invitations to Institute 'open days' and provision of copies of Institute publications including the Annual Report. As an experiment, we are also to produce for members of the Association a newsletter or bulletin which will aim to interpret research results and to keep members abreast of the progress of experimental work which is of direct interest to them. By these means we hope to promote an exchange of information between the horticultural industry and the Institute which should be of mutual benefit and will perhaps abolish some current misconceptions of the Institute's aims and objectives.

Farm and Experimental Crops

W. I. A. JACK

If all seasons were like that of 1967, we would have little to complain of. Apart from the rather cold and windy spring months which delayed field work and growth of crops, it was an excellent year. For once fruit-picking was done in an almost unbroken spell of dry weather; there was little grey mould in either raspberries or strawberries–perhaps a disappointment for the pathologists–and yields were good despite damage from spring frosts. In escaping the worst effects of these, we were more fortunate than many of our neighbours. The grain harvest exceeded expectations. We are normally an early farm and this year had a lead which enabled us to combine harvest almost the entire 90 acres of barley in a week of superb weather. The yield, 42.2 cwt./acre, was the highest for some time and the moisture content such that half the crop was of malting quality as harvested. The wheat, reputedly one of the best local crops, yielded 53.2 cwt./acre and potatoes at 10.5 tons/acre also did well.

Fruit-picking began with strawberries on 6 July and raspberries followed on 14 July. The area under strawberries has temporarily decreased so the total crop, 8.5 tons, was less than last year; raspberries yielded rather more than in 1966, 18.25 tons. The experimental block planted in 1952 is still yielding surprisingly well and Malling Jewel cropped at the rate of 4 tons/acre. Much of the blackcurrant acreage was not in bearing because of pruning treatments; unpruned bushes suffered from frosts and the total yield was only 1 ton.

With the encroachment of housing schemes to the vicinity of Invergowrie, the growing of tree fruit at the Institute is becoming increasingly hazardous. Decisions to grub out the rootstock trials planted in 1954, 1959 and 1962 and to decrease in size and replant the museum collection of apple varieties are therefore something of a relief. This year's crop of 6.5 tons of apples is therefore probably the largest there will be for some time.

Cabbages (7.25 tons), Brussels sprouts (4.25 tons) and smaller amounts of beetroot, sweet corn, French beans and parsnips were marketed locally and a crop of calabrese was grown to supply experimental material for processing.

Plans for the season's work were well in hand when Mr Gray left in June. Until my transfer from Auchincruive in October, the Director acted as overseer of farm affairs and the success of the season's enterprises was due to the able management of the grieve, F. Ritchie. In the interim, plans had been made for a revision of the whole system of land usage with the objects both of ensuring adequate rotations and of easing the tasks of documenting land use and organising field work. The Institute had become accustomed to a patchwork system of allocation of land for experimental purposes that was both wasteful of land and troublesome because of the resulting scatter of small areas of individual crops and the difficulty of accurately recording the cropping and manurial histories of individual fields. We plan to operate most of the larger fields on a strip system and, where possible, to group together experiments using the same crop. It may be some time before this system becomes effective but a start has been made and the end result should be an improvement in efficiency.

With the aid of Mr K. Simpson and his colleagues of the Edinburgh School of Agriculture, a programme of annual and detailed soil analyses of the Institute's fields has been initiated. The results so far have been revealing and suggest the need for radical changes in our manurial programme. Soil sampling for potato root eelworm done by the East of Scotland College of Agriculture has also disclosed disturbing levels of infestation in many fields and caused us to reduce drastically the acreage of the commercial potato crop for the time being. Experimental crops are being restricted to the cleanest fields and all planting material will be of F.S. grade.

Shelter belts, as they age, are also posing problems both because of the increasing area they occupy and the difficulty of deciding whether the programmes of thinning and maintenance originally proposed are in fact now the best for our purposes. With the help of Mr J. K. Ferguson of the Forestry Commission, to whom we are grateful, plans for thinning and replanting some of the larger mixed breaks have been made with the object of retaining their best features and adding trees whose value for shelter has been proven by experience. In conjunction with the Crops Research Section some trial plantings of different clones of *Cupresso-cyparis* and *Chamaecyparis* are to be made.

Some of the drainage problems referred to last year have been dealt with. The most successful operation was the draining and subsequent cultivation of Haugh field which had become waterlogged and unusable during the last few years. The removal of a poplar windbreak on the north edge of South Bullion incurred criticism but was the necessary cure for blocked field drains. Other troublesome patches elsewhere on the farm seem attributable to panning consequent on excessive rotary hoeing.

Farm equipment has been added to and improved during the year and the new farm buildings now nearing completion should provide much needed space for crop handling and storage.

Glasshouse Section

J. CANTWELL

The prime function of the Section is to produce supplies of plants for experimental purposes to order. As the Institute's activities have gathered momentum over the years so have the demands for plants increased both in number and variety. The average monthly throughput of potted plants raised from seed is of the order of 5,000-6,000; and this is a regular demand separate from the seasonal needs for potting off strawberry runners, raspberry and blackcurrant seedlings, Brassica breeding material and the raising of vegetable crops for transplanting to the field. Taken together, these demands have taxed the man-power of the Section and the fact that excellent supplies of plants have been maintained for so long is in itself a tribute to the foreman, R. D. Taylor and his staff.

Much experimental work in an Institute such as ours is heavily dependent on the quality of glasshouse-grown plants, and hence there is a natural reluctance to depart from the conventional methods of plant-raising with which the Institute has grown up and which are of proven efficiency. To follow this path allows no escape from a situation where too many plants are chasing too few hands, and no one has time to do the experimentation necessary to find reliable and labour-saving alternatives. This was one of the reasons for separating the Glasshouse Section from the management of the Institute's estate and giving to the glasshouse manager the task of exploring techniques of plant raising alternative to those in use.

Two approaches are being made, namely, attempts to define the optimum environment for each species of experimental plant and searches for equipment and materials that will permit the exploitation of this knowledge to the best advantage. The year's work has aimed at the definition of perspectives and problems, but some useful results have emerged from the limited number of observational exercises undertaken.

Satisfactory plants of several species, including tobaccos and *Chenopodium*, have been grown on solid, irrigated benches in soilless composts contained in plastic pots. The indications are that use could be made of automatic or semi-automatic watering systems together with mechanical mixing and handling of composts for a large proportion of the Section's output at a considerable saving of labour.

Carbon dioxide enrichment was introduced on a pilot scale in the autumn and later extended to both propagating houses. It is hoped to enrich a third house this year. Beneficial effects were most evident on *Chenopodium amaranticolor* and *Nicotiana clevelandii*.

One of the major problems to be examined is the effect of light on plant growth. The basic needs are for methods of restricting natural light in summer and discovery of the most efficient source of artificial light for supplementary use in winter. An attempt is being made to obtain data on how much light is required to grow specific plants to a given maturity in a given time, and we have a Kipps' solarimeter plus an electronic integrator to help us. In addition the Crops Research Section is collecting radiation data (on a 24 hr. basis) throughout the year and this will be invaluable for calculating percentage radiation losses in glasshouses. When sufficient data are available it should be possible to make rational decisions as to when to apply and remove summer shading, and when to switch on artificial lights for supplementary illumination. Artificial lighting is a complex subject, and the approach here must necessarily be empirical. However, a change, from HPMV lamps with tungsten added, to MBF/U lamps without tungsten resulted in production of consistently better plants of *Chenopodium quinoa* under winter conditions. Possibly other species may benefit from the change, but this has yet to be demonstrated conclusively.

Difficulties in maintaining supplies of *Nicotiana clevelandii* have been overcome by the use of GA-treated seed and the quality of plants much improved by CO_2 enrichment combined with an 18 hr. illumination period.

Practical points which may be of use to others emerged from experiments on control of pests and diseases. Watering plants with TEPP has been used here as part of routine control measures against Sciarid flies. Plants of *Chenopodium amaranticolor* so treated are liable to develop severe and persistent leaf deformation. Similarly *C. quinoa* cannot be treated with phosdrin for aphis control without risk of damage. Grown in pots under glass, many species of umbellifers are very subject to powdery mildew. Spraying plants to run off with 2 ml. lime sulphur (25-28% polysulphide sulphur) per litre water proved the safest and most effective treatment in comparative tests with four other fungicides.

Crops Research

P. D. WAISTER

Appointments made during the year have allowed us to start a programme of crop environment studies. P. J. Joy joined the Section as Assistant Experimental Officer after completing a tour of duty in Botswana, and J. M. Anderson was appointed Scientific Assistant. The post of Meteorological Observer was filled by J. L. Milne, who took over the duties formerly assigned to J. Sunderland.

J. S. Wiseman came to us from Stockbridge House Experimental Horticulture Station as an Assistant Experimental Officer to work on weed control problems, and R. Suttie replaced J. Stoa as Scientific Assistant for this work.

With the formation of the Institute Association and the proposal to produce a bulletin for growers, an outlet is provided for publication of that part of the development work which is of immediate application in horticulture, and particularly that which is rapidly 'dated.' This applies most obviously in the case of vegetable variety work, where the increasing numbers of new varieties and hybrids appearing on the market make it essential for details of performance to reach the industry promptly. With these considerations in mind the reports on field experimentation have been abbreviated, and only those points considered of wider interest have been treated in detail.

The agronomic work of the Section is directed towards the integration of research findings into crop management systems. Weed control studies are increasingly concerned with crop/weed relationships, in the hope that this will lead to more logical and economical use of herbicides in the general cropping system. As part of this integrated approach, the effect of non-cultivation systems on raspberry plantation management continues to receive attention.

In field experimentation on vegetables, we have concentrated on examination of potential yield of varieties in factorial experiments involving a range of cultural treatments. This work has three main aims. First, it seeks to establish the conditions necessary for maximum or optimum yield of a variety while examining its 'plasticity' – the extent to which cultural methods can be manipulated to give the type of product required by the industry. An example of this is the way in which the Brussels sprout variety, Peer Gynt, can be induced to produce high yields of small sprouts for freezing or of larger sprouts for fresh market. Secondly, the information from these experiments should assist the Plant Breeding Section in deciding which components of yield should take priority in a breeding programme. Finally, we aim to be able to specify the methods by which new varieties issued by the Institute should be grown.

Co-operation with other Sections in fruit investigations is exemplified by the experiment on *Botrytis* control in strawberries, where the research findings of the Mycology Section have been used as the basis for the design of fungicide spraying schedules.

Parts of the Section's activities were demonstrated to vegetable growers on three farm walks covering peas and Brassica crops, and members of staff addressed meetings of growers and advisory officers during the year. Supported by a travel grant from the Agricultural Research Council, I visited research centres in Holland at Wageningen, Duiven and Alkmaar. A welcome feature of the year's work has been the increased co-operation with the Agricultural College Advisory services both in planning our own experiments in the light of growers' needs, and in designing district trials to follow up work done at the Institute.

Our thanks are due to the chemical firms and others who have assisted with the Section's activities during the year.

CROP ENVIRONMENT

Crop responses to shelter

Raspberry and strawberry plantations were established with and without the shelter provided by plastic netting of 50% permeability. Measurements of vegetative growth made in this first, non-fruiting year showed that protection against the prevailing winds had increased total length of cane in raspberries by more than 25%, and width of strawberry plants by 17%, within a distance of six times the height of the screens. The windbreaks successfully withstood a storm in January 1968 when wind speeds of over 100 m.p.h. were recorded at Leuchars.

Irrigation

Despite the abnormally dry season, there was no significant increase in yield of peas irrigated at flowering and at flat pod stage, though there was an increase in growth of haulm.

The stand of red beet increased greatly in plots irrigated during a dry period shortly after sowing in early June. Following thinning to equal stands on all plots, water was applied whenever soil moisture tension at 6 in. exceeded 30 cm. mercury, but this resulted in no significant increase in final yield.

Both summer cauliflowers and celery responded well to irrigation in this dry year, as would be expected. Head weight in celery was increased by over 50%, and curd weight of cauliflowers by 25%.

Raspberry and strawberry plantations were established for irrigation experiments scheduled to start in 1968.

Winter injury in raspberries

Cane death during winter has been attributed to genetic characteristics and to level of plant nutrition, but neither reason seems adequate to explain why dead canes should commonly be found in otherwise apparently vigorous stools. Examination of such canes suggested damage to stem bases as a possible cause of death of the whole cane or part of it. During picking time and up to the 'tying-in' stage, breakage may occur, due to damage by pickers or by wind. Growers normally remove any canes which are prostrate but tie in those apparently still firmly attached but lying obliquely. Canes in this category were labelled in the winter of 1966/7 and the extent of cane death (dead length as percentage of total length) noted in the spring. On this basis the mean dead length for upright canes was 9% and for 'oblique' canes 42%.

Growth of tulips

The first part of an experiment, designed to compare tulip bulb production under the differing climatic conditions of the Midlands of England and the East of Scotland, was completed in 1967. The same stocks of Rose Copland were grown on identical soil mixes, with soil moisture controlled via tensiometers. Changes in leaf area and dry weights were recorded by fortnightly sampling throughout the growing season. The final yield of dry bulbs was 15% higher at the Institute than at the University of Nottingham School of Agriculture at Sutton Bonington, and the number of bulbs above 9 cm. was 10% higher. This is in agreement with Continental experience, where bulb increase is found to be at its maximum under cool northern conditions, while bulbs for very early forcing are best produced under warm southern conditions. Bulbs harvested at the two centres are being forced for examination of date of flowering and quality of blooms. (P. D. Waister, P. J. Joy).

WEED CONTROL

Raspberries

In the long term experiment comparing various cultural and chemical methods of controlling weeds and raspberry suckers, the relative yields from treated plots did not differ greatly from those in 1966 (see Annual Report 1966, p. 17). Treatments involving some form of cultivation again significantly outyielded those involving no cultivations. Traditional cultivation techniques produced a crop of 94 cwt. fruit/acre, while those involving paraquat/diquat or simazine plus paraquat/diquat yielded 20% less fruit. Simazine, supplemented by hoeing, yielded 9% less fruit than the traditional cultivation treatment. Yield differences were contributed to by greater numbers of canes tied in and reaching tipping height, and better winter survival on the highest-yielding plots. Differences in 100 berry weight and yield per cane were, however, not significant. Once again, an annual top dressing of 10 tons/acre farmyard manure applied to uncultivated plots produced no increase in yield. Competition from inadequately suppressed sucker growth may be contributing to the lower yields on the non-cultivation treatments. Alternatively, the paraquat/diquat may itself be affecting the growth of stool canes despite careful application.

An experiment, started in 1967, is designed to assess the merits of the traditional 'furring up' operation on the establishment and productivity of a plantation. Experience in the management trial reported above has suggested that 'furring up' may have contributed to the superiority of cane production and yield on these plots, at least in the early years of the experiment. If so, some form of earthing up may be worth retaining in otherwise uncultivated raspberry plantations.

Efficiency of weed control and relative yields in the four-year-old experiment comparing annual applications of simazine, atrazine, bromacil and chlorthiamid did not differ greatly from those in 1966. The hoed control plots continued to outyield the uncultivated, herbicide plots. The difference is thought to be due partly to more efficient removal of sucker growth in the alleys and between stools in the hoed plots. Plots treated with bromacil yielded significantly less than those treated with simazine.

Strawberries

An experiment was planted in April 1967 to compare various weed control programmes involving hoeing, simazine, chloroxuron and lenacil. Factors to be studied include the efficiency of the programmes in terms of weed control, and their effects on the crop and the weed flora of the plots over the life of the plantation. In 1967, plots treated with chloroxuron (5 lb. a.i./acre) or lenacil (1.6 lb. a.i./acre) each required hoeing nine weeks after application, only two weeks after the first hoeing on the untreated control plots. Fat hen, pansy and speedwells were troublesome on plots treated with lenacil, and fumitory and speedwells on those treated with chloroxuron. The control plots were re-hoed on the same day as the lenacil and chloroxuron-treated plots partly to control a dense germination of *Poa annua* and partly to see whether any residual activity of the two herbicides remained. The two herbicide treatments subsequently maintained a satisfactory level of weed control for five weeks longer than the control treatment and did not require further hoeing until mid-October. Treatment with simazine (1 lb. a.i./acre), applied in early July after the strawberry plants had grown four new leaves, kept plots adequately free from weeds until the end of the growing season and had no adverse effect on the growth of the crop.

Vegetables

Several residual pre-emergence herbicides were compared with dinoseb and prometryne in peas in 1967. Those which gave acceptable weed control without checking germination or crop growth were C6313, C7019 (both at 2 lb. a.i./acre), buturon and SD 11831 (both at 1 lb. a.i./acre).

The search for effective and safe residual herbicides for use in direct-drilled and transplanted Brassicas continued. The most effective material was trifluralin (1 lb. a.i./acre) incorporated into the soil pre-sowing or pre-

transplanting. This herbicide has consistently performed well under the soil conditions and on the weed flora of Mylnefield, and has been much superior to propachlor (6 lb. a.i./acre) except when applied at times other than the main germination period of fumitory. C7019 at 2 lb. a.i./acre controlled weeds reasonably well and 4 lb. a.i./acre was as effective as trifluralin in transplanted winter cabbage. There was evidence, however, of some damage to direct-seeded Brassica crops treated with C7019 at 2 lb. a.i./acre pre-emergence.

Propachlor had no adverse effect on swedes at dosage rates up to 5.2 lb. a.i./acre and controlled all weeds adequately except fumitory.

Where red beet was grown in 6 in. rows for 'baby' beet production, the use of a stale seedbed, involving the application of paraquat/diquat one week before crop emergence, gave acceptable weed control throughout the life of the crop. The efficiency of the technique was aided by early seedbed preparation, dry weather conditions, and the rapid formation of a leaf canopy by the crop. The addition of residual herbicides to the paraquat/diquat treatment did not give a worthwhile increase in weed control under these conditions.

Weed competition studies

Two experiments begun in autumn 1967 are designed to investigate the effects of weed competition and timing of weed removal on the growth and yield of spring cabbage and of narcissus. Further experiments of this type are planned in close-drilled vegetable crops grown for processing, in particular to investigate the smothering effect of the rapidly attained crop canopy on the competitive ability of weeds. (H. M. Lawson, J. S. Wiseman).

FIELD EXPERIMENTATION

VEGETABLE CROPS

Beetroot

Yields and size-grade distribution were examined in a factorial experiment involving three nitrogen levels, four sowing rates, and three sowing dates. There was no yield response to nitrogen above 200 units/acre, the lowest rate used. The heaviest total yield of roots, 25 tons, was obtained by sowing at a rate of 10 lb. seed/acre on 18 May, and yields decreased with sowings on 8 and 29 June to 19 and 11 tons respectively, at this seed rate. The maximum yield of 'baby' beet (6.5 tons/acre of roots $\frac{3}{4}$-$1\frac{1}{2}$ in. diam.) was from sowings at the rate of 40 lb./acre of seed made at either of the two earlier dates.

On the basis of performance in observation plots, the varieties Vroege Kogel, Baby, Detroit Nero, and Crimson Lake were selected for further test.

Brussels sprouts

Five varieties were grown at four nitrogen levels and three plant spacings i.e. 2 ft. x 2 ft., $1\frac{1}{2}$ ft. x $1\frac{1}{2}$ ft., and 1 ft. x 1 ft. Maximum yield at the widest spacing was obtained with 300 units nitrogen, and at the closer spacings with 400 units. The heaviest yielding variety was Peer Gynt, with 10.9 tons/acre of

marketable sprouts at the two close spacings at a single harvest. Though the total yields at these spacings were the same, 1 ft. square spacing gave 6.7 tons/acre in the freezing grade ($\frac{3}{4}$-$1\frac{1}{8}$ in. diam.), compared with 3.3 tons at $1\frac{1}{2}$ ft. square. At 2 ft. square the yield in this grade was only 1.8 tons. Each decrease in plant spacing delayed the date of harvesting by about 10 days, and reduced the percentage of blown sprouts.

Plants of eight varieties were raised by sowing in autumn, sowing under glass in spring and sowing outdoors in spring. In this and all other sprout experiments the plants were spaced at $2\frac{1}{2}$ ft. square. The best all-round variety was Roem van Kloosterburen which yielded 6.9 tons/acre when autumn sown, 7.1 tons glasshouse raised, and 5.1 tons from spring sowing out-of-doors. Peer Gynt gave 5.3 tons/acre from outdoor spring sowing but did not yield so well when propagated by either of the two other methods. The variety Norga I was least prone to bolting.

Other trials showed that the varieties Gronalto, Stam Bloem, and Focus yield well under northern conditions, as they have done in the south. The SHRI hybrid No. 9 again produced a heavy yield of freezing grade sprouts of good colour, and new F_1 hybrids from Dutch and British seed firms performed well and will be included in further trials.

Cabbage

The heaviest yields in a spring cabbage variety trial were obtained from Harbinger, Flower of Spring and Early Spalding in succession of cropping from mid-May to mid-June. Though firm, Harbinger was of poor appearance; Durham Early and CS 650884 had the best market appearance with the latter the most uniform variety of the eight in the trial. Several F_1 hybrid stocks of spring cabbage from foreign sources were sown in July to crop in 1968.

In late December, the SHRI winter-maturing F_1 variety gave a yield of over 30 tons/acre of marketable heads, averaging 1.6 lb. each, when grown at 1 ft. x 1 ft. with 300 units nitrogen, using plants raised from seed sown on 19 April or 10 May. When sown on 31 May and planted 2 ft. x 2 ft., $2\frac{1}{2}$ lb. heads were obtained but the total yield was only 12 tons/acre. The varieties Winter Pride and January King did not produce marketable heads at 1 ft. x 1 ft. spacing from the early sowings, or at any other spacing when sown on 31 May.

Calabrese

A block of the variety Rex, grown for processors' assessments, yielded at the rate of 36 cwt./acre of primary heads. None of the nine other varieties examined was more uniform in heading than Rex.

Cauliflower

Twenty early varieties were sown in autumn in frames and in spring under glass. Spring sowing gave the better quality curds though Romax, followed four days later by Snowball Remo and Improved Snowdrift, also gave a high

percentage of good quality curds when autumn-sown. Twelve days later, Finney's Everyday cropped well. Many of the other later varieties produced a high proportion of discoloured heads. Heading occurred at the same time irrespective of whether the plants were raised in autumn and overwintered in frames, or sown in early spring under glass.

The varieties Champion and All Year Round were judged the most suitable for canning of six varieties tested. The level of nitrogen had no measurable effect on canning quality.

Celery

Eleven varieties of green and self-blanching celery were assessed for yield and quality. Of the green types, both FMA5 and Compak 1 were heavy-yielding with long stalks. The semi-blanched variety, Lathom Blanching, produced a heavy crop of shorter-stalked heads, and a line from the National Vegetable Research Station was the best of the white, well-blanched varieties.

French beans

The variety Glamis was grown at four levels of nitrogen application, 0, 100, 200 and 300 units/acre. The maximum yield of 108 cwt./acre at a maturity ratio of 8.9% (seed weight/seed+pod weight) was from plots receiving 200 units N. With increasing nitrogen, leaf colour darkened appreciably and pod colour slightly, but at 300 units pod maturity was delayed. In a variety trial, Glamis was earlier than any of the 13 commercially-available varieties tested.

Peas

Sown at rates of approximately 2, 3 and 4 cwt. seed/acre, field establishments of 8, 11 and 16 plants/sq. ft. were obtained with Dark Skin Perfection, 10, 14 and 18 with Kelvedon Wonder and 10, 14 and 19 with Dwarf Witham Wonder. There were no significant differences in yield or size grading at the different plant spacings, though the 4 cwt. seed rate gave a crop that matured more rapidly between the freezing and canning stages (an extra increase of one tenderometer unit per day). Over the same period the tenderometer readings for Dwarf Witham Wonder increased at a rate of eight units per day, compared to an increase of five units per day with the other two varieties in the experiment.

Twenty-one varieties of peas were sown on 7 April in a replicated variety trial. Precursor, a small-seeded, short-stemmed variety, was a week earlier in cropping than the standard, early, freezing variety Jade, but yielded only 73 cwt./acre compared with Jade's 91 cwt. at tenderometer 100. Scout, a large-seeded variety, yielded 103 cwt./acre, and Coronet, a small-seeded variety, 99 cwt./acre, cropping at the same time as Jade. Multifreezer 410 outyielded Dwarf Witham Wonder in the mid-season group (113-105 cwt./acre). The late, freezing variety Puget yielded 105 cwt./acre, compared with 98 cwt./acre from Dark Skin Perfection. The early canning variety Dorla, with 99 cwt./acre slightly outyielded Gregory's Surprise with 91 cwt./acre at

tenderometer 120, but the latter was much smaller-seeded. Perfection 317, a small-seeded variety, gave 138 cwt./acre, significantly higher than the 104 cwt. from Small Seeded Canners Perfection. In all the pea experiments prometryne gave excellent weed control.

Potatoes

In response to enquiries from processors and growers, preliminary experimental work was started on the production of small, new potatoes for canning. Seed of the variety King Edward was cool-stored to induce multiple sprouting and planted at three densities, on three different dates, with two levels of nitrogen application. The highest yield of immature potatoes in the ¾-1¼ in. grade was 6 tons/acre, obtained from plots planted at the end of March and fertilized with nitrogen at 100 units/acre. This treatment produced about 14 stems/sq. ft.

On the basis of results from elsewhere, 20 varieties were chosen and grown at the Institute for quality comparison, and a number of these varieties were also grown on two types of peat in Aberdeenshire, with the assistance of the North of Scotland College of Agriculture. Samples were canned by the Fruit and Vegetable Preservation Research Association at Chipping Camden, but quality assessments have not yet been analysed.

Spinach

Of five varieties tested, the heaviest yielding was No. 24, which gave 13.7 tons/acre total plant weight, or 8.4 tons/acre leaf blades, when harvested on 4 July from a sowing made on 17 April.

Swede

Four varieties were sown at the end of April and end of May, given four rates of nitrogen and thinned to three within-row spacings. The object was to select a variety and appropriate cultural treatments to give the maximum yield of swedes in the 4-6 in. diam. grade for household use. The varieties CHO and Pentland Harvester both showed internal browning or breakdown, not, apparently, associated with boron deficiency. Acme and Danestone yielded 36 and 39 tons/acre, respectively, in the required size grade when sown on the 28 April and thinned to 5 in. in the row, and 32 and 29 tons when sown on 30 May. These figures are averages for all nitrogen treatments. The response to nitrogen and its interactions with sowing date have not yet been analysed.

Sweet corn

Successful sweet corn crops can be grown in eastern Scotland by raising plants under glass and transplanting to the field in late May. This is a costly method of production and an alternative method was examined, in which seed was sown direct in the field on 30 April, sprayed with simazine, and covered with clear polythene. Following emergence, slits were cut to allow

plants to grow through the sheet. Plant development was good and yield was higher than with glasshouse-raised plants, though the latter were harvestable a week earlier. (H. Taylor, C. D. Mason).

FRUIT CROPS

Raspberries

This season, like last, was notable for the very limited crop losses from *Botrytis*. No significant increases in yield of Malling Jewel resulted from application of fungicides in an experiment in which dichlofluanid, captan, and Daconil 2787 were applied at two spray pressures, 50 and 300 p.s.i. Latent infection was assessed by incubating fruit plugs, and, although there was less in all treatments than in the unsprayed controls, there were no differences between treatments.

A number of varieties in the 1952 variety trial continue to crop well. Malling Jewel yielded at the rate of 4 tons/acre in this fifteenth year after planting.

The 1960 variety trial has been used to assess the competition between new cane growth and fruit production. In half the replicates new shoots were regularly removed, and in the other half allowed to grow normally. All varieties responded by producing higher yields in the treated plots than in the untreated, the increase ranging from 9% in Malling Jewel (92 cwt. to 100 cwt.) to 46% in Norfolk Giant (87 cwt. to 127 cwt.).

Two new experiments were planted in 1967. The first is designed to compare the establishment of plants of Malling Jewel propagated in the normal way, i.e. spawn cane, with those propagated from root cuttings raised in whalehide pots, and to investigate the effect of mowing maiden year canes on the subsequent performance of the plants. The second experiment investigates the feasibility of establishing plantations directly from root cuttings planted in the field. The variable factors are time of planting, size of root cutting, and depth of planting.

Strawberries

An experiment on *Botrytis* control, similar to that on raspberries reported above, showed no significant differences in yield between plots of Crusader sprayed at high and low pressures, or in fact between treated and untreated plots. These results are probably due to the slight amount of infection in this experiment; only 6% by weight of berries from control plots were infected.

A one-year-old block of Crusader was used to try to determine the optimum periods for spray application. Five schedules were compared: three 3-spray programmes, which were staggered to cover the whole of the flowering period, and two 5-spray programmes over the same period, all with 5-day intervals between sprays. Dichlofluanid was used at a rate of 2 lb. a.i./acre per application for the 3-spray programmes, giving the recommended total of 6 lb. a.i./acre. By reducing the rate per application in one of the 5-spray

programmes to 1.2 lb. a.i., the same total amount was applied. In the remaining 5-spray treatment the rate was maintained at 2 lb. a.i./application, giving a total of 10 lb. a.i./acre. Flower development was recorded and the schedules related to the stages of development discussed by W. R. Jarvis in the 1966 Report (p. 29). All spray treatments significantly reduced fruit loss due to grey mould, and although differences between spray programmes did not reach significance, the 5-spray programme applying 10 lb./acre gave the best results, followed by the latest of the 3-spray programmes. The success of the high rate of application is perhaps not surprising, but the effect of the late 3-spray programme is interesting. Applications coincided with the stage of development when the numbers of opening flowers were declining and the rate of petal-fall was high–from approximately 20% to 80% petal fall. The results suggest that this period of development, when petals are withering and falling, is the most susceptible to infection by *Botrytis* and therefore the time when protection is most needed. In Crusader it lasts from about 10 days to 28 days after first open flower.

The 1964 variety trial was cropped for the last time. All varieties, with the exception of Cambridge Favourite, gave an increased yield in response to defoliation. Redgauntlet produced 6.75 tons/acre (24% increase due to defoliation), Talisman 6.25 tons (31%), Templar 5.3 tons (44%), and Crusader 5.3 tons (7%). The untreated plots of Cambridge Favourite yielded 5.3 ton/acre–22% more than the defoliated plots. Defoliation also failed to induce an increase in yield in a five-year-old plantation of Templar, but this merely confirms earlier conclusions that response decreases as a plantation ages.

The third and last stage of the defoliation experiment planned by the Horticulture Committee of the Scottish Agricultural Improvement Council was cropped in its final year and crown counts made. The data from this experiment at the Institute and those at the other three centres are now being analysed.

A sub-committee appointed by the Horticulture Committee of the Scottish Agricultural Improvement Council has reviewed the present Museum Collection of Apple Varieties and selected 300 varieties for retention in a new Apple Variety Collection.

The trial of four North American varieties on four Malling Merton rootstocks is now reaching the stage of rapid increase in cropping, the trees on MM 106 fruiting particularly well, with MM 111 next; trees on MM 104 and MM 109 are slower to reach high levels of yield. Golden Delicious, Double Red McIntosh, Bancroft and E 6, planted as fillers on M IX, also fruited satisfactorily.

Miscellaneous

A number of blueberry varieties, fruited in pots last year, were planted in the field and cropped in 1967. Varieties of cranberries, elderberries, and saskatoons are being grown for assessment of their commercial possibilities. A collection of clones of *Cupressocyparis leylandii* has been established with a

view to selecting those most suitable as windbreak material. (M. R. Cormack, G. G. Hutchison).

PUBLICATIONS

TAYLOR, H. and CASE, M. W. (1968)[1]. Leek variety trials 1961-64. *Expl. Hort.* (in press).

WAISTER, P. D. (1967). Crop responses to water at different stages of growth, by P. J. Salter and J. E. Goode. (Book reviews). *Hort. Res.*, **7**, 157-158 and *Scott. Agric.*, **47**, 49.

[1]Stockbridge House Experimental Horticulture Station.

Mycology

A. R. WILSON

Some of the more interesting developments during the year have been on the potato side. While it is too early to be definite, the possibility of growing low-sugar Record potatoes by manipulating the conditions under which the seed is stored and of achieving some measure of control of gangrene by heat therapy could well yield results of considerable value to the industry, particularly in Scotland. Of importance for somewhat different reasons is the discovery that *Rhizoctonia solani* can produce sclerotia hidden in otherwise healthy tuber flesh. The implications for both control by dipping and visual inspection for black scurf may be far reaching if such sclerotia prove to be common.

Pressure of other commitments has forced me to give up my personal project on tomato grey mould but I am pleased to say that the work will be continued by W. R. Jarvis in conjunction with a diminishing programme on grey mould of soft fruit.

Various staff changes have occurred during the year; Carol Pugh joined the Section as an Assistant Experimental Officer to work under W. R. Jarvis; Janet Barclay, Aileen Crockatt, Barbara Hume and T. Q. Neilson were appointed as Scientific Assistants and D. Bain, T. Boyle and Eileen Jackson resigned; Norah Cotogno was appointed as a Laboratory Attendant.

It is with great pleasure that we congratulate Dorothy Spencer on being awarded the degree of Ph.D. (St. Andrews) in October.

As well as the usual lectures given and meetings attended by the staff, meetings in Norway of the Council of the European Association for Potato Research and of its Pathology Section were attended by myself in May and by Dorothy Spencer in August, respectively, while W. R. Jarvis gave a paper on '*Botrytis* control in Scotland' at a symposium on raspberry culture held by the International Society for Horticultural Science in Dundee in September. R. A. Fox was elected to the Council of the British Mycological Society in December. He has been invited to go to the University of Ceylon as a Royal Society Visiting Professor.

We should once more like to express our appreciation of the continued interest and support of Dr T. H. Nicolson and his staff at the Botany Department, University of Dundee in our joint seminars during the year.

As usual I also wish to thank the many people, in addition to those mentioned by name later in this report, who gave facilities and assistance to the Section or who supplied samples of fungicides, seeds and other materials.

Post-harvest storage

The efficacy of single and multiple twenty-minute exposures of strawberries, raspberries, and blackcurrants to 0.25% and lower concentrations of sulphur dioxide has now been demonstrated over a number of seasons and in several cultivars. Although grey mould is controlled, treatment of wet and bruised fruit and fruit affected by powdery mildew is less satisfactory as it is prone to SO_2 damage. Continuous exposure of fruit to lower concentrations of SO_2 given off by solutions of sodium metabisulphite has given promising results and warrants further investigation.

Fumigation fails to control leak (*Rhizopus stolonifer*) in warmer seasons so that cool storage after treatment is then advisable.

A 40% water-miscible formulation of dichlorophen[1] was tried as a post-harvest dip at concentrations of 0.004% to 0.04% a.i. The highest concentration gave some degree of grey mould control, but the fruit was tainted. (W. R. Jarvis).

Rot control in artificially-ripened strawberries (see p. 50)

Only *Botrytis cinerea* and *Rhizopus stolonifer* occurred in appreciable amounts. Following fumigation with 0.25% SO_2, numerous small, pale brown, sunken lesions developed which enlarged and deepened as the fruit expanded; grey mould was almost completely controlled but leak was more prevalent. (W. R. Jarvis with D. T. Mason, Plant Physiology).

Effect of fungicides on strawberry pollen

Germination of pollen (cv. Talisman) *in vitro* was reduced almost to inhibition by dicloran and dichlofluanid and to a lesser extent by thiram and captan, at a concentration of 0.001% a.i. The same concentration of dichlofluanid and captan hardly affected the germination of spores of *B. cinerea* while dicloran and thiram reduced it by 60-70%. (W. R. Jarvis, C. G. Pugh).

STAMEN BLIGHT OF RASPBERRY

Observations in 1966 and 1967 on a plantation established in 1965 with canes of Malling Jewel infected with stamen blight (*Hapalosphaeria deformans*), showed that the spread of infection in 1965 and 1966 had been very localised. It was mainly within stools, infrequently to the next stool in the row and rarely to the nearest stool in an adjoining row.

In 1967, counts of spores trapped in the field up to 6 ft. from their source suggested that less than 40% were dispersed beyond the region of the parent stool.

An estimate of the time of maximum spore dispersal in 1966 was obtained by studying the relationship between flowering period of diseased inflorescences and rainfall. When young cane growth at this time was examined, it was possible to forecast accurately the position on the cane, but not the number, of diseased inflorescences the following year.

Plots with a low incidence of diseased flowers gave a higher yield than those with a high incidence, but the difference was not significant.

Spraying young canes to run off with 0.3% Elvaron (50% wettable formulation of dichlofluanid) significantly decreased the number of diseased flowers the following year–compared with control plots in which the number had increased.

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

RED CORE OF STRAWBERRY

Infection of healthy runners of Cambridge Favourite in the glasshouse was significantly reduced by a soil drench of 0.14% Dexon (70% wettable formulation of p-dimethylaminobenzenediazo sodium sulphonate) applied two weeks before inoculation of the soil with *Phytophthora fragariae*. Dipping plants in 0.14% Dexon prior to planting had no effect. Sporangial production and zoospore motility was inhibited by the same concentration *in vitro*. (I. G. Montgomerie).

COLD STORAGE OF STRAWBERRY RUNNERS (See P. 50)

The fungi most frequently isolated from Cambridge Favourite runners stored at 30°-31°F. and sampled at intervals over a period of 11 months, were *Botrytis cinera*, *Gnomonia fructicola*, *Cylindrocarpon radicicola*, *Fusarium avenaceum*, a *Pythium* sp. and a sterile fungus. Tests in cold storage showed *Gnomonia fructicola* to be pathogenic and the *Pythium* sp. non-pathogenic. (I. G. Montgomerie).

GANGRENE OF POTATO

The survey initiated in 1966 was continued. Samples were examined from 98 stocks of Scottish seed potatoes representing 40 cultivars. *Phoma exigua* Desm. var. *foveata* (Foister) Borema* was isolated from 260 lesions, *Phoma exigua* Desm. var. *exigua* (*sensu* Borema and Höweler)* from 10 and *P. eupyrena* from 8. Thus in 1966 and 1967 var. *foveata* was present in 88% and 94% respectively of lesions yielding *Phoma* spp. Co-infection was very rare.

Isolates of var. *foveata*, obtained in both surveys, varied in their reaction to temperature. All tested were, however, killed by exposure to 33°C. for 1 week or 45°C. for 2 hr. Tubers, wounded in four places and dipped in mixed

[1]'Panacide' supplied by B.D.H. Ltd.

*Formerly known as *P. foveata* and *P. solanicola* respectively.

mycelial homogenates, were subjected to these two heat regimes at varying intervals after inoculation and then incubated at 40°C. for seven weeks. Treatment at the lower temperature was useless, the number and size of lesions being equal to or greater than those on check tubers. The best result following treatment at the higher temperature was a reduction in incidence of 63%. Other observations suggest that humidity, not controlled in these initial experiments, may be an important factor. Though the results obtained at 45°C. were poor they are, nevertheless, considered promising particularly in relation to a similar treatment tested in Norway (43°C. for 2 hr.) which reduced by 80% the amount of tuber surface which subsequently developed skin spot (*Oospora pustulans*).

Observations made in N. Ireland, that planting infected tubers may lead to symptomless invasion of stems on which pycnidia form as the haulm dies, were confirmed. To assess the effect of such infection on disease incidence in the crop, stems of the cultivar Majestic were either untreated, or wounded at the base with or without immediate inoculation with a mixture of culture homogenates. The haulm was killed with acid six weeks later and plots harvested after a further two or four weeks. Immediately before each harvest the haulm was pulled and bagged. Each plot was split to give two tuber samples and both were severely wounded, one whilst mixed with half the quantity of haulm removed from its plot. In all treatments both per cent incidence and severity ratings were highest in the ware grade and lowest in the chats. In the seed grade, adding haulm at the first harvest nearly doubled the incidence in the check plots, but in all other plots only slightly increased it. Stem wounding alone had no effect on incidence in the seed grade but when followed by inoculation gave increases ranging up to more than twice those obtained in the check plots. In general, spores released from the haulm into the soil before harvest were a more important source of infection than those released when it was mixed with the tubers. Isolations were made from lesions on tubers from the second harvest. In comparison with the check and inoculated plots, wounding alone resulted in a higher proportion of lesions containing *P. eupyrena* and a lower proportion containing var. *foveata*. An experiment attempting to relate disease incidence and soil infectivity, using a most probable number method and tuber baits as a selective medium, gave erratic results which, however, sufficed to show that potato baiting, traditionally used to determine the presence of var. *foveata* is an insensitive technique. It may fail to detect this fungus in contaminated soils able to cause 50% or more infection in a crop. (R. A. Fox, E. P. Dashwood).

BLACK SCURF ON POTATO[1]

Rhizoctonia solani grew on the surface of inoculated tubers, both in the presence and absence of soil, at high humidities. At 20°C. sclerotia formed within twelve days of inoculation, but at 4°C. not until six to eight weeks.

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

Spread of infection between tubers has not been examined in the laboratory but evidence was obtained that it may occur in bulk storage. Samples of tubers, taken in October from black scurf-infected plants four weeks after destroying the haulm with acid, were placed 1 ft. below the stack surface in a commercial bulk store. After six months the number of tubers bearing sclerotia, but not the number of sclerotia on a tuber, had increased significantly.

Preliminary studies on the course of infection of Majestic tubers, grown in pots, showed that most sclerotia were confined to periderm tissue. Some, however, were formed within the cortex or between vascular bundles. This finding is important, especially if confirmed in the field, as these sclerotia may escape eradication by fungicidal dips. It also casts doubts on the validity of current visual phytosanitary inspections. In addition, such sclerotia, with an enhanced food base, may contribute to spread of the fungus in storage.

As in 1966 the timing and type of haulm destruction and the interval between destruction and harvest affected the incidence of black scurf. When treatments were applied early in the season to plants that were growing vigorously, significantly more tubers were infected, and to a greater extent, in acid-sprayed plots, than in those where haulm had been pulled or left untouched. Treatments applied to dying haulm had no significant effects.

There were no consistent differences in pathogenicity between isolates of *R. solani* from sprouts or tubers, assessed either by tests on sprouts or on detached sprouts, leaflets or stem tips of different cultivars or by incidence of black scurf on tubers from plants grown in soil inoculated with culture homogenates. The relative aggressiveness of isolates on any one tissue was not constant, but varied both with age of tissue and cultivar tested.

Isolates assigned to *R. solani* by mycelial characteristics have been assumed in the past to have *Thanatephorus cucumeris* as their perfect state. Cytological examination showed, however, that some isolates from sharp eye-spot of wheat and some from potato tubers were bi- as opposed to multinucleate; the former type has been shown by American workers to belong to an entirely different genus, *Ceratobasidium*.

Bulk storage facilities were kindly provided by Mr D. W. H. Cargill, Benholm, Montrose. (D. Spencer).

BACTERIAL SOFT ROT AND BLACKLEG OF POTATO

Two approaches to this problem are being made: the identity and role of pectolytic bacteria associated with soft rot breakdown of tubers in store are being investigated and survey work is being done to establish when and in what manner tubers become contaminated with bacteria capable of causing soft rot in store.

Three varieties of *Pectobacterium carotovorum–carotovorum, atrosepticum* and *aroideae* have been found associated with rotting tubers. Of these, var. *atrosepticum* occurred most commonly in tuber samples drawn at intervals from commercial bulk stores. Out of 253 isolates of pectobacteria 83% were var. *atrosepticum*, 14% var. *caratovorum* and 3% var. *aroideae*.

These three organisms seem to differ in their ability to survive in soil. Whereas none of them could be isolated in February from unsterilised soil inoculated and buried, since the previous November, in perforated polythene bags in the field, all three could still be isolated in February but only var. *atrosepticum* and var. *aroideae* in June, from inoculated tuber halves also buried the previous November. Although the tuber halves were largely rotted, they produced healthy sprouts, suggesting that, for at least the two last-mentioned organisms, groundkeepers might carry infection through a rotation. That the previous cropping history of soils is probably an important factor is borne out by observations on eight stocks of three cultivars, derived from single tuber selections or stem cuttings and which had been grown on recently cleared woodland. No pectobacteria could be isolated from any samples. They were, however, obtained from a few tubers of the third and fourth generation crops of three stocks originally raised from tuber selections and grown for the first and second times, respectively, on land previously under grass. Of 21 *Pectobacterium* isolates thus obtained, only six were var. *atrosepticum*.

Observations throughout the growing season on a crop of Majestic showed that few pectobacteria occurred on progeny tubers before August but that the numbers increased sharply after mid-September apparently coincident with the final breakdown of the mother tuber.

In November 1967, 23 stocks representing 10 cultivars, grown in Kincardineshire, Angus and Fife, were examined to determine the extent of tuber surface and lenticel contamination. There were considerable differences between stocks, those harvested after mid-September being usually more heavily contaminated than those harvested before. Only 65% of 182 representative pectolytic isolates proved to be pectobacteria of which 85% were var. *atroseptica*. When, however, the tubers were induced to rot, var. *atroseptica* accounted for only 72% of 94 isolates of pectobacteria. Characterisation of those isolates which were not pectobacteria and which were able to rot potato slices suggest that most belong to the genera *Pseudomonas*, *Klebsiella*, *Bacillus*, and possibly *Aeromonas*. (M. Pérombelon).

SUGAR CONTENT OF POTATO TUBERS

Further examination of the first year's (1966) data has revealed some highly significant correlations between distance north and both the rate and extent of accumulation of sugars in tubers of cv. Record. Thus, the total sugar contents, both at mid-season and maturity, the amount of reducing sugar at maturity, the estimated rate of translocation of carbohydrate to the tuber and the size of haulm at the time of tuber initiation are all inter-dependent and all highly correlated with distance north. The results suggest that daylength during the growing season is critical to both the rate and extent of accumulation of sugars and that a possible remedy may be the use of seed 'aged' by high temperature storage (15°-20°C.) as this results in tuber initiation while the haulm is still very small. (A. R. Wilson, W. G. Burton[1]).

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

SEEDLING ESTABLISHMENT

Peas

Emergence trials of 28 seed samples of five common cultivars were sown at East Craigs, Edinburgh, on 29 March and at Invergowrie on 9 March. Mean emergence at East Craigs was higher than at Invergowrie (62 and 32% respectively), but the range was smaller (32-86% and 6-91% respectively). Correlation between the results from the two sites was not high and discrepancies in rank order occurred.

The amount of soluble carbohydrate and electrolytes leached from seeds into water correlated well with emergence for 28 samples of several cultivars in one field trial, but not so well in a second trial of 10 samples of Kelvedon Wonder. The quantities of carbohydrate leached into water were not related to the total soluble carbohydrate extractable from the seeds, and no differences in the soluble carbohydrate:starch ratios were found in seeds of varying vigour.

Seeds of several cultivars which had matured and dried on plants grown together in a glasshouse were sown in the field on 9 March to detect any heritable variation in emergence ability. The cultivars Alaska, Harrison's Glory, Jade, Kelvedon Wonder, Meteor, Onward, Perfected Freezer and Witham Wonder all emerged well, with a mean of 92%, despite the adverse conditions which resulted in a mean emergence of only 32% in the commercial seed lots sown on the same day, thus confirming the phenotypic nature of low vigour in most cultivars. Gregory's Surprise, with a significantly lower emergence of only 57%, may be an example of a cultivar with genetically controlled low vigour.

The susceptibility of seed sown in sterile sand containing a suspension of *Pythium ultimum* was related to its field emergence ability. Many cotyledons became infected within 24 hr. at 20°C. and addition of glucose to the sand did not increase the pathogenicity of the fungus. Plumules of equivalent size from high and low vigour seed of Kelvedon Wonder were equally susceptible to infection by the fungus.

Carrots, brassicas, beetroot

The field emergence of 23 lots of Chantenay-type carrots and 21 lots of cabbage, Brussels sprout and swedes sown on 20 April and 3 May respectively correlated well with their official germination. Mean emergence of 6 samples of beetroot seed sown on 30 May increased 13% following thiram soak treatment, with the greatest improvement (36%) in the most heavily infected sample.

Thanks are due to the Official Seed Testing Station, Edinburgh, for their help and co-operation. (D. A. Perry).

MISCELLANEOUS

Cavity spot of carrots

In a field trial at East Scryne, Carnoustie, 10 cwt./acre gypsum reduced the

incidence of cavity spot from 20% to 11%, while neither 30 cwt./acre lime or 20 cwt./acre sulphate of potash had any significant effect.

Thanks are due to Mr A. G. Porter for providing the land for this trial.

(D. A. Perry, T. G. Rubens[1]).

PUBLICATIONS

BURTON, W. G.[2] and WILSON, A. R. (1967). The production, translocation and accumulation of carbohydrates and contents of sugars, as affected by locality. *Eur. Potato J.*, **10**, 330-331.

(Abstract of paper, read at a meeting of the Physiology Section of the European Association for Potato Research at Rostock, DDR, 3-6 July 1967; deals with some of the earlier results mentioned on p. 34 of this Report).

FOX, R. A. (1967)[3]. The role of biological eradication in root-disease control in replantings of *Hevea brasilensis*. *Tech. Doc. F.A.O. Pl. Prot. Comm. S.E. Asia* No. 54.

(Abstract of a paper of the same title published in 'Ecology of soil-borne pathogens' University of California Press, 1965; deals with current recommendations for the control of root diseases and some aspects of the mechanisms of biological eradication).

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(A short review of methods for post-harvest fumigation of soft fruit to prolong storage and of limitations imposed by legislation, toxicology and processing technology).

JARVIS, W. R. and BORECKA, Halina (1968)[4]. The susceptibility of strawberry flowers to infection by *Botrytis cinerea*. *Hort. Res.* (in press).

(The susceptibility of flowers of various ages and cultivars in relation to blossom blight, establishment of latent infection, and fruit rot).

MONTGOMERIE, Isabel G. (1967). Stamen blight of raspberry. *Grower*, **68**, 102.

(A popular account of the symptoms of the disease, the life cycle of the pathogen and methods of control).

PERRY, D. A. (1967). Vigour of germination *in vitro* as an indicator of field emergence ability in peas. *Hort. Res.*, **7**, 148-50.

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

SPENCER, D. (1967). Some aspects of infection of *Solanum tuberosum* L. by *Rhizoctonia solani* Kuhn. *Ph.D. Thesis Univ. St. Andrews.*

(Stolon severing by *R. solani* in the field is too infrequent to affect yield and tuber size distribution. Harvesting practices affect the development of sclerotia on the crop; some may form within tuber tissue. Isolates vary in ability to form sclerotia and differ in pathogenicity to different parts of the plant).

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

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

[3]Reports work done at the Rubber Research Institute, Kuala Lumpur, Malaysia.

[4]Instytut Sadownictwa, Skierniewice, Poland.

Plant Breeding

C. NORTH

Since Mr R. D. Reid retired, the staff and work of the West of Scotland Unit have been absorbed in the Plant Breeding Section and will, it is anticipated, largely be transferred to Invergowrie in 1970 or 1971. However, field resistance to red-core remains the main objective of the strawberry breeding programme, so the heavily infected field at Auchincruive will be retained for screening seedlings. We are very conscious of the success and reputation of Mr Reid's work, and it is unlikely that the objectives of the strawberry breeding will be radically altered for several years, though a new look at the work is inevitable.

In the past the Institute has introduced new varieties of strawberry only, but now we are approaching the time when varieties of other crops, bred at Invergowrie, will become available. It is almost certain that, within the next few years, varieties of raspberry, French bean, Brussels sprout and cabbage will be released. This coincides with considerable activity in the launching of Plant Breeders' Rights Schemes and the founding of the National Seed Development Organisation, and several of us have been involved in meetings of committees set up to discuss relevant matters. Also, in the course of producing varieties of some vegetables, by-products, in the form of incompletely selected material, have become available. Rather than expend our facilities on the final stages of their improvement it has been agreed to pass on some stocks to that section of the British seed trade actively engaged in plant breeding; cabbage and runner bean breeding material has already been distributed in this way.

The main lines of work in the Section are similar to those of 1966 but, following the resignation of H. J. V. Gledhill and acting on the advice of the A.R.C. Visiting Group, the programme on carrots has been discontinued. It is intended that the vacant post will be used to acquire a worker on problems arising from the use of heterosis in *Brassica oleracea* crops. One new project, not previously reported upon, is the breeding of blackberries with erect thornless canes. Varieties of this type might extend the berry fruit season and permit the more economic use of raspberry harvesting machines.

We were fortunate to have as a guest worker Dr Hugh A. Daubeny from the Experimental Farm, Agassiz, British Columbia. He spent six months at Invergowrie, working mainly on mildew resistance in raspberries. This gave an opportunity to compare results for segregation of this feature in Scottish and Canadian breeding material, and a joint paper on this subject with

Pauline Topham and D. L. Jennings has been submitted for publication. From the Research Station Wädenswil, Zürich, Miss Marlies Kümin came to work as an assistant for six months during the summer. She was a lively and popular temporary member of the Section.

There were several staff changes; E. N. Bent joined the unit at Auchincruive to replace W. I. A. Jack, who was transferred to Invergowrie as Field Experiments Officer. Three new assistants were appointed, Eveline M. Holmes and Sheena K. Fyfe at Invergowrie, and Mrs Gillian M. Innocent at Auchincruive. We are pleased to record that D. L. Jennings was promoted to Principal Scientific Officer, Greta Priestley to Senior Experimental Officer and that Eleanor Carmichael and D. Bruce were re-appointed to the Section as Assistant Experimental Officers.

H. J. Gooding continued to serve on the City and Guilds of London Institute Standing Committee on Agricultural Subjects in Tropical Countries and was appointed an examiner in crop husbandry. I have been appointed Chairman of the Horticultural Crops Section of Eucarpia, which organises meetings in European countries on the breeding of vegetable and ornamental crops.

The Institute acted as host to a working group of the International Society of Horticultural Science for a symposium on problems of the cultivation and breeding of raspberries. D. L. Jennings organised the meeting, which attracted 37 visitors representing 11 overseas countries.

A travel grant from the Agricultural Research Council enabled me to visit several institutes at Wageningen and the Unilever Research Laboratory, near Arnhem. H. J. Gooding took the opportunity, whilst on holiday in Germany, to visit the Max-Planck Institute at Cologne.

A. B. Wills has put the finishing touches to the Primer of Chromosome Practice written by him and the late Dr G. M. L. Haskell and steered it through the printers. It is intended as a guide for teachers and students, but should also prove useful to technicians and research workers not already familiar with the field.

Ever since the departure of H. J. V. Gledhill the Section has continued with the role of adviser on statistics; D. L. Jennings and Pauline Topham have contributed much time to assisting other Sections in the preparation of tapes for the Rothamsted computer, and Eleanor Carmichael to administrative aspects of this service. Whilst we are pleased to assist our colleagues, this is time-consuming work and we look forward to the appointment of an officer who will take over from us.

The Section does not have much call on large items of equipment, but the purchase of a new Zeiss fluorescence microscope has greatly facilitated cytological studies. The phase contrast system is especially valuable for observations on pachytene stage of meiosis. Another piece of equipment which has greatly contributed to the work is the shaking device for experiments on the mechanical harvesting of raspberries. Our thanks are due to the National Institute of Agricultural Engineering Scottish Station, for designing and making this equipment.

BEAN

Dwarf French

An application for Plant Breeders Rights has been made for the variety Glamis, and 70 lb. seed has been passed to the National Seed Development Organisation. The variety continues to be early-maturing in British trials, and has given promising results in Denmark. It is hoped that it may be released in 1970/71.

Dwarf runner

The material described in last year's Report was grown and assessed for processing qualities by the Fruit and Vegetable Preservation Research Association at Chipping Campden and the Pea Growing Research Organisation. Although the colour and flavour compared quite favourably with standard varieties of runner bean, maturation of the pods is protracted and this limits its usefulness to processors. However, it has some potentially useful characters and has been offered to commercial breeders. (W. G. Priestley, J. Walker).

BLACKBERRY

A small number of families were planted in 1967. The most promising are those derived from crosses between the cultivar Early Harvest, which is early, erect and suckering, and three thornless derivatives of Merton Thornless, two raised in the United States and one by the late Dr Haskell. It is hoped that the second generation of these crosses will yield seedlings which combine good pomological qualities with earliness and thornless canes of erect and suckering habit. (D. L. Jennings, B. M. M. Tulloch).

BLACKCURRANT

The programme for this crop has been revised and it has been decided to concentrate the main effort on combined resistance to American gooseberry mildew and leaf spot. Work on blackcurrant gall mite will be continued, with special emphasis on the use of resistance from the sub-species *Ribes nigrum sibericum* and its derivatives, but studies on yellows variegation and midge will be discontinued.

American gooseberry mildew

Field infection was especially severe and affected seedling populations, including progenies from Brödtorp, though infection was sufficiently severe to cause die-back of shoot tips in only a small proportion of seedlings. The most outstanding resistant seedlings were from families derived from Öjebyn, Seabrook's Black and *Ribes dikuscha*.

In a glasshouse screening test, two further varieties–Taylors Seedling (Kippen's Seedling) and Willoughby–were found to have resistance to the disease.

Blackcurrant leaf spot

About 50% of the F_2 seedlings from *Ribes dikuscha* planted 1963/4 were recorded as immune (no acervuli observed on healthy leaves) from leaf spot and a similar proportion of back-cross seedlings planted in 1966 were also immune. Unfortunately these *R. dikuscha* derivatives still do not have the fertility of commercial varieties.

The most fertile leaf spot-resistant F_2 seedlings mentioned above were crossed with material resistant to American gooseberry mildew, and open-pollinated seed was harvested from plants which had most resistance to both diseases.

Blackcurrant gall mite

The *R. nigrum sibericum* variety Barchatnaja showed considerable resistance to infestation by gall mite in a field test. A more intensive examination will be made of this and the similar varieties Rus, Koksa, Marjadnaja, Wista and Hysa in the hope of finding other sources of resistance. A notable feature of Barchatnaja is the dense pubescence of its shoots and it is thought that this might be associated with mite resistance. (M. M. Anderson).

BRUSSELS SPROUT

At a wide range of National Institute of Agricultural the Institute's F_1 variety No. 9 continues to give high yields of sprouts suitable for processing Botany trial centres. However it is not yet certain whether this variety can be maintained on a commercial scale, so seed has been passed to the N.I.A.B. for multiplication of the two parent lines and for investigation of some problems which might arise in large-scale production of hybrid seed.

Two more complementary 'glossy' genes have been discovered, one in the variety Seven Hills and a second one from Irish Elegance. Four different types of 'glossy' plants are now available, any pair of which, when crossed together, will give 'normal' plants. Work to improve this material as potential parents for new F_1 varieties continues. One of the possible weaknesses of some glossy lines is their relative lack of hardiness, so attempts are being made to transfer hardiness from the curly kale, Lerchenzungen, by a back-cross programme.

CABBAGE

The winter-maturing F_1 cabbage has now given good results in two years of N.I.A.B. trials. It tends to produce rather large heads at wide spacing, but experiments by the Crops Research Section have indicated that heads of a more acceptable size may be obtained by closer spacing (p. 23). Seed of the two parent lines is being multiplied by the N.I.A.B. so that an adequate quantity will be available if release is decided upon.

The autumn-maturing line shows promise but one or two years' results from N.I.A.B. trials will be required before its full potentiality can be assessed.

Two lines have been handed over to commercial breeders through the British Association of Plant Breeders. Both are segregating material of winter-maturing types which require several generations of breeding before they are likely to produce potential varieties. One of them is homozygous for 'white-petal' which could be a useful marker character if and when a Plant Breeders Rights Scheme is introduced for cabbage. (W. G. Priestley, J. Walker).

LILY

No headway has been made with the breeding for disease resistance since adequate screening tests are not yet available. However, crosses were made between species and varieties which have some apparent disease resistance, with the intention of subjecting them to tests later.

Crosses between *Lilium lankongense* and *L. davidii Maxwill* gave chaff-like seed with no endosperm and minute embryos which became necrotic as the capsule ripened. When such embryos were cultured on sterile nutrient agar they developed into healthy plants, and an examination of their karyotypes confirmed that they were true hybrids. Very small embryos and deficient or faulty endosperm occurred in mature seeds when *L. pyrenaicum* was crossed with *L. pomponium*, *L. carniolicum* and *L. ponticum* types; again hybrid plants were obtained by growing on the embryos *in vitro*. These results suggest that barriers to interspecific hybridisation of other species of *Lilium* may be overcome by embryo culture and the technique will be further exploited. (C. North, E. M. Holmes).

RASPBERRY

The last Report mentioned that three seedlings were being propagated so that one or more could be released if performance in trials is adequate. One of the early-ripening selections yielded especially well in 1967 and had particularly good fruit quality but the yield of the late-ripening selection was less satisfactory, apparently because the late fruits did not develop fully during the dry weather in early August.

Assessments of more recent material were made with an eye to suitability for mechanical harvesting and several selections appeared promising. These have been propagated for further tests and also crossed with other parents chosen as sources of improved disease resistance. (D. L. Jennings, P. B. Topham, B. M. M. Tulloch).

Mechanical harvesting

The report of the delegation which visited America to study developments in mechanical harvesting of raspberries recommended that we should assess the response of Scottish-grown raspberries to the kind of shaking action used by the Agricultural Sciences machine. A device which simulates this action was designed and built by the National Institute of Agricultural Engineering Scottish Station and used on five raspberry varieties at Invergowrie. In tests

during July, it was found that, with a stroke of $\frac{7}{16}$ in. and a vibration frequency of 10,000 r.p.m. (calculated to give an acceleration of 2410/sec./sec.), the percentages of fruits removed which were sound, ripe and without stalk were 90, 87, 79, 69 and 61 for Burnetholm, East Malling Seedling M, Malling Exploit, Malling Jewel and Norfolk Giant respectively. Better results were obtained in August when the fruit was very overripe, but such fruit would suffer mould damage in wetter seasons. It was concluded that varieties whose fruits separate from the plant as easily as those of Burnetholm or Seedling M would be suitable for harvesting mechanically in Scotland, but that other varieties would be suitable only in favourable seasons.

The results suggested that the total amount of fruit removed was proportional to the acceleration imparted to the fruiting laterals by the device, but that the proportion of unwanted fruit (unripe or ripe with stalk) became unacceptable at high acceleration rates. It is planned to test this hypothesis in 1968 by comparing the results when similar rates for acceleration are obtained by different combinations of stroke and frequency. (D. L. Jennings, D. Bruce).

Studies of the breeding system

Studies of factors which affect fertility in *Rubus* were continued. In a series of experiments concerned with pollen density, it was found that dilution of the pollen led to poorer set of druplets, slower fruit development, larger and broader nutlets, seeds and embryos, and less deviation from expected ratios for segregation of spiny canes; maternal parents differed in their tolerance to pollen dilution. In another experiment, histological evidence indicated that a high initial stimulus to fruit development, characteristic of certain parent combinations, was associated with the development of relatively narrow nutlets and seed, possibly because of earlier differentiation of the tissues. Further evidence was also obtained for an hypothesis that deficiency of S (spiny) genotypes in certain segregating families is due to their association with increased endosperm development which delays or prevents germination.

In an attempt to improve the fertility of sub-fertile crosses in the breeding programme, the effect of several combinations of gibberellin and synthetic auxins on the developing fruits and seeds of one raspberry clone was studied. The treatments improved drupelet set but not seed development. Further work will be done to find whether this applies to other clones, and if so, why the raspberry differs in this respect from the blackberry. (D. L. Jennings, P. B. Topham, B. M. M. Tulloch and E. Carmichael).

STRAWBERRY

Strawberry breeding at Auchincruive has aimed at the production of general purpose cultivars having fruiting characters acceptable to commercial growers and possessing field resistance to red core disease and freedom from virus infection. The material has also been field-screened for other major diseases including grey mould (*Botrytis cinerea*) and mildew (*Sphaerotheca humuli*), and emphasis has been placed on survival value, adaptability, productivity and quality. Whilst this basic programme will be largely adhered to, several modifications are being tried to make screening procedures more efficient.

As far as possible, the 1-2% seedlings which survive the first field selection are now being fruited the following year under cloches. Here, conditions especially favourable for attack by *Botrytis* can be obtained, permitting a more stringent selection for resistance than is possible under field conditions.

We are seeking objective methods for measuring certain aspects of fruit quality, such as firmness and the ability to withstand transportation. These measurements must be rapid so that it is possible to cope with the number of seedlings raised annually. With the anticipated introduction of mechanical harvesting, crops are likely to be harvested by a once-over operation which will give an overall reduction in yield that may be only partially compensated for in existing varieties by closer spacing and post-harvest ripening of unripe fruit. New varieties, adapted to this method of harvesting are therefore urgently needed. Because of the increasingly exacting standards demanded of new cultivars, systems of progeny testing will be examined in an attempt to improve the chances of identifying superior parents.

Screening advanced seedlings

It is not at present possible to combine resistance to all major diseases in any one variety, but it is highly desirable that the reactions of each new variety to diseases should be known. Arrangements have therefore been made with the Mycology Section for laboratory testing of all advanced seedlings for susceptibility to *Verticillium* wilt disease, and with the Virology Section for field assessment of reactions to nematode-borne viruses.

Field resistance to red core

Field resistance may be described as the ability to survive in the field in the presence of the red core organism, but the real nature of this type of resistance is incompletely understood. It is clearly not simply a capacity to resist infection by certain physiological races of *Phytophthora fragariae*, for both Talisman and Templar are resistant to the same races but the former appears much more field-resistant than the latter. Furthermore, the selection 53 Q13 also reacts to the same races as Talisman, yet it is the most field-resistant genotype available.

In collaboration with the Mycology Section, studies have been commenced on two aspects of plant behaviour which are thought to be major factors in 'field resistance' namely, the capacity of different genotypes to affect the rate of penetration of the fungus and to regenerate new roots. It is hoped that studies of this type may lead to more objective assessments of field resistance than is possible through the present lengthy and uncertain method of selecting plants exposed to infection in the field. (H. J. Gooding, K. C. McConnell, W. I. A. Jack, G. M. Innocent).

Brassica

The first series of crosses designed to elucidate gene linkage relationships was made between plants from approximately 300 seedling families raised to maturity in 1967. The genes include crinkly petal, male-sterility, several glossy-foliage forms and acyanic types previously isolated in the Institute's Brassica breeding programme; dwarf, albino and a thick-leaved type recently isolated here; and others described in the literature. A cabbage stock from Shetland has been a useful source of genes. In an attempt to obtain new markers for use in these studies, seed was obtained from plants grown from gamma-and neutron-irradiated seeds, one plant of which shows a possible petal mutation, and from seed treated with the chemical mutagen ethyl-methyl-sulphonate.

The efficiency of induction of tetraploidy in seedlings was compared using different colchicine treatments, alone and in combination with indolyl-acetic acid and dimethylsulphoxide. This experiment is not yet complete but no enhancement of induction has so far been observed. The indications are that the most efficient induction of tetraploidy will be obtained by the application to newly germinated seedlings of relatively high concentrations of colchicine for short peroids.

The search for lines suitable for accurate pachytene analysis has continued. Progress has so far been difficult because of the close non-homologous association at pachytene of heavily chromatic areas situated adjacent to the centromeres, making it impossible to discern individual bivalents. Best pachytene staining has been achieved by propionocarmine after softening with hydrochloric acid followed by a short period of orcein staining. The method gives satisfactory differentiation of the nucleoli and of the linear components of the chromosomes when observed by phase-contrast microscopy.

Lilium

In order to clarify the taxonomic affinities of the European *Lilium* species, karyotypes were determined from seedlings cultured on agar. Karyotypes have been obtained for five species, all of which show the usual *Lilium* chromosome complement of two long sub-metacentrics and 10 acrocentrics of varying lengths. Some plants show heteromorphic pairs, and further studies are required to determine the extent of variations within species. The relationship of *L. pyrenaicum* to *L. pyrenaicum rubrum* and to other species is of special interest; present studies show no obvious karyotypic affinities. There are distinct differences in chromosome morphology between all species examined and no close similarities have been revealed.

Meiosis was studied in the complex species hybrid cultivar Redbird. In addition to some abnormalities expected in hybrids–inversion bridges and heteromorphic bivalents–a unique configuration was frequently observed at telophase. This followed the association of four chromosomes and resulted in a bridge comprising four centromeres. There was a remarkable degree of association between the genome derived directly from *L. tigrinum* and the remainder of the chromosomes derived from a pedigree involving two Asiatic and a European species. (A. B. Wills, S. Fyfe).

PUBLICATION

HASKEL, G. M. L. and WILLS, A. B. (1968). Primer of Chromosome Practice. Oliver & Boyd, Edinburgh.

(Instructions are given in this manual on the elementary practical aspects of chromosome cytology requiring the minimum of apparatus and equipment. Quick and reliable modern methods for investigating chromosome behaviour in both somatic and reproductive tissues of plants and animals are detailed. There are three basic parts: the theory and ideas behind the experiments; a laboratory manual; methods of presenting data collected and the sort of conclusions that can be drawn).

Plant Physiology

C. G. GUTTRIDGE

By a concerted effort on the part of the Maintenance Section, the set of eight new growth cabinets was completed for use in April 1967 and since then automatic humidification has been fitted. The cabinets have proved eminently satisfactory and reliable in operation, a fact which redounds to the credit of Mr Couttie and his staff who not only built them but contributed to their design. These cabinets and the glasshouses completed in 1966 have greatly enhanced our facilities for work in controlled environments. Two new growth rooms, designed particularly for growing plants at autumn and winter temperatures, are nearing completion.

The radio-isotope laboratory was completed, and work using equipment recently acquired is in progress. In other directions heavy demands on somewhat inadequate resources have been made by the work of extracting and purifying hormones from strawberry tissue. However, Mrs Abdel-Galil (O.M.K. Gabr) is to be congratulated on finding (+)-abscisic acid in the foliage of dormant strawberry plants, and P. B. Goodwin, in association with J. B. Garrie and A. Gordon, has made progress with the purification of several growth promoters extracted from strawberry runner tips and young leaves.

Dr M. A. Hall, who had been working in the Biochemistry Department of the University of California, Riverside, joined us in October 1967 on an S.R.C. Rehabilitation Fellowship. He is investigating polysaccharide changes induced by the application of gibberellic acid, in the cell wall of excised *Helianthus* hypocotyl segments.

A. Gordon resigned to take up a professional career in music, which has long been his ambition. J. G. Harrison joined the Section as Assistant Experimental Officer, primarily to take charge of the routine management of the growth cabinets. Aileen Kinninmonth was appointed as Scientific Assistant in place of Carolyn Chambers who left, upon her marriage to D. Bain (Mycology Section). The couple have emigrated to Canada where they are employed in scientific work.

A travel grant from the A.R.C. enabled me to attend the International Symposium on 'Cellular and Molecular Aspects of Floral Initiation' held in September 1967 at the University of Liège as part of their Tricentennial Celebrations, and this proved a rewarding visit.

The Section is grateful to Dr Cornforth (Shell Research Ltd.) for several gifts of (±)-abscisic acid and to Drs B. V. Milborrow and G. Ryback for spectropolarimetric analyses of several samples of plant extracts thought to contain abscisic acid.

The action of gibberellic acid on flowering

Exogenous gibberellic acid usually inhibits flower induction in strawberry, thus simulating the effects of long photoperiods, but in two experiments it failed to inhibit flowering. Wide variations in the critical dose have been observed previously, and it seems likely that in some environmental conditions only a small proportion of applied gibberellic acid is transported from the leaves to the shoot apex. The mechanism of the inhibitory action is unknown, but gibberellic acid may substitute at the apex for an indigenous gibberellin. If this is so, then marginal doses of gibberellic acid and photoperiods which are marginally inhibitory would be expected to act additively. This was demonstrated with plants of the variety Talisman which were grown in photoperiods of 12-15 hr. duration, increasing by ½ hr. steps, and sprayed with gibberellic acid at three dosage rates. The result is not, however, definitive evidence that gibberellic acid substitutes for the native hormone or that the two act in the same biochemical pathway. A kinetic study, which might provide such evidence is not applicable to situations such as this where a single event is inhibited by both factors. (C. G. Guttridge).

Extraction of gibberellin-like substances from strawberry

Techniques have been developed for the extraction and partial purification of the strawberry gibberellins and applied to small samples of runner tips and mature leaves, and to a 4 cwt. sample of young leaves. Gibberellin-like activity is distributed between several fractions of diverse chemical character. Small amounts of the most active substance, which is found in the water fraction after charcoal/celite chromatography and is strongly absorbed by silica gel, have been purified, and purification of a number of the other fractions is reaching an advanced stage. Attempts are being made to identify these substances, most of which are expected to be new gibberellins. (P. B. Goodwin, J. B. Garrie, A. Gordon).

The isolation and identification of (+)-abscisic acid from the leaves of dormant strawberry plants

After prolonged exposure to short daylengths, strawberry plants become dormant. This condition is characterised by restricted but not necessarily weak vegetative growth, and although there is no absolute dormancy and no resting bud, there are obvious parallels with woody plants, suggesting that growth-inhibiting compounds may be present in strawberry plants in autumn.

Leaves of dormant Talisman plants were collected in October and extracted with methanol. The acidic-ether fraction was found to inhibit coleoptile growth in germinating wheat embryos. Inhibitory compounds were eluted from granular charcoal columns by 10% and 20% acetone in water and, later, by 10% ethyl acetate in chloroform from columns of celite/silicic acid (2:1). After characterisation by bioassay and thin layer chromatography

(+)-abscisic acid was identified spectropolarimetrically by Dr B. V. Milborrow, Shell Research Ltd., Milstead Laboratory, Sittingbourne, Kent. Both the purified extract and synthetic (±)-abscisic acid inhibit growth of strawberry seedlings. (O. M. K. Gabr).

Hormone regulation of growth in Fuchsia

Gibberellic acid was sprayed onto *F. magellanica x fulgens* plants growing in different daylengths. Results from several experiments suggest that the photoperiodic effects on internode lengths are mediated at least partly by an indigenous factor with which gibberellic acid does not interact or replace. Attempts with two-branched plants to ascertain whether the indigenous factor is a promoter or inhibitor of elongation were inconclusive. (D. T. Mason).

FIELD INVESTIGATIONS

Effects of defoliation, temperature and site on the yield of fruit of strawberries

In earlier trials fruit yields of second and subsequent crops (but not of first crops) of Redgauntlet and Talisman have differed in different fields at the Institute, sometimes substantially; low yields being caused by sub-optimal numbers of trusses. In 1967, the fruit yield from the second crop from Templar (28 months from April planting) was more than 60% lower in Laboratory field than it was in Garage field. As before, the deficiency was corrected by post-harvest defoliation in the previous August. The result in 1966, in which the first crop (16 months from planting) from Templar was deficient in Laboratory field was not repeated in 1967, and new plantings of both this variety and Crusader yielded satisfactory first crops in all four fields in which they were planted, including those mentioned. (H. McC. Anderson, C. G. Guttridge).

The causes of sub-optimal flower formation are not completely understood, but appear to be environmental. Besides post-harvest defoliation, which has invariably corrected deficiencies in numbers of trusses in Institute experiments, deficiencies have been alleviated by autumn cloching which, among other effects, raises the temperature of the plants. The warmer climate in southern England may be the reason for the much lower incidence of the severe deficiencies in flowering sometimes met with in Scotland. Temperature may be a factor. Experimental defoliation and removal of the straw mulch on 8 August 1967 increased the surface temperature of crowns of the cultivar Talisman by 4.5°F. during the day but had little effect on the temperatures of the crowns at night. Flower initiation was increased from 0.2 trusses/crown in the intact plants to 1.1 trusses/crown in the defoliated ones. Removal of the straw mulch in the absence of defoliation on 21 August also increased the temperature of the crowns and initiation was increased to 0.5 trusses/plant. Thus possibly some of the effects of defoliation may reside partly in the exposure of the crowns to higher temperature. (D. T. Mason).

Eucarpia trial

Detailed measurements of vegetative growth and fruit yield were recorded on the Institute's plot of the international strawberry variety trial sponsored by Eucarpia and organized by Drs E. and A. Bauer. Compared with other strawberry plantations on the Institute, yields were low, so varietal comparison must be viewed circumspectly. However, the four best-yielding varieties were Talisman, Abundance, Lassen and Senga Sengana. Lassen, considering that it is an established variety in California, cropped surprisingly well but produced relatively few runners. In spite of a preventative spray programme, the variety Precoce was severely damaged by an attack of the Shallot Aphid (*Myzus ascalonicus*) to which it seems to be highly susceptible. (H. McC. Anderson, C. G. Guttridge).

The control of runner formation in strawberry

Fruit yields were recorded on a small trial in which (2-chloroethyl) trimethyl ammonium chloride (Cycocel) and N-dimethylamino succinamic acid[1] were used in 1966 with varying degrees of success to control runner formation on four varieties. Approximately 0.8 gm. active ingredient in aqueous solution was applied in 1966 individually to each plant by hand sprayer. This dose was equivalent to about 5 gm. per 10 ft. row. Runners which were not controlled by the treatment were allowed to root freely. In spring 1967 the plantation was rotary hoed to remove runners which had rooted in the pathways, leaving the matted rows to crop. Fruit yields showed that matted rows in which runnering had been more or less successfully inhibited, outyielded rows in which runner control had not been attempted. In Templar and Crusader the yields were almost doubled, to approximately 8 lb. and 6 lb. of fruit per 10 ft. row length respectively, by an 8% spray of Cycocel+1% spreader (Shellestol). Increases were much less in an earlier experiment, and the use of these growth retardants for runner control must still be considered experimental.

In this trial and in previous ones, B 995 has been less effective than Cycocel rate for rate, although in other species it is frequently found to be the more effective and persistent chemical of the two. Poor uptake of B 995 through the leaf surface in some circumstances may be the reason. The addition of polyethylene glycols to aqueous solutions of B 995 greatly increased the response of plants sprayed with them; runners were inhibited by concentrations which were ineffective without the carbowax additive. Carbowax grades 1500, 4000 and 6000 were effective but 200 was less so. Carbowax 4000 had no effect on the response of plants to foliar sprays of Cycocel. Probably the carbowax assisted the foliar uptake of B 995 under the low relative humidities prevailing in the glasshouse in summer. The value of a carbowax additive in the field has not yet been demonstrated but may depend upon atmospheric humidity and even upon the water status of the plants. (C. G. Guttridge, H. McC. Anderson).

[1]This compound, known as B 995 is supplied under the UniRoyal trade names as B-Nine and Alar.

Single pick harvesting of strawberries

Feasible means of mechanically harvesting the strawberry crop are non-selective and involve the removal of the whole crop in a single pick. It is of interest, therefore, to know how varieties differ in the proportions of over-ripe, ripe and unripe fruit they produce at any given time during the picking season, at what stage the proportion and weight of ripe fruit is maximal, and whether unripe fruits will ripen after picking. Assessments were made on five varieties, and the whole crop was harvested in a single pick on three occasions; when the primary fruits were fully ripe, one week and two weeks later, respectively. The trusses were cut from the plants and the fruits were plucked, graded and recorded. Pooling the results for the five varieties, single picks gave, respectively for the three picking occasions, 28%, 41% and 47% of the total marketable yield obtained from control plots by repeated hand picking. Plots of Cambridge Favourite gave both the highest absolute yield of fruit and the highest proportion of ripe fruits–60%–a proportion attained on both the second and third picking occasions. Ripe berries of this variety have a low spoilage rate and this is likely to be a useful character in varieties selected for mechanical harvesting. The variety Crusader yielded an exceptionally high percentage of ripe fruit (50%) in the first pick. (H. McC. Anderson).

Unripe fruits coloured rapidly when kept in humidified jars in growth cabinets, and even those which were hard and green at the time of picking coloured and softened after 6 days at 22°C., although the quality was sub-normal. Colour developed slower at 18°C. but the final appearance of the fruit was better. At the relative humidities used (85-95%) the loss in weight was slight[1]. (D. T. Mason with W. R. Jarvis, Mycology).

Cold storage of strawberry runners[1]

The deterioration of runner plants in storage was again investigated and the ability of runners of the variety Cambridge Favourite, lifted in December, to grow after storage for nine months at 30-31°F. examined. Stripping off mature and dead leaves before storage, as against no prior treatment, significantly increased the numbers of plants that survived after growing on for six weeks in the glasshouse; so also did dipping the plants in thiram (2%) before storage. Survival was best of all when the two treatments were combined. Dipping in thiram after storage was also effective, indicating that much of the rotting occurred after removal from the store.

Plants were inoculated with two of the fungi previously isolated from rotting tissues of plants in the cold store; one of these, *Gnomonia fructicola*, was highly pathogenic, killing nearly all the plants during the storage period, while the other, *Pythium* sp. was not. The addition of dead strawberry trash to plants in storage confirmed last year's results; survival was decreased, but only when a thiram dip was omitted and when the trash was in contact with the plants and not when it was separated from them by a vapour-transmissible barrier of cellulose acetate film. These results confirm the value of

[1]The results of joint work with the Mycology Section are reported on pp. 30-31.

hygienic measures, such as stripping off the old foliage, in increasing survival and they indicate that pathogenic fungi can be a cause of deterioration and rotting in storage. (C. G. Guttridge with I. G. Montgomerie, Mycology).

Raspberry propagation

A problem encountered in the production, at the Institute, of raspberry plants from root cuttings is the fact that a proportion of the plants, varying with variety and season, cease terminal growth after planting out in the field and show symptoms of dormancy. In some plants growth is later resumed from lateral buds. Affected plants frequently become infected with powdery mildew which may delay recovery. Dipping plants in aqueous solutions of 20 or 50 p.p.m. of gibberellic acid before planting decreased the numbers of affected plants, improved establishment, increased the mean cane length and decreased branching. Dipping in an inorganic copper fungicide (Fungex) did not appreciably affect these growth responses nor did dipping in an anti-transpirant (S 600). The incidence of incipient dormancy and the resultant stunting was less in a second batch of plants, which were raised later than the first batch and were subjected to a later and shorter hardening-off period in cold frames.

It is too soon to know whether the treatment with gibberellic acid will have any long-term advantages. The use of gibberellic acid to offset dormancy, which may here have been induced during a long hardening-off period, could have applications in nursery propagation of woody species both in forestry and horticulture. (H. McC. Anderson, C. G. Guttridge with J. Chambers, Virology, and D. L. Jennings, Plant Breeding).

Morphactins which are known to decrease correlative inhibition in some plants were used in an attempt to increase the production of shoot cuttings from raspberry roots. Soaking 6 in. lengths of root for 5 and 25 min. in a 5 p.p.m. solution of IT 3456, or for 25 min. in a 20 p.p.m. solution or 5 min. in a 100 p.p.m. solution of IT 3233 doubled the number of shoots which emerged. Unfortunately because growth was slow and the leaves very small, the shoots were probably unsuitable for propagation. (D. T. Mason).

The regulation of cane growth in raspberry

The possibility that cane length might be decreased by spraying raspberry plants with growth retardants was tested, the aim initially being, by shortening internode lengths, to concentrate a greater number of fruiting buds below tipping height. The young canes of three-year-old plants of the varieties Norfolk Giant, Malling Jewel and Malling Exploit were sprayed on 9 June–when they were about 2 ft. high–with B 995 in aqueous solutions at concentrations of 0.5, 2.0 and 4.0% with 10% carbowax or 1% Shellestol to assist spreading and uptake. The numbers of nodes were decreased by between 17% and 63% by these treatments, but internodes were not shortened and the first objective was not attained. The plants were retained for observations on winter hardiness and fruiting. (H. McC. Anderson, C. G. Guttridge).

GABR, O. M. K. and GUTTRIDGE, C. G. (1968). Identification of (+)—abscisic acid in strawberry leaves. *Planta*, **78**, 305-309.

(A brief summary of this work is given on p. 47 of this Report).

GOODWIN, P. B. (1968). Studies on the inhibitor of receptacle growth in non-pollinated strawberry fruit. *Nature, Lond.* **27**, 389.

(The effects of medium composition on the growth of isolated strawberry fruits and receptacles in sterile culture was studied. Growth was depressed by the presence of either fertilised or non-fertilised carpels. Partially purified methanol extracts of both pollinated and unpollinated fruit inhibited growth of isolated receptacles. In three experiments no inhibition specific to unfertilised fruits was obtained).

GUTTRIDGE, C. G. and ANDERSON, H. McC. (1968). Some effects of polyethylene glycols on the uptake of gibberellic acid and growth retardants by strawberry. *Hort. Res.* **8.**

(A summary of this work is given on p. 49 of this Report).

GUTTRIDGE, C. G. (1968). *Fragaria.* A chapter in L. T. Evans (Ed.) Induction of Flowering. MacMillan (in press).

(A discussion on the physiology of flower induction in strawberry).

GUTTRIDGE, C. G. (1968). The hormone physiology of growth regulation in strawberry. In *Plant Growth Regulators*, a monograph to be published by the Society of Chemical Industry and the Phytochemical Society.

(The effects of photoperiod, temperature and chilling on growth and flower formation in strawberry are briefly described, and the evidence for postulating a vegetative growth-promoting hormone is discussed. The hormone apparently inhibits flower formation. The similarity between the activities of the hormone and of exogenous gibberellins are reviewed and the tentative conclusion drawn that, although increased biosynthesis of gibberellins is part of the photoperiodic response, the natural hormone messenger between leaf and apex cannot be an active gibberellin like gibberellic acid, although it could be an inactive form or a precursor. There is evidence for a second independent photoperiodic factor operating on petiole growth. Photoperiodic stimuli and exogenous gibberellic acid are additive in their inhibition of flowering but this does not necessarily mean that the two act in the same metabolic pathway. Abscisic acid promotes flowering, and extracts of dormant strawberry leaves contain abscisic acid. Extracts of non-dormant leaves and of stolon tips are active in the lettuce hypocotyl test for gibberellins. (2-Chloroethyl) trimethylammonium chloride (CCC) depresses vegetative growth but does not usually promote flower formation).

MASON, D. T. (1967). Inflorescence initiation in the strawberry. III. Some effects of cloching during induction. *Hort. Res.*, 7, 135-143.

(Covering strawberry plants with glass cloches during inflorescence induction frequently increased the numbers of trusses which were initiated in the autumn and which emerged the following summer. This effect was due to a higher rate of truss initiation–apparently promoted by the increase in temperature–and not to accelerated leaf production).

THOMPSON, P. A. (1967). Promotion of strawberry fruit development by treatment with growth regulating substances. *Hort. Res.*, 7, 13-23.

(4-(indol-3 yl)-butyric acid (IBA) and 2-naphthoxyacetic acid (2NoA) induced parthenocarpic development of strawberry fruits when they were applied in lanolin emulsions or in agar gels to individual flowers. Combined applications of auxins and gibberellic acid showed strong synergism and resulted in fruits equal in size or nearly so to pollinated control fruits. Attempts to reproduce these effects with overall aqueous sprays of these chemicals were largely unsuccessful).

Virology

B. D. HARRISON

A few changes of personnel occurred during the year. Family commitments compelled Susan Allen to leave in September. Also in September, Mr D. J. Engelbrecht of the Fruit and Food Technology Research Institute, Stellenbosch, S. Africa, arrived to spend a year's study leave working on sap-transmissible raspberry viruses. Mr H. S. Abu Salih of the Gezira Research Station, Sudan, and the University of Dundee, again spent a good deal of his time with us. Among the Scientific Assistant Staff, W. M. Robertson was appointed an Assistant Experimental Officer in the Zoology Section in October, and Morag Lindsay was appointed in his stead.

In September, B. D. Harrison read a paper at the Sixth Conference of Czechoslovak Plant Virologists at Olomouc, and afterwards visited laboratories at Bratislava and Prague. A. F. Murant read a paper at the Seventh European Symposium on Fruit Tree Virus Diseases, held at Aschersleben, German Democratic Republic, in July and visited laboratories at Braunschweig, Federal German Republic, before the conference. These visits were made possible by travel grants awarded by the Agricultural Research Council.

The new animal house was completed early in the year, and nearby three Minibrite glasshouses, to be used as insectaries for the time being, are in course of construction. The Siemens Elmiskop I electron microscope was modified to bring it up to the model IA standard of performance.

Most of the research described below stems from that reported last year. In particular, firm foundations were laid for the work on viruses of tulip, narcissus and potato. A new line of work is the use of ultra-thin section methods to study viruses within cells, which promises to help generally in understanding the behaviour of viruses. Another new line is the application of meristem tip culture techniques, which can be used to produce virus-free plants of those cultivars of vegetatively propagated species that are totally virus-infected. Our work was again helped by the high standard of experimental plants produced throughout the year by the glasshouse staff.

MULTIPLICATION OF TOBACCO RATTLE VIRUS

Properties of defective isolates

Work was continued on defective isolates of tobacco rattle virus (referred to earlier as NM isolates) that produce virus ribonucleic acid (RNA), but not the tubular nucleoprotein particles typical of the virus. Very infective

preparations of virus RNA can be obtained, with the aid of phenol, from plants infected with such defective isolates, but as reported last year, these contain ultraviolet absorbing impurities, probably peptide. New work shows that very infective nucleic acid preparations that are free from this peptide material can be obtained by the method of Click and Hackett (*Biochim. Biophys. Acta* **129**, 74, 1966) using 0.07 M phosphate buffer (pH 8.5) in place of glycine buffer.

Free virus nucleic acids can be protected from inactivation by bentonite clay, which also removes tobacco rattle virus nucleoprotein particles from suspension. However, most extracts made with the aid of bentonite from plants infected with defective isolates were less infective than those made with buffer alone. This suggests that the RNA of defective isolates is partially protected by other material which may be adsorbed to the bentonite. As a start to studying the possible association of the virus RNA with subcellular organelles, a method of obtaining nuclei was devised. This involves disrupting the leaves in a Waring Blendor running for 4 seconds at full speed using an ice-cold medium containing 0.34 M sucrose+0.002 M calcium chloride+4% gum arabic. The product was subjected to differential low and high speed centrifugation through sucrose solutions of 0.34 M and 2.2 M, containing 0.002 M calcium chloride. Nuclei from infected *Nicotiana clevelandii* leaves did not contain infectivity but this does not necessarily rule out the nucleus as the site of virus RNA in the cell.

During the summer months only poorly infective inocula can be obtained from glasshouse-grown plants infected with defective isolates. Effects of temperature were therefore studied for 7 days after inoculation. Infectivity of defective isolates derived from either strain CAM or strain PRN increased at 15°C., but at 22-30°C. increased and then soon decreased to low levels, especially at the higher temperatures. The parent PRN strain behaved like the defective isolates except that the fall in infectivity at the higher temperatures was less dramatic, but the parent CAM strain multiplied appreciably at 30°C. and little at 15°C. These results indicate that the RNA of defective isolates is degraded in plants at the higher temperatures, but degrees of protection are imparted by the protein coat of the virus. CAM protein seems more protective at high temperatures than that of PRN. (S. Allen).

Properties of nucleoprotein particles

Previous work has failed to detect serological or chemical differences between the long and short nucleoprotein particles of tobacco rattle virus. Now, however, differences of other kinds were found by equilibrium centrifugation and by zone electrophoresis. Three light-scattering bands (two major and one minor) were formed when purified preparations of the CAM strain were centrifuged at 100,000 **g** for up to two days in sucrose density gradients or up to one day in caesium chloride gradients. The two major bands formed at densities differing by about 0.02 g./ml., and the upper of these appeared to contain the short particles. When subjected to zone electrophoresis in a sucrose density gradient at pH 8.6, a band containing predominantly long

particles migrated slightly faster than a second band containing predominantly short ones.

Work was started to identify the kinds of genetic information carried by the nucleic acids of long and short particles. (J. I. Cooper, B. D. Harrison).

Early stages of infection

Using doses of ultraviolet radiation that had little effect on lesion number when given to *Phaseolus vulgaris* leaves immediately before inoculation, the changes occurring after inoculation were studied. The PRN strain survived at about 3% of the potential lesion sites when freshly inoculated leaves were irradiated, but at half the sites when irradiation followed 5 hr. incubation of the inoculated leaves at 25°C. or 9 hr. at 15°C. When virus nucleic acid was used as inoculum instead of nucleoprotein, these changes occurred sooner. Hence, as with other viruses, an initial stage in virus multiplication seems to be avoided by using inocula of virus nucleic acid, or infection is better synchronised. These times compare with about 11 hr. needed for the first increase in infectivity to be detected in tobacco leaves inoculated with nucleoprotein, kept at 25°C. and extracted with buffer. (J. I. Cooper, B. D. Harrison).

ELECTRON MICROSCOPY

The Siemens Elmiskop I was modified by fitting an anti-contamination trap, a higher stability electronic system, and in a number of other minor ways, to bring its performance up to that of the model IA machine. There were some teething troubles but the microscope's resolution is improved and it can more readily be used alternately for examining virus preparations and ultrathin sections. So that maximum use could be made of the microscope, additional members of the Section were instructed in the routine examination of virus preparations, leaving more time for work using specialist techniques.

To permit the quantitative assay of viruses by electron microscopy, an apparatus for producing spray droplets of 3-5 μ diam. was constructed. (J. Cathro).

ULTRASTRUCTURE OF INFECTED TISSUES

Tobacco rattle virus

Infected leaves of *Nicotiana clevelandii* were used to develop methods for the fixing, staining and embedding of tissue with maximum preservation of structural detail. The method finally adopted involves fixing in 5% glutaraldehyde at pH 7.4, post-fixing in 0.1% osmium tetroxide, staining in uranyl acetate and embedding in a 6:1 mixture of methyl methacrylate and styrene. Good quality sections about 600 Å thick were consistently obtained from both young and older leaves. (I. M. Roberts).

The virus particles were distributed in a novel manner in cells of systemically infected leaves of plants inoculated five days previously with strain

CAM. Nearly all the mitochondria, but not the nuclei or chloroplasts, had the long (c. 200 mμ long) virus particles arranged radially around them. The ends of the particles seemed appressed to, but did not penetrate, the outer mitochondrial membrane. The short virus particles were not associated with the mitochondria, though leaf extracts contained as many short as long particles. A few short, but not long, particles could be discerned free in the cytoplasm. Further work is needed to decide whether the long particles are specifically adsorbed by the mitochondria or whether the mitochondria are their site of assembly.

No virus-like particles were seen in sections of leaves systemically infected with a defective isolate of strain CAM. (B. D. Harrison, I. M. Roberts).

Carrot mottle virus

Previous work over several years has shown that this virus is unstable and difficult to purify. Its behaviour in equilibrium and rate zonal density gradients suggests it has a low buoyant density and is somewhat variable in size, and electron micrographs of partially purified preparations show bag-like objects, many of which are about 50 mμ in diameter. Whether these particles are the virus was not clear. However, electron microscopy of sections of infected *N. clevelandii* leaves showed particles (c. 50 mμ diam.) not seen in sections of healthy leaves, and similar, but somewhat more uniform in size, to those in partially purified preparations. These particles were located in the vacuole close to the vacuolar membrane, and some micrographs suggest they are formed at the surface of the membrane. The properties of the virus, and the general appearance and location in the cell of these particles, suggest closer affinities with some lipid-containing viruses of vertebrates than with other plant viruses. (A. F. Murant, I. M. Roberts).

SEROLOGICAL METHODS

Previous work showed that the sensitivity of serological tests for detecting plant viruses can be much increased by attaching the antibody to relatively large carrier particles, such as tanned red blood cells (the passive haemagglutination test) or bentonite clay. In new work, the passive haemagglutination test, which is 20-80 times more sensitive than the bentonite test, was compared with the latex test used by Dr R. Bercks at Braunschweig. The latex test was 8-40 times less sensitive for detecting arabis mosaic, narcissus mosaic, parsnip yellow fleck, raspberry ringspot, tobacco mosaic and turnip yellow mosaic viruses, but 12-100 times more sensitive than the tube-precipitin test. However, sensitized latex particles were easier than sensitized red cells to prepare, were stable for longer periods, and could be sensitized with smaller amounts of antibody, so that weaker antisera could be used than for passive haemagglutination.

An important application of these sensitive tests may be for the detection of viruses in naturally infected plants from the field. It was found that non-specific effects caused by the tannins in raspberry and strawberry leaves could

be avoided by making extracts in 2.5% nicotine solution. Raspberry ringspot virus was detected in such extracts of leaves from raspberry plantations by the passive haemagglutination test but not by the latex test. However, even the passive haemagglutination test failed to detect parsnip yellow fleck virus in field-infected parsnip plants, except when they were newly systemically infected. (A. F. Murant, with H. S. Abu Salih and M. J. Daft, University of Dundee).

NEMATODE-BORNE VIRUSES

Raspberry ringspot virus in raspberry

The resistance-breaking strain of raspberry ringspot virus described previously, which can infect raspberry cultivars immune from the common Scottish strain, seems to occur rarely in Scotland although the nematode *Longidorus elongatus* transmits it as efficiently as the common Scottish strain. A possible explanation of its rarity may be that it is less readily transmitted than the common strain through the seed of host plants and thus may less often survive in soils during periods of fallow, or fasting of the vector. In a replicated experiment, it was found in only 10% of the progeny of infected *Stellaria media* plants, whereas seed collected from plants infected with the common Scottish or English strains each produced 23% infected seedlings. (A. F. Murant, R. A. Goold).

NEPO viruses in narcissus and tulip

With the increase in propagation of narcissi and tulips in eastern Scotland, and the interest in high quality stocks, the incidence, effects and method of spread of viruses in these crops assumes added importance.

NEPO viruses seem common in narcissus; raspberry ringspot, tomato black ring, arabis mosaic and strawberry latent ringspot viruses were all obtained from field stocks of one or more varieties. As part of a study of flower blindness in the variety Double White, ten plants from each of four selections from a long-established Scottish stock were indexed. Sixteen plants contained raspberry ringspot virus, 13 tomato black ring, 5 arabis mosaic and 1 strawberry latent ringspot virus; 12 were free of NEPO viruses. By contrast, only arabis mosaic and strawberry latent ringspot viruses were obtained from an English stock. Flowering performance was not, however, obviously impaired by infection with any of these viruses. Field trials are in progress to compare the speed and incidence of infection by raspberry ringspot and tomato black ring viruses in several other narcissus cultivars grown on land infested with virus-carrying populations of *Longidorus elongatus*.

NEPO viruses seem far less common in tulip than narcissus. Arabis mosaic virus was obtained a few times from the variety Korneforus, and tomato black ring virus once. (W. P. Mowat).

Tobacco rattle virus in potato

Two trials were made on sandy land bordering the Moray Firth to compare the susceptibility of fifteen cultivars to spraing caused by tobacco rattle virus.

Although virus-carrying populations of the nematodes (*Trichodorus* sp.) occurred at both sites, spraing was rare at one and less common than expected at the second. This probably reflects the extreme dryness of the soil during June-August, which was unfavourable to the vector nematodes. Reactions to tobacco rattle virus mostly resembled those found previously in an experiment in Norfolk. The variety Alpha, which was not tested in Norfolk, had the largest percentage of tubers affected (25%), and no infection was detected in Arran Pilot or Bintje. This virus was also found in several other varieties in Scotland.

Soon after harvest, tobacco rattle virus can often be detected in spraing-affected tubers by inoculating sap from them to indicator plants, but this becomes increasingly difficult as the period of storage increases. When extracts were made at monthly intervals from tubers stored at 4°C., those prepared with the aid of phenol were consistently more infective than extracts made in phosphate buffer+cysteine hydrochloride+sodium diethyldithiocarbamate. With increasing time of storage only extracts made with phenol were infective, until no infectivity was detected after nine months. Whether the phenol acts mainly by protecting unstable defective forms of the virus, or by inactivating substances in tuber sap that hinder detection of the virus, or in both these ways, is not clear.

The idea that the corky arcs that form within the tuber flesh mark the boundary of the virus-infected tissue was disproved. At least as much infectivity was extracted with the aid of phenol from tissue 0.25-0.5 cm. outside the corky arcs as from that within them. (J. I. Cooper, B. D. Harrison).

OTHER VIRUSES IN FLOWER BULBS

Tulip

Further work on diseases of the Augusta type confirmed the importance of temperature in the plunge bed on the subsequent appearance of affected shoots containing tobacco necrosis viruses. The disease occurred in 10% of the plants kept in a warmed part of the plunge bed, but in none of those kept at normal temperatures.

Other viruses obtained from tulips with necrotic diseases, some of which resembled Augusta disease, included tobacco rattle virus, cucumber mosaic virus and an assortment of isolates, as yet unidentified and difficult to maintain in culture. The strain of tomato bushy stunt virus previously obtained from a necrotic tulip plant, by contrast with the type strain, was transmitted back to tulip; however, it did not cause necrosis in the two varieties used. A virus serologically related to carnation ringspot virus was obtained from one plant. (W. P. Mowat).

Narcissus

Viruses are more prevalent in narcissus than tulip. Because many Scottish stocks were derived relatively recently from English or Dutch ones, and the varieties have been in commercial production for many years, their basic

virus contents are likely to be similar. In addition to the NEPO viruses, narcissus mosaic, narcissus yellow stripe and cucumber mosaic viruses were found in one or more varieties. In preliminary tests, narcissus mosaic, arabis mosaic and tobacco rattle viruses were not eliminated by hot air treatment (4 weeks at 34°C.) of dormant bulbs of the variety Carlton. (W. P. Mowat).

Apical meristem cultures were started with the aim of obtaining virus-free plants of some of the varieties popular in Scotland. (J. Chambers).

POTATO MOP-TOP VIRUS

One of the remarkable features of this virus is the wide range of symptoms it can cause in potato. These depend greatly on the cultivar and the environmental conditions. Haulm symptoms range from stunted 'mopped' shoots to golden yellow markings or barely discernible chevrons on the leaflets. The tubers produced by infected plants may be distorted, have deep cracks, fine reticulate cracks, superficial blotchy discoloration, or pigmented rings at the tuber surface sometimes accompanied by corky arcs (spraing) running through the tuber flesh. The raised rings and spraing are also typical of new infections in the current growing season but such primary symptoms are differently distributed on the tubers than secondary ones. Of the many varieties examined, King Edward, Kerr's Pink and Record showed only slight haulm symptoms whereas Alpha, Arran Pilot and Red Craig's Royal showed obvious ones. Alpha, Arran Pilot and Pentland Crown had the most severely affected tubers.

A small-scale survey of growing crops showed that the virus occurred in many stocks of Red Craig's Royal and Arran Pilot, though the incidence in most was small, and the highest figures for the two varieties were 25% and 8% respectively. Occurrence of the virus in high grade stocks of some varieties indicates that seed-growers should be prepared to take pains to propagate only from virus-free clones. In some instances, infection could be traced to particular clones, in others to growing stocks on land infested with virus-carrying vector organisms.

An improved method of detecting infective vectors in soils consists of air-drying soil at room temperature for about two weeks and then remoistening it and planting seedlings of *Nicotiana debneyi*. After 5-6 weeks these begin to show characteristic necrotic markings in their leaves. Using this method the virus was obtained from twelve fields in four Scottish counties but not from several others. The soil types ranged from light sand to heavy loam.

Further evidence was obtained that the virus is transmitted in the field by the powdery scab fungus (*Spongospora subterranea*). Both vector and fungus survive air-drying of soil, both can pass a 300-mesh sieve, both can be obtained from root washings, and the species that become infected with virus from the soil are all hosts of *S. subterranea*. Spore balls of *S. subterranea*, scraped from tubers infected with potato mop-top virus and stored dry for five months, passed the virus to *N. debneyi* seedlings. Root washings, from tobacco and tomato seedlings infected with virus-carrying cultures of *S. sub-*

terranea, caused spraing disease when watered onto growing Arran Pilot tubers.

The host range of *S. subterranea* is commonly thought to be confined to Solanaceae but many zoosporangia were found in roots of *Chenopodium album* and a few in *Lolium italicum* and *Stellaria media* when these were exposed to large numbers of spore balls. This raises the possibility that wild plants play a role in maintaining *S. subterranea* and the virus, which can persist for five years or more between potato crops. The main way the virus spreads from field to field is probably in spore balls carried by virus-infected tubers. Virus-carrying *S. subterranea* was shown to become established in the field in this manner. In a field trial to test possible control measures, pentachloronitrobenzene (128 lb. a.i./acre) did not decrease the incidence either of powdery scab or of potato mop-top virus infection of Arran Pilot, but applying sulphur at 10 cwt./acre, which changed the soil pH from 5.5 to 4.5, greatly decreased both. The vector was not killed by the sulphur, because later applications of lime restored its ability to transmit the virus.

Potato mop-top virus was not eliminated from tubers by keeping them in air at 37°C. for seven weeks. Sap soon loses much infectivity when kept at room temperature or when treated in ways used to purify other viruses. The pattern of systemic invasion of plants resembles that of free virus nucleic acids, but infective sap contained a few elongated virus-like particles, some in aggregates. (R. A. C. Jones, B. D. Harrison).

RUBUS VIRUSES

Raspberry propagation

As stated in last year's Report, about 3,000 young virus-free plants raised in the glasshouse were planted at an isolated site in Perthshire in 1966. This stock obtained a Special Stock Cane Certificate in 1967, and yielded 40,000 canes for distribution to growers. However, Malling Jewel, the most popular variety yielded poorly (13,000 canes from 1,600 plants) as compared with Malling Promise (20,000 canes from 800 plants).

In 1967 the yield of shoots from root cuttings was low, and fewer than 3,000 plants were set out in cane nurseries near those of the previous year. The mild winter of 1966/7 may not have chilled the roots adequately to induce the shoots to grow. This point is being studied by storing the roots in controlled conditions. (J. Chambers).

Sap-transmissible viruses in raspberry

The transmission of raspberry bushy dwarf virus from raspberry to *Chenopodium quinoa* by inoculation of extracts made with alumina and 2% nicotine does not always succeed. Failures are commonest in summer and probably occur because the virus is in too low concentration or because inhibitors of infection are inadequately counteracted. Previous records of the rate of spread of this virus in raspberry are therefore certainly underestimates. Microplots were planted at several sites to reassess the effect of removing the fruiting canes on the spread of this pollen-borne virus. (J. Chambers).

In the course of studies of the inter-relationships of viruses from raspberry, *Prunus* and *Pomoideae*, an isolate designated BQ 20 was obtained from Malling Enterprise raspberry. Preliminary work shows that it resembles apple chlorotic leaf spot virus in host range and stability but is more virulent in herbaceous plants. Clarification of leaf extracts with chloroform and hydrated calcium phosphate gave less erratic virus yields than with bentonite. Final virus concentration depended much on the temperature at which the source plants were kept, and was highest below 18°C. Contaminating plant antigens were removed from partially purified virus preparations by ascending density gradient electrophoresis. (D. J. Engelbrecht).

Blackberries

Three varieties of blackberry obtained through the Nuclear Stock Association all contained viruses transmissible by grafting to *Rubus henryi*. Attempts, which have so far not succeeded, are being made to obtain virus-free plants by hot air treatment. (J. Chambers).

PARSNIP YELLOW FLECK VIRUS

The transmission of this virus by aphids was found to depend on the presence in the source plants of a second virus, anthriscus yellows, which is persistent in aphids, infects chervil and coriander but not parsnip and carrot, and is not transmissible by inoculation of sap. Thus the aphid *Cavariella aegopodii* acquired parsnip yellow fleck virus from aphid-inoculated chervil or coriander plants but not from those infected by manual inoculation of sap, nor from aphid-inoculated carrot or parsnip. Aphids acquired parsnip yellow fleck virus from infected chervil plants which were manually inoculated with parsnip yellow fleck virus and then aphid-inoculated with anthriscus yellows virus, but not from plants containing parsnip yellow fleck virus alone. This phenomenon resembles that known, but not understood, in a few other systems, and will be studied in more detail. Preliminary results suggest that anthriscus yellows virus can either enhance or suppress the accumulation of parsnip yellow fleck virus, depending on the conditions of the experiments. (A. F. Murant, R. A. Goold).

EXOTIC VIRUSES

Yam brown spot

White Lisbon yam (*Dioscorea* sp.) tubers affected by brown spot, a disorder of unknown cause, were received from the Department of Agriculture, Barbados. The shoots produced by these tubers were stunted and mottled, suggestive of a virus infection, as compared with those produced by normal White Lisbon tubers. Attempts failed to transmit virus from affected and normal shoots by inoculation of sap to herbaceous plants, but flexuous virus-like particles about 750 mμ long were found in extracts from both kinds of plants. This suggests that all White Lisbon yams may contain at least one virus, and those showing brown spot more than one. (B. D. Harrison).

Eggplant mosaic virus

Leaves of eggplant (*Solanum melongena*) thought to be infected with the beetle-transmitted eggplant mosaic virus of Dale (*Ann. appl. Biol.* **41**, 240, 1954) were received from Trinidad. A virus transmitted by inoculation of sap from them to a range of solanaceous species has many properties of Dale's virus. It was purified and proved to be serologically related to Andean potato latent virus (Gibbs *et al.*, *J. gen. Microbiol.* **44**, 177, 1966). (B. D. Harrison with A. J. Gibbs, Australian National University, Canberra).

PUBLICATIONS

ABU SALIH, H. S., MURANT, A. F. and DAFT, M. J.[1] (1968). Comparison of the passive haemagglutination and bentonite flocculation tests for serological work with plant viruses. *J. gen. Virol*, **2**, 155-166.

(The passive haemagglutination and bentonite flocculation tests were compared for detecting plant viruses, using antibody-sensitized tanned red cells or bentonite particles. They were respectively about 2-5 and 100-125 times more sensitive than tube-precipitin tests for detecting the elongated viruses (narcissus mosaic, potato *X* and tobacco rattle) and about 10-20 and 500-600 times more sensitive for detecting isometric viruses (parsnip yellow fleck, raspberry ringspot and turnip yellow mosaic). The minimum concentrations of virus detected were 1.8–2.6 μg./ml. with the bentonite flocculation test and 0.04–0.24 μg./ml. with the passive haemagglutination test. Red cells treated with formalin before they were tanned and sensitized with antibody could be preserved at –14°C. for up to eight weeks without loss of activity. Crude extracts from healthy plants of eight species had little or no effect on either test.

Antibody-sensitized red cells were used in haemagglutination-inhibition tests to determine antiserum titres; antisera to turnip yellow mosaic and raspberry ringspot viruses gave titres 32 times higher than those obtained in tube-precipitin tests).

LISTER R. M. (1968). Functional relationships between virus-specific products of infection by viruses of the tobacco rattle type. *J. gen. Virol*, **2**, 43-58.

(Preparations of nucleoproteins from stable variant infections of viruses of the tobacco rattle type were separated, by density gradient centrifugation, into 'top' and 'bottom' fractions containing predominantly 'short' or 'long' particles respectively. Comparison of the products of infection when these fractions were used as inocula alone and mixed indicated that though lesion production and RNA replication were mediated by 'long' particles, the presence of 'short' particles was necessary for virus protein coat production. The coat-inducing function of 'short' particles could also be used to stabilize RNA from homologous or closely related unstable variant infections. Inoculating systemic hosts with 'short' particle preparations together with phenol extracts from the unstable variant infections, resulted in stable variants similar to those from which the unstable variants were initially derived).

MOWAT, W. P. (1968). *Olpidium brassicae:* Electrophoretic mobility of zoospores associated with their ability to transmit tobacco necrosis virus. *Virology*, **34**, 565-568.

(Zoospores of vector isolates of *Olpidium brassicae* have a greater net negative charge than those of nonvector isolates. The effect of divalent cationic salts on their electrophoretic mobility and ability to transmit two strains of tobacco necrosis virus is reported. The possible significance of the surface charge of the zoospore in determining transmission is considered in terms of the theory of colloidal stability).

[1]University of Dundee.

MURANT, A. F., TAYLOR, C. E. and CHAMBERS, J. (1968). Properties, relationships and transmission of a strain of raspberry ringspot virus infecting raspberry cultivars immune from the common Scottish strain. *Ann. appl. Biol*, **61**, 175-186.

(Plants of Lloyd George and Seedling M raspberry (*Rubus idaeus* L.) were found in eastern Scotland infected with raspberry ringspot (RRV), a virus to which these varieties were previously considered immune. Most RRV isolates from affected plants caused milder symptoms in herbaceous test plants than did the type isolates of the common Scottish and English strains. In graft-transmission tests the Lloyd George strain of RRV infected all the raspberry cultivars tested, including those immune from the common Scottish strain. No consistent differences were found between isolates of the two strains in *in vitro* properties or serological behaviour. Both strains were transmitted in seed of *Stellaria media* and in soil containing *Longidorus elongatus*. Possible reasons why the new strain is uncommon in Scotland are discussed).

TOLLIN, P.[1], WILSON, H. R.[1], YOUNG, D. W.[1], CATHRO, J. and MOWAT, W. P. (1967). X-ray diffraction and electron microscope studies of narcissus mosaic virus, and comparison with potato virus *X*. *J. mol. Biol*, **26**, 353-355.

(X-ray diffraction patterns of narcissus mosaic virus and potato virus *X* were very similar, with a series of marked meridional reflections at essentially the same spacings. With phosphorus pentoxide in the camera, the layer line spacing was 33Å and at 98% relative humidity it was 36Å. Electron microscopy of narcissus mosaic virus using eight different electron dense stains gave poor results; only uranyl formate gave a slight indication of periodicity. When a critical amount of formic acid was added to uranyl formate, however, distinct cross-banding was evident at 34-38Å intervals. The spacing of the layer lines in the X-ray diffraction patterns apparently represents the pitch of the helix of the particle, and its alteration with change in hydration may be characteristic of viruses with flexible particles).

[1]University of Dundee.

Zoology

C. E. TAYLOR

Research has been mainly concentrated on the biology of nematode vectors of plant viruses and on the mechanism of virus transmission. Entomological interests have always suffered from lack of staff and Hanne Holmes' resignation in April brought the work on raspberry mite to a close. The vacant post was used to appoint an Assistant Experimental Officer to assist with the work on the ultra-sectioning and electron microscopy of nematodes, which has been almost at a standstill for over a year following re-organisation associated with the separation of Zoology from the Virology Section, and accordingly W. M. Robertson's appointment in October was a welcome addition to the Section. During the year P. R. Thomas and myself attended a short course on Ultramicrotomy, organised by the Royal Microscopical Society and held at the Zoology Department of St. Bartholomew's Medical College, London. We also attended the Fourth British Insecticide and Fungicide Conference at Brighton and with the aid of a travel grant from the A.R.C. were able to participate in the Ninth Symposium of the European Society of Nematologists held at Warsaw, Poland. I participated in the A.R.C. Insecticide and Fungicide Research Workers Conference, which on this occasion was held at the Plant Pathology Laboratory, Harpenden.

Several overseas workers visited the Section during the year and R. M. Goodman from the Department of Plant Pathology, Cornell University, spent 10 weeks here to acquire experience with nematodes and virus transmission.

NEMATOLOGY

Nematode survey

Until recently, knowledge of the distribution of *Longidorus* and *Xiphinema* virus vectors in Scotland has been limited to the investigation of disease outbreaks in crops, especially raspberry and strawberry, and nothing was known of their possible wider distribution in association with natural vegetation or in crops unaffected by virus infection. A random survey has now been started, and will continue as time and opportunity permit, to obtain a wider knowledge of the distribution of these nematodes in relation to soil type, cropping and natural vegetation, and potential sources of virus infection. Advisory and specialist officers of the Colleges of Agriculture have helped in this by sending soil samples to us.

Eastern Scotland, north of the Forth, has been fairly extensively surveyed and a limited number of samples have been obtained from the north west and

the south east of the country. *Longidorus elongatus* is abundant and widespread in central and eastern Scotland in cultivated, free-draining, light loams and sandy soils. *Xiphinema diversicaudatum* has so far been found on heavy, moist soils in the Edinburgh area, the Lothians and the Clyde Valley. The most northerly location to date is at Cupar, Fife. In most cases the infestations were associated with arabis mosaic and strawberry latent ringspot viruses.

Longidorus goodeyi and *L. leptocephalus* have also been found in some of the areas sampled, but they are not known to transmit viruses. (C. E. Taylor, P. R. Thomas).

Longidorus elongatus

The life cycle of *L. elongatus* is being studied by analysing the population in a strawberry crop at two-monthly intervals. The egg-laying period extends from early April to mid-September with a main peak in April/May. Most of the eggs hatch by July, judged by the increase in the numbers of first instar juveniles at this time, but their presence later in the year suggests that a delay in hatching may also occur, probably with those eggs produced at the end of the egg-laying period. A peak in nematode numbers usually occurs in November, by which time some of the juveniles have reached the third instar. The increase in total population is about five-fold, but during the winter many of the nematodes die and the annual increase is only two- to three-fold.

In a glasshouse experiment 25 crop and weed plants were compared as hosts for *L. elongatus*. The nematode multiplied readily on strawberry, rye grass and clover and on *Stellaria media*, *Poa annua* and *Veronica officinalis*. Raspberry ringspot and/or tomato black ring viruses were transmitted to most of the plant species in the experiment, but the frequencies of infection were not always directly related to the suitability of a species as a host for the nematode. For example, *L. elongatus* failed to reproduce on *Senecio vulgaris* but plants became infected with raspberry ringspot and tomato black ring viruses as frequently as did plants of *S. media*, a good host for the nematode. *Lamium amplexicaule*, *Trifolium pratense*, *Brassica sinapis* and *P. annua* also frequently became infected.

On most plants, feeding by *L. elongatus* caused swelling or distortion of the subterminal portions of the young roots but this damage appeared to have no significant effect on their growth. (P. R. Thomas).

Xiphinema diversicaudatum

An outbreak of strawberry latent ringspot virus in a plantation of Malling Jewel raspberry at Cupar, Fife, coincided with an infestation of the vector, *Xiphinema diversicaudatum*. Arabis mosaic virus was not detected in the crop but was transmitted, together with strawberry latent ringspot virus, from many weeds. Both viruses were transmitted through the seed of some of the weed species.

Monthly sampling within the infested area showed that *X. diversicaudatum* laid eggs from April to July and that populations subsequently reached

a peak in the autumn. The rate of multiplication at this stage was about ninefold but because many of the nematodes died during the winter, the annual rate of increase in population was finally about two-fold. Most of the *X. diversicaudatum* occurred between 4-12 in. deep and more were found within than between the rows of raspberries.

In laboratory experiments populations of *X. diversicaudatum* increased on strawberry, white clover, Italian ryegrass, raspberry, *Poa annua* and *Stellaria media*, but not on *Capsella bursa-pastoris* or *Mentha arvensis*. Arabis mosaic and strawberry latent ringspot viruses were transmitted to all of these plant species, except for Malling Jewel raspberry, which is immune to arabis mosaic virus, and Italian ryegrass, which became infected only with strawberry latent ringspot virus. (C. E. Taylor, P. R. Thomas).

Association of virus and vectors

In Scotland, natural infections with raspberry ringspot and tomato black ring viruses are invariably associated with *Longidorus elongatus*, whereas those with arabis mosaic and strawberry latent ringspot viruses are associated with *Xiphinema diversicaudatum*. This specific association of particular viruses with a particular vector is maintained in nature despite the fact that all of the viruses can infect strawberry, which is a host for both nematode species. The question of whether specific transmission of viruses is maintained under experimental conditions was investigated by feeding *L. elongatus* and *X. diversicaudatum* on herbaceous host plants infected with each of the four viruses. By macerating batches of *L. elongatus* and inoculating the suspension to *Chenopodium quinoa* test plants it was shown that all four viruses may be ingested by the nematode, but nematodes allowed to feed on *C. quinoa* 'bait plants' transmitted only raspberry ringspot and tomato black ring viruses. This suggests that transmission cannot be a purely mechanical process but is influenced by some biological association between vector and virus. On the other hand, *L. elongatus* immersed for 25 minutes in antiserum to raspberry ringspot virus failed to transmit, although by macerating the nematodes it was shown that the infectivity of the raspberry ringspot virus in the intestine was unaffected; nematodes immersed in normal serum transmitted. This could be explained if the virus available for transmission were retained in the buccal capsule of the vector, where it probably would be readily exposed to the antiserum, but this explanation fails to explain transmission of certain viruses and not others.

Experiments so far indicate that there is a close biological association between *X. diversicaudatum* and the viruses it transmits, and that the association differs in many respects from that found in *L. elongatus*. (C. E. Taylor).

Chemical control

The performance of a prill (granular) formulation of dazomet (tetrahydro-3 dimethyl-2 H1, 3, 5-thiadiazine-2-thione) nematicide (Boots Pure Drug Co. Ltd.) was first examined in trials with the potato root eelworm, *Heterodera rostochiensis*. The dazomet prill was applied to infested soil at the rate of

400 lb./acre on 15 April 1967 and, after the usual procedure of forking the ground some three weeks after application, Epicure potatoes were planted on 13 May. Plants in treated plots were slower to emerge than in untreated plots because of the slight phytotoxity of the methyl isothiocyanate, which had not been fully released by planting time owing to low soil temperatures. However, by harvest on 7 September all haulms of the untreated plots were dead or dying back, while those of the untreated plots were still upright, dark green and vigorous. Treated plots outyielded untreated plots by 30% in weight and more than 100% increase in the number of ware size tubers.

To overcome the slow release of methyl isothiocyanate at the low soil temperatures prevailing in the spring, further experiments were done with dazomet applied in September to fallow soil infested with *Longidorus elongatus*. Soil samples taken at intervals after treatment showed marked decreases in nematode numbers following applications at 150 or 300 lb./acre. The efficiency of this control in relation to the spread of viruses transmitted by the nematode will not be known until strawberry or raspberry crops are planted in spring 1968. (C. E. Taylor).

Electron microscopy

Studies of the fine structure of *Longidorus elongatus* have been restarted, after being held in abeyance for some time, and progress has been made with araldite embedding and staining techniques. Other species of *Longidorus* are also being studied and the structure of the feeding apparatus compared with that of *Xiphinema diversicaudatum* to complement research on the mechanism of virus transmission.

The appearance of a periodic structure in the cuticle of *L. elongatus* has prompted enquiries into the feasibility of an X-ray diffraction study on the moulted cuticle.

Some preliminary work has been done on sectioning the big bud mite, *Cecidophyopsis ribis*, in an attempt to locate reversion virus in particular organs. So far, no virus particles have been identified in sectioned material but macerations of the mites, stained with phospho-tungstic acid, contained polyhedral particles, about 270 Å diameter. Similar particles were found in macerated preparations of 'big buds' taken from blackcurrants infected with reversion virus, but none was found in healthy plant tissue. (C. E. Taylor, P. R. Thomas, W. M. Robertson).

ENTOMOLOGY

Raspberry aphids

Granular and spray applications of insecticides for the control of aphids in Malling Jewel raspberry cane nurseries were compared in a randomized block experiment. The materials used were ethoate-methyl (Fitios B/77, Berk Ltd.) in spray and granular formulations, granular disulfoton and dimethoate spray. The spray materials were applied five times between mid-June and early September and the granular materials three times. Ethoate-methyl and

dimethoate sprays prevented the build-up of aphid populations (*Amphorophora rubi*) but granular applications of ethoate-methyl or disulfoton did not. (C. E. Taylor with J. Chambers, Virology).

Raspberry beetle

An examination of the nature of the resistance of *Rubus phoenicolasius* to the raspberry beetle continued with laboratory tests of a series of fractions from leaves and flower buds (prepared by Dr J. T. Martin, Long Ashton Research Station). A wax acid fraction from the flower buds proved to be most repellent to the beetle. Since adult raspberry beetles are available for only a few weeks during the year feeding tests were also done with a stored products beetle, *Tribolium confusum*, to see whether it was an effective substitute. The *T. confusum* ate corn flakes treated with the raspberry beetle-repellent fraction but were repelled from corn flakes treated with another acid fraction. Linoleic acid and linolenic acid, which are chemically similar to this fraction, also repelled *T. confusum*. (C. E. Taylor with D. L. Jennings, Plant Breeding).

PUBLICATIONS

MURANT, A. F., TAYLOR, C. E. and CHAMBERS, J. (1968). Properties, relationships and transmissions of a strain of raspberry ringspot virus infecting raspberry cultivars immune from the common Scottish strain. *Ann. appl. Bio.*, **61**, 175-176.

(For summary see Virology Section).

TAYLOR, C. E. (1968). The association of *Longidorus elongatus* with raspberry ringspot and tomato black ring viruses. *Proc. 9th Intern. Nematology Symp., Warsaw*, 1967 (in press).

(Under experimental conditions several serologically distinct strains of raspberry ringspot and tomato black ring viruses can be transmitted by *L. elongatus*. In nature two strains of the same virus are sometimes found in the same disease outbreak but it is more usual for one strain to predominate. These observations are discussed in relation to specificity of transmission in *L. elongatus*).

THOMAS, P. R. (1968). *Aphelenchoides ritzemabosi* on *Saintpaulia*. *Pl. Path.* **17** (in press).

(A description of symptoms of damage caused by the eelworm, and control by hot-water treatment).

THOMAS, P. R. and TAYLOR, C. E. (1968). Fine structure of the oesophageal region of *Longidorus elongatus*. *Proc. 9th Intern. Nematology Symp., Warsaw*, 1967 (in press).

(A description of the fine structure of the digestive tract, including features of spear replacement and the homology of the spear extension).

Meteorological Records 1967

P. D. WAISTER, J. L. MILNE

MYLNEFIELD

Wind

The total run of wind for the year was higher than the average for the previous six years, mainly due to a more than usually stormy March, with a wind run of nearly double the average.

Temperature

The months of January, February and March were milder than usual, but a late frost in May caused considerable damage to early blossom of strawberries and raspberries. Over 70% of the first-formed flowers of Malling Promise were destroyed in one plantation at the Institute.

Rainfall

With the exception of May, the year was unusually dry. Potential transpiration in coastal Angus during the summer months April to September averages 16.5 in., and rainfall for this period in 1967 was only 11.3 in. compared with the ten-year average of 14.7 in. The rainfall in December was the lowest for that month since records began at Mylnefield. The dry conditions in July and August made this an easy fruit picking season and reduced the damage due to *Botrytis*.

Sunshine

There were nearly 200 more hours of sunshine than average – March, April and June being particularly sunny.

The meteorological recording facilities have been augmented by the installation of a Kipp solarimeter with chart recorder, integrator and 24-hour print-out unit. Returns of total radiation have been submitted to the Meteorological Office, Kew, since October 1967.

AUCHINCRUIVE

Total rainfall for the year was near to the ten-year average, but, as at Mylnefield, June, July and August were dry months and May very wet.

Sunshine hours in May were correspondingly low and the total sunshine for the year was below average.

AUCHINCRUIVE 1967

Month	Temperature (°C.)[1] Mean of daily maxima		Mean of daily minima		Rainfall (inches)	Sunshine (hours)	Ground Frost (days)
January	6.8	**44.4**	2.1	**35.8**	2.36	59	16
February	7.3	**45.3**	2.4	**36.4**	3.21	74	9
March	8.3	**47.1**	2.9	**37.3**	3.93	85	2
April	10.0	**50.2**	3.5	**38.3**	2.00	130	19
May	11.9	**53.7**	5.2	**41.5**	3.20	133	3
June	16.5	**62.1**	8.6	**47.6**	1.71	215	1
July	17.5	**63.9**	10.5	**51.1**	2.91	138	0
August	17.1	**63.2**	10.6	**51.3**	2.30	148	0
September	15.8	**60.9**	8.7	**47.8**	3.58	134	2
October	12.0	**53.9**	6.5	**43.8**	6.76	97	2
November	8.6	**47.6**	2.7	**36.9**	2.39	47	12
December	7.2	**45.0**	2.1	**35.8**	2.72	52	18
Year	11.6	**53.1**	5.5	**42.0**	37.07	1312	84

[1] Fahrenheit equivalents shown in bold figures

Erratum. In the 1966 weather report for Mylnefield, the accumulated temperature figures were shown in degrees F. instead of degrees C.

Temperature (°C.) Fahrenheit equivalents shown in bold figures

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[3]	Ground Frost (days)	Rainfall Inches	Rainfall Deviation from average[2]	Sunshine Hours	Sunshine Deviation from average[1]	Run of Wind Miles
January	6.4	**43.5**	+0.6	1.7	**35.0**	+1.4	17	66	11.1	13	−5.0	5	2.3	+0.3	18	2.21	+0.28	73	+23	5514
February	7.5	**45.3**	+1.1	2.0	**35.7**	+1.1	23	47	11.7	2	−2.3	14	4.1	+2.0	15	1.91	+0.06	66	−10	7139
March	9.3	**48.8**	+0.7	2.6	**36.6**	+0.8	47	39	15.0	21	−1.7	31	5.2	+0.9	13	1.49	−0.36	153	+48	11069
April	12.4	**54.4**	+1.4	3.6	**38.4**	+0.4	98	24	21.1	28	−3.8	1	7.0	−0.3	10	0.74	−0.87	191	+51	7424
May	11.9	**53.4**	−2.1	5.3	**41.6**	0.0	108	11	17.2	29	−1.8	3	9.6	−0.6	5	3.27	+1.27	123	−43	5844
June	17.2	**62.9**	−0.5	8.0	**46.4**	−0.2	213	3	22.2	16	2.8	12	13.8	+0.2	0	0.98	−0.71	221	+39	5251
July	18.4	**65.1**	−1.0	10.1	**50.2**	−0.6	268	0	22.2	30	6.1	22	14.8	−0.5	0	1.41	−1.15	159	+ 5	5795
August	18.9	**66.0**	+0.2	9.7	**49.5**	−0.5	271	1	23.9	20	4.4	5	15.2	+0.4	0	2.09	−1.18	173	+32	4366
September	15.8	**60.5**	−0.6	8.8	**47.9**	+0.7	204	1	18.3	10	2.8	7	13.1	+0.2	0	2.78	+0.78	94	−28	4050
October	12.3	**54.1**	−0.3	5.4	**41.7**	+0.1	113	13	16.1	8	−0.6	30	9.2	−0.5	6	2.97	+0.37	122	+27	6652
November	8.7	**47.7**	+0.2	1.7	**35.0**	−0.8	34	42	14.4	11	−1.7	26	5.1	−0.8	18	1.87	−0.45	90	+27	4390
December	7.2	**44.9**	+0.5	1.0	**33.9**	−0.2	14	72	14.3	3	−7.6	20	2.8	−0.9	14	0.50	−2.02	69	+28	5918
Year	12.2	**53.9**	+0.1	5.0	**41.0**	+0.2	1410	319	—	—	—	—	8.5	0.0	99	22.22	−3.98	1534	+199	73412

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

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