The Scottish Horticultural Research Institute

18th Annual Report for the year 1971

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

†West of Scotland Unit.

COLIN HOUGHTON CADMAN, B.SC., PH.D., F.R.S.E., F.I.BIOL.
Director 1965-1971

Colin Houghton Cadman, B.SC., PH.D., F.R.S.E., F.I.BIOL.
Director 1965 - 1971

Colin Cadman's notable achievements during almost three decades of work at Dundee, and earlier at Corstorphine, have been detailed elsewhere. Here, I would like to write of him more personally, as I knew him, first as a scientist and later as an administrator, although many of the qualities he brought to his science were equally apparent when he became Director of S.H.R.I. in 1965.

To his virological work he brought perception and imagination coupled with hard thought, and manipulative skill both in glasshouse and laboratory. His quiet manner gave little hint of the tenacity with which he wrestled with a problem or the single-mindedness with which he pursued his purpose. His belief in the power of reason and his desire to test ideas by experiment were profound and unshakable and acted as the mainspring of his research. To talk to him was not only to be informed effectively and concisely but also to be challenged to contribute. Those not possessing an appropriate technical background found his explanations were of the clearest and most helpful but they too did not escape questioning in relation to experience in the field or as growers. It was said that, at times, he seemed irascible or even 'difficult' but I do not believe this was ever apparent to any who were genuinely interested and concerned for his work; pretentiousness and scientific or other gossip he abhorred. His group was welded together through the gift he had of communicating his enthusiasm and inspiration, and stretched to its limit by his demands on their ability. Consequently, it is not surprising that S.H.R.I's international reputation was first built upon their work.

I have left until last those two qualities whereby he turned these endeavours into a lively way of life, for they played no little part in his subsequent success as a Director. I mean, of course, his sense of humour and his profound appreciation of the beautiful, in a garden, in the hills, in music or pictures. His wry humour, especially his ability to laugh at himself, transformed science into a humane activity: his appreciation of order, of the fitness of things, caused all his activities to be, in the highest sense of the words, both human and profound.

When appointed Director, no one came to high office more diffidently and with less certainty of their abilities to fill the post effectively than did Colin Cadman. He cared deeply for the Institute, not only for its scientific reputation, but also that it should be a genuinely effective instrument in furthering more effective horticulture. Latterly his concern extended to the well-being

and effectiveness of the whole Agricultural Service in the U.K. This deep concern and total commitment to these causes coupled with those characteristics which had made him an outstanding scientist, made him in a short while an outstanding Director. Logic and reason were his guides; imagination led to novel departures, like the more effective scientific re-organisation he introduced, or the development of links with the bulb industry. His ability to communicate led to closer links with farming and industry and the success of the Institute's Association is largely due to him. These achievements are well known, less so are his contributions, at the annual meetings of Directors of Research Institutes, to ideas on how the national Agricultural Service should, and ought to develop both scientifically and in the service of agriculture and horticulture.

None of his achievements was gained lightly. Perhaps his most difficult periods were when his plans, although logical, clear and effective, could not be put into practice for reasons outwith his control. He suffered much frustration and became deeply concerned at times over what seemed to him the negation of reason and the torpidity of bureaucracy. Yet little of this seeped into his day-to-day activities. He pursued his tasks as Director as tenaciously as he pursued his scientific activities. His concern for the good of the Institute was manifest to all, and the measure of his success was that all responded naturally and eagerly to his leadership, staff and governing body alike.

It was good to have known Colin Cadman; I only wish that I had known him better. Scientific inspiration and knowledge lasts and he contributed much to these: leadership and concern for others lives on in the thought and actions of men: he will not easily be forgotten.

J. H. BURNETT

Introduction

C. E. TAYLOR

Investment in agricultural research as with any other industrial research, on the face of it, should be economically productive. It is difficult, however, if not strictly impossible, to make any accurate estimate of the returns from research investment; the precise outcome of a research project cannot be predicted in advance, and even when a new scientific technique or principle has been established, the extent of its commercial exploitation is by no means clear. This applies equally to the problem-solving type of research which in its implementation may set in train a series of changes that are not foreseen at the outset. Nevertheless, despite a high degree of uncertainty surrounding cost effectiveness exercises in respect of projected research, the evidence of past results leaves no doubt about the value of the research investment for the maintenance and future development of the agricultural industry in this country.

Much of the research done at this Institute is of an applied character, with practical goals as objectives and yielding results that are of direct use to industry. But a balance is also established with fundamental research, which may have no immediate practical outlet but which contributes to the establishment of scientific principles; this type of research differs little from any other in the way it is done, and in reality cannot be separated from research on practical problems. Moreover, fundamental research is seen as an essential element in the maintenance of scientific expertise and capability, which are the basic tools for solving problems and reaching objectives. The White Paper 'Framework for Government Research and Development' (Command 5046, July 1972) does not foreshadow any radical changes in this approach to scientific methods of investigation. The application of the customer/contractor principle to applied research projects is unlikely to greatly affect our work programme since this is already seen to be established in our relationship with the Department of Agriculture for Scotland, which grant-aids this Institute, together with seven sister Institutes in Scotland. However, the closer integration of the agricultural research service with the Government's central policy-making activities, as outlined in the White Paper, could well yield many benefits, not least of which might be the development of a strategy which will maximise the transfer of technology from research to practical operation.

The establishment of meaningful research objectives ensures that the research organisation is attuned to the needs of the industry which it serves.

For this Institute this means an awareness of where, in the context of horticulture in the U.K., the future for horticulture in Scotland lies. At a time when the whole industry is undergoing a series of changes, and with prospect of entry to the E.E.C., it is inappropriate to dogmatise about the future of crop production in Scotland. There seems little prospect of an increase in real demand for horticultural produce other than that created by a rise in population. Nevertheless in regional Scottish terms, opportunities are presented for competitive production of crops such as raspberries, strawberries, black currants, flower bulbs and a range of vegetables, and the possible establishment of new crops such as blueberries. The future is far from bleak and research investment can ensure a continuing perception and anticipation of opportunities for the development of the industry.

General Report

C. NORTH

Throughout the year the affairs of the Institute were overshadowed by the indisposition of Dr Cadman and his death in September. When he was taken ill in March, most of us realised that his condition was serious but none of us anticipated that he had such a short time to live. His unexpected death was an especially sad blow because he seemed to have made a very good recovery and was in such high spirits after a holiday abroad. This is not the place for an obituary notice but it is appropriate to draw attention to his long association with the Institute. He could in fact be described as 'the founder member' since he came to Dundee from East Malling in 1944 to initiate, almost single-handed, the Raspberry Investigation Unit, and our Institute as it is to-day has developed mainly from this small nucleus. He was always at the hub of the Institute's affairs as a highly respected adviser, even before he became Director, and his contribution during the last six years towards the building of an efficient research organisation cannot be over-rated.

The year will also be remembered as one of considerable uncertainty about the future organisation of agricultural research and development as a whole. From the comparative calm of the Institute we looked out on troubled waters suggesting reforms and rumours of reforms. The most controversial proposals were those arising from the Government's Green Paper 'A Framework for Government Research and Development'–a publication which gave rise to much internal discussion, to comments from the Institute's senior staff members for discussion by the A.R.C. Directors and Directors of Scottish Agricultural Research Institutes, and to recommendations from the Institute's Governing Body for consideration by the Government Select Committee on the Green Paper.

We were involved in project costing exercises; initially a rough assessment requested by the Cabinet Office, later a more refined exercise for the Planning Unit of the A.R.C. and finally the adoption of a system of monthly returns to the A.R.C. At first this work seemed to be merely another routine chore, but the enforced thinking around the subject has already been a useful exercise in helping us to orientate our plans for future research. We also witnessed the founding of the Scottish Agricultural Development Council which has set us wondering what our relationship to this body will be, especially in the realm of applied research and development work. Finally, we have had to adopt the Fulton merger of scientific classes, an exercise which is undoubtedly a step forward, but one which has its fair share of pitfalls.

In spite of the troubled waters comparative calm prevailed within the Institute and allowed work to go ahead without serious disruption. The main contributions of the research work are described under the Section reports but some merit special comment. The current highlight of our work on diseases is the discovery that *Fusarium avenaceum* is often associated with the mysterious 'die back' of raspberries. It is perhaps too early to say whether this is the main cause of this disease complex but at least it offers a new approach to a problem which has baffled us for the last twenty years.

Work of a more fundamental nature with multicomponent viruses in the Virology Section is beginning to cast light on the genetic control of the biological properties of some viruses. In these viruses the genetic material is in more than one piece and artificial hybrids with novel combinations of properties can be made by taking the different pieces of genetic material from different virus strains. Needless to say the objective is to aid the study of the viruses and their hosts and not to synthesize and release new virus strains!

Plant breeding is a slow process but when a programme is well under way it can launch material for testing in official trials at fairly regular intervals. The Institute has currently six raspberries, six black currants, five strawberries, two French beans, one cabbage and five lilies undergoing trial as potential new varieties. Once a new variety is released there is generally no great difficulty in encouraging growers to try it even though it may not find a permanent niche. This enthusiasm to try new varieties does not seem to extend to potential new crops. The Institute has from time to time demonstrated that some crops hitherto not grown in Scotland will thrive well here and although some visitors apparently have shown great enthusiasm few have taken up the challenge to grow them. It is encouraging, therefore, to see that the Crops Research Section's efforts to launch blueberries and calabrese as new crops are at last making some progress. During the last year blueberries were planted commercially for the first time in Scotland and the quick freezing industry has encouraged an expansion of calabrese production.

The building of the new laboratory block, scheduled to be completed by autumn 1973 started a few weeks later than had been anticipated but has made good progress. To ensure smooth progress of the work the Institute has appointed a Clerk of Works, R. Jack. Before the remnants of the old farm buildings could be demolished to make way for the new development it was necessary to rehouse most members of the Crops Research and Zoology Sections. This was made possible by the generous co-operation of the Department of Agriculture and Fisheries for Scotland in providing at late notice, four temporary Portakabin buildings. The re-organisation enabled us to settle the Zoology electron microscope in its permanent site on the ground floor of what has now become known as the 'new wing' of the main building. We were also fortunate to gain a share of the money made available through the Department's Additional Work Scheme, enabling four new staff houses to be built. On a slightly lower plane, though not at a low cost, a new 'rabbitry' was built for work of the Virology and Plant Breeding Sections, to specifications approved by the Home Office.

March 1971 marked the ending of one of the triennial periods when changes are generally made in the membership of the Governing Body. We welcome five new members: Messrs. J. Arbuckle, D. W. H. Cargill, I. D. Lowe, and Professors N. F. Robertson and W. D. P. Stewart. All members are busy men and whether they are newly appointed or have served for many years, it is often difficult for them to get to know as much as they would like about the activities and personnel of the Institute. We are grateful to them for giving their time to our affairs and especially pleased to see the spontaneous efforts of some members to make themselves better acquainted with our work.

We welcomed R. J. A. Exley to the newly-created post of Information Officer. In addition to his liaison work, he will take over responsibility for the Visual Aids group which was previously responsible to the Administration Section. Other new faces include T. J. W. Alphey, successor to P. R. Thomas in the Zoology Section; B. Boag on a Natural Environment Research Council appointment, also in the Zoology Section; H. Barker to replace Aileen A. Crockatt in Virology, and P. Smith to Plant Breeding to replace B. M. Henley. In the Crops Research Section, Louise Findlay, D. Husband and I. R. Urqhuart replaced respectively Maureen Robertson, Anna McGibbon, Agnes Lowson–the last-mentioned having transferred to the Virology Section. Mrs Georgina A. Laing was appointed to a new post in the Mycology Section as assistant to J. M. Duncan. Sheena Morton and Irene Niven joined the Zoology Section on behalf of N.A.T.O. and N.E.R.C. respectively. We also lost the services of some old colleagues through resignation and our best wishes go to Mrs Isobel Anderson who joined the staff in 1963 and has been a champion of the cause for many junior members of staff, G. Cathro who reached retiral age as a fit-looking 'young' man after sixteen years' service with us, and J. Sunderland, our photographer, who resigned after 18 years here to take on the responsibility as a Warden in a Home for Mentally Handicapped at Chesterfield, Derbyshire. A new photographer, J. I. Campbell, has been appointed but will not take up his responsibilities until 12 June 1972.

We were pleased to have two foreign workers in the Virology Section: S. El Nagar from the United Arab Republic, and T. Yamamoto from Japan whose stay was unfortunately cut short.

Three senior staff members, R. A. Fox, B. D. Harrison and C. E. Taylor attended Senior Management Courses at the Civil Service College at Sunningdale and London.

At the end of December R. A. Fox retired after four years' service on the Council of the British Mycological Society and two years as its representative on the Committee of the Federation of British Plant Pathologists.

Rather more overseas visits than usual were made during the year. R. A. Fox again made a brief consultancy tour of the South East State of Nigeria; D. L. Jennings was invited to take part in a Program Review Conference on Cassava at the Centro Internacional de Agricultura Tropical, Cali, Colombia; C. E. Taylor paid three visits to the Laboratoria di Nematologia, Bari, Italy

and gave four lectures at Wageningen on invitation from the International Agricultural Centre and the Agricultural University of Wageningen, and A. B. Wills read a paper at a meeting of the European Molecular Biology Association held in Rome. Travel grants from the Agricultural Research Council enabled B. D. Harrison and A. F. Murant to participate in the International Congress of Virology at Budapest, H. M. Lawson to visit the Netherlands, C. North to attend the first Eucarpia Meeting on the breeding of Ornamental Crops held in Wageningen, D. A. Perry to attend the 16th International Seed Testing Congress in Washington and M. Pérombelon the Third International Conference on Plant Pathogenic Bacteria at Wageningen. The Institute Association kindly provided funds for A. B. Wills to visit the Plant Breeding Institute at Versailles.

Two conferences were organised by members of staff. Arrangements for the annual summer meeting of the Association of Applied Biology held at Dundee in July were made by a committee of members of the Institute and of Dundee University led by C. E. Taylor. Dr Cadman, as President of the Association for the year, initiated the arrangements but was not well enough to finalise them or to take part in the meetings. He was presented with a gift by the participants in his absence and received some of the members at his home. Later in the month a Eucarpia (European Association of Plant Breeding) meeting on strawberry breeding was held at Ayr. H. J. Gooding organised this conference and it was gratifying to see nearly all European strawberry breeders there and to have as a guest speaker such a distinguished authority on the crop as Dr R. S. Bringhurst of the University of California. Financial support, made available by the A.R.C. from the Underwood Fund, made it possible to invite Dr Bringhurst and Dr G. Staudt from Pfalz.

Mr G. M. Hodge retired from the office as Chairman of the Institute's Association after having carried the responsibility during the formative years of the Association. His period of chairmanship will be remembered not only for his pioneering work with the Association but also for the enthusiasm he brought to work on the mechanical harvesting of raspberries. He is succeeded by Mr J. A. Forbes. Newcomers to the Executive Committee include Messrs T. Hay, J. A. Inverarity, R. A. P. Leach and I. D. Salmon. Messrs I. D. Lowe and D. W. H. Cargill are members of the committee as representatives of the Institute's Governing Body. The third Annual General Meeting of the Association, held in June, was followed by a discussion on some aspects of the economics of marketing horticultural crops, with papers presented by Mr I. Bowie from Edinburgh University and Mr W. Martin. Other activities included organised inspections of the fruit and vegetable work at Mylnefield and a popular one-day symposium on weed control which attracted 130 participants. This meeting, prepared by H. M. Lawson, was supported by papers from Messrs H. J. Nation (N.I.A.E.), H. A. Roberts (N.V.R.S.), G. W. Cussans (W.R.O.) and D. S. C. Erskine (Edinburgh School of Agriculture). The importance of regarding herbicides as a management tool for the whole crop rotation, rather than merely as a means of controlling weeds in one particular crop, was stressed.

Other liaison activities included a one-day meeting of the S.H.R.I./Colleges Liaison Committee at which the Senior Advisers of the three colleges put forward their views on new and recent problems in horticulture and during the afternoon selected topics of the Institute's research activities were discussed. The Institute received a one-day visit from members of the Horticultural Advisory Council who also called at our Unit at Auchincruive during their tour in Scotland. Several other parties and numerous individuals visited us during the summer. It is not possible to list them all but the more distinguished foreign visitors included a party led by Professor R. F. Carlson (Michigan); Professor J. Carew (Michigan); Professor Z. Hidaka and Messrs S. Matsuoka, K. Sakara (Japan); Dr Z. Tesovic (Yugoslavia); Mr Ho Chai Yee (Malaya); Mrs H. Ondrejova (Czechoslovakia); Dr Istvan Sarvari (Hungary); Mr R. Whitcomb (Oregon); Mr M. Darbonne (France); Dr D. Globerson (Israel); Dr P. Rosati (Italy); Messrs P. Dorsman, J. Hiddema, C. Wassenar, Miss H. G. Kronenberg, Dr Th. de Bruin (Holland); Messrs M. I. Boldrev and V. G. Trushechkin (U.S.S.R.); Dr Y. E. Orten Turkey); Messrs K. Kristensen and A. Thuesen (Denmark); and Dr D. J. Hoslains (Australia).

During the year in which I acted as caretaker in the Director's chair I received much co-operation and encouragement from my colleagues, particularly from N. D. Anderson and Miss McGill who guided me around the Director's files and facilities and from D. L. Jennings who temporarily took over responsibilities for the Plant Breeding Section. Dr C. E. Taylor was appointed as our new Director on 1st March 1972. He is no stranger to us, having joined the staff of the Institute in the Virology Section in 1959. We have watched, with admiration, the way he has developed the Zoology Section during the last few years and raised his nematology work to international standing. Our best wishes go with him in his new and demanding role as our Director.

Farm and Experimental Crops

W. I. A. JACK

Progress has been maintained in making more effective and efficient use o land and other resources for field experiments. The system for siting experi ments in pre-determined and more or less permanently defined strips, which was started here for vegetable crops in 1955, has now been extended t nearly 70% of the farm and is used also for work on fruits and other crops As an aid to routine farm operations and to help provide a more rationalise rotation, field plots of the same or similar crop species have been groupe together. A simple six course rotation based on cereals and grass has bee adopted, the grass being cut for drying or for hay and in some circumstance grazed by sheep. At present the cereals are spring-sown, but a switch t autumn-sown cereals is contemplated to help control the simazine resistan spring germinating weeds which are especially troublesome in soft frui experiments. The introduction of a new wage grade structure in 1969 ha facilitated the setting up of smaller labour groups, usually with specifi responsibilities, and this reorganisation has considerably increased th efficient use of the farm labour.

The year began with land work ahead of schedule. Fine spring weathe enabled cereal sowing to start on 10 March and a large spring programme o work on field experiments to be handled without difficulty.

Farm crops included 97 acres of cereals and 22 acres of grass. The barle harvest, started on 17 August, gave a high yield of 41 cwts/acre (39.4 cwts acre in 1970) with the grain obtained in fine condition and with a low moisture content. Oats were less successful and lodging was so troublesome tha harvesting started on 7 September almost became a salvage operation Nevertheless the yield of oats was reasonable, with 45.8 cwts/acre (48 cwts acre in 1970). Grass was successfully cut for drying on 18 May and hay production, started on 25 June, was arduous because of a deterioration i the weather but nevertheless gave a very good yield of 3.5 tons/acre.

The acreage of experimental crops of raspberries and strawberries remained the same as in 1970 (32 and 7 acres respectively) but there was an increase from 9.75 to 11 acres of black currants. Fourteen acres of vegetables, 5 acres of potatoes and 7 acres of other crops were grown for experimental purposes Fine dry weather during the fruit harvesting season resulted in relatively low yields of small-sized fruit but picking was easy and the picking season one o the shortest on record at the Institute. However, in spite of an increased acreage harvested the yield of soft fruits was only 40.9 tons, a fall of 2.8 tons

compared with the previous year. Weather conditions favoured the growth of potatoes and yields of approximately 20 tons/acre were well above average, but lifting conditions were difficult and led to more than usual damage to the tubers and consequently poor keeping qualities.

Beech hedges were planted on the west boundaries of Low and Mid Pilmore and North Bullion fields and boundary fences were erected round Bungalow and North Bullion. The amenity planting round the main buildings was continued and work started on improving the appearance of the east side of the main drive.

A prolonged period of illness prevented me from taking as active a part as usual in the manegement of farm affairs and I should like to record my thanks to R. W. Reid who so ably managed the affairs of the section during my absence.

Glasshouse Section

J. CANTWELL

After three years of continuous disruption due to redevelopment on the glasshouse site, 1971 was a year of consolidation and one in which to re-examine the functions and objectives of the Section as outlined in the 196 Annual Report. At that time there was a continuous increase in scientific staff and consequently an increasing load on glasshouse facilities. Progres has been made in improving management and production procedures and al the glasshouses now have automatically controlled heating and lighting, mos have automatically controlled ventilators and the propagating houses have in addition, soil warming facilities and CO_2 enrichment.

A labour saving has been attained by the virtual elimination of the use of sterilized soil and the introduction of a peat/sand compost and a square polypropylene pot which can be steam sterilized. This combination gives a light-weight unit which is economical of space both in the glasshouse and the transportation system.

During the last five years the procedures for propagating virus-tested raspberries have been examined and this project is now virtually completed although it is possible to refine the techniques still further. There are four distinct phases in the method of propagation investigated, and the usefulness of the findings are such that they have been incorporated into the standard procedure. In summary, the resulting programme now is:–

(i) *Treatment of virus-tested mother plants to produce maximum root yield.*

The system adopted uses a standardized peat/sand compost with two plants isolated in each container at a density of 2250 cm^2 per plant. The plants are watered through a low-level sprinkler line. The system gives an increase in root yield over the original system of 200–300% with Malling Jewel for plants potted in May and harvested in December the same year. This enables the rapid multiplication of desirable cultivars for it is now economic to lift one-year-old plants.

(ii) *Treatment of roots from mother plants to produce soft-wood cuttings.*

The root is cut into lengths of 10–20 cm and about 500–600 cm is placed in a standard horticultural seed tray 30×20×5 cm deep containing an unfertilized mixture of 25% sand and 75% peat and the roots are covered 1½–2 cm. The boxed root is kept at a temperature below 4°C until required. In the 2nd or 3rd week of February the boxes of root are placed in a heated glasshouse at 20°C but with the roots at 25°C. As soon as shoots appear

supplementary lighting is given to extend the daylength to 16 hr. Watering is not critical but the compost is not allowed to dry out nor become water-logged.

(iii) *Treatment of shoots to produce rooted cuttings.*

Shoots appear within about 10 days and the first are ready for detachment about 5 days later, thereafter the process is continuous. The shoots are cut off with a scalpel as close to the parent root as possible when they are about 2.5 cm above compost level with 3–4 leaves.

The cuttings are inserted in an unfertilized 25% sand 75% peat compost in plastic trays which are placed on heated cables covered with moist peat. The propagating area is covered with clear polythene. No misting is used. Air T° is kept at about 18–20°C, compost T° at about 25°C and supplementary illumination provides a 16 hr day. 'Damping-off' may occur if high light intensities are not maintained but it has been found that benomyl gives moderate control if sprayed early enough. The cuttings root in about 10 days.

(iv) *Treatment of rooted cuttings.*

The new plants are potted up into 9×9×12 cm deep polypropylene pots containing a fertilized compost of 25% sand and 75% peat. The plants are kept in the glasshouse at 20°C for a week and thereafter the temperature is gradually reduced until the plants are moved into the open about 4–6 weeks after potting. The move coincides with average daily temperature of not less than 10°C and a daylength of not less than 14 hr. The plants may rosette if either of these requirements is not met.

The procedures outlined provide a base from which further work may proceed and permit speedy identification of specific areas of low productivity and faulty management. It is hoped that by combining clearly defined growing techniques with accurate data collection it will be possible to predict output more accurately than in the past. The help of members of the scientific staff and the practical skills of the glasshouse workers contributed much to this project.

Crops Research

P. D. WAISTER

Research into the effects of weather on cropping only rarely produces result which could lead directly to commercial exploitation in the field. This year's confirmation of shelter effects on strawberries, and the magnitude of these effects, suggests that provision of some form of windbreak may help not only in raising average yield but also in stabilising the yields of this crop from year to year in eastern Scotland.

The indication that low temperature-sensitivity is common in many carrot seed lots and that insensitive seed lots show much greater consistency of emergence in the field, could lead to better prediction of populations for canning carrots where control of population is vital in determining returns.

An important result of this year's weed control work in raspberries is the finding that weed competition is critical in the establishment stage, and that there is a good chance that a successful herbicide treatment may be developed. There is as yet no officially-approved herbicide for this stage in a plantation's life.

Following a number of years of agronomic work on blueberries and calabrese, two potential new crops for Scotland, it is encouraging to learn that the first pilot plantings of blueberries on growers' holdings have been made this year and that support by the freezing industry has encouraged an expansion in calabrese production.

The Section's contribution to the International Biological Programme ended in March, and J. Q. Neilson, who has been in charge of this 2-year project, left the Institute. There were three changes in assistant staff: Anna McGibbon, Sandra Petrie and Agnes Lowson were replaced by D. Husband, R. J. Clark and I. R. Urquhart.

H. M. Lawson visited research stations in the Netherlands, supported by an A.R.C. grant, and at Mylnefield organised a very successful symposium on the efficient use of herbicides, held under the auspices of the Institute Association. A report will be published in the Institute Association Bulletin on this symposium and on other aspects of the Section's work of immediate interest to growers.

CROP ENVIRONMENT

Crop response to shelter

In a new plantation laid out in 1970, strawberries were planted on both sides

of windbreaks running north to south. In the first cropping year, 1971, the yields from the sheltered plots, expressed as a percentage of the average yield of exposed plots, were 144% (east of the windbreaks) and 121% (west). The reduction in run of wind, recorded at 1 m height, was 32% in the east plots compared with 22% in the plots to the west of the windbreaks. Plants on plots sheltered from the west had on average 5 more leaves at the end of their first season than did the plants on exposed plots, and 8 more leaves at the end of the second season. There seemed to be little if any differential effect on leaf survival overwinter. Plants sheltered from the east showed much smaller growth responses.

Attempts were made to measure tissue temperatures with thermistors mounted in hypodermic needles but even such small sensors proved unsatisfactory for leaf temperatures. The temperatures of receptacles and berries were similar on sheltered and exposed plants but, in contrast, the crown temperatures in the exposed plots during the summer showed higher maxima and lower minima than those observed in the sheltered plots. By September the minimum temperatures were only slightly lower in crowns of exposed plants, and the maximum temperatures were similar.

In the sheltered plots, during the winter 1970-71, soil temperatures at 20 cm were consistently lower than those in exposed plots. At 0.5 cm too, temperatures in the sheltered plots were frequently lower than those in the exposed plots, but air temperatures over the two plots were similar. During the summer, soil temperatures in the sheltered plots were consistently higher than those in the exposed plots.

Measurements were begun of soil moisture fraction profiles in one exposed and one sheltered plot, and also in a bare plot using the neutron moderation method. The equipment broke down after less than a month's use in the field and so conclusions must as yet only be tentative. What results were obtained, however, indicated that the upper horizons of the soil in the sheltered plots were drying more rapidly than were those in the exposed plot.

The investigations into the influence of shelter from wind on the yield from strawberries have up to the present been conducted on Cambridge Favourite. This year 10 cultivars have been planted to assess their tolerance of exposure.

Overall yields of raspberries were low in 1971 and canes growing in sheltered plots yielded only slightly more berries than did canes in exposed plots. Yield increases were only 6% when considering the full plots of 20 rows to the east of the windbreaks (or about 20 times the height of the windbreak above the crop) and still only 11% when considering the first 10 rows, compared with exposed plots. Shortly before the first harvest of raspberries there were 2 days of high winds resulting in damage to leaves and fruits. In samples taken at the first harvest, 72% of the berries in the exposed plots showed wind damage and 36% in the sheltered plots.

In a pilot experiment planted in the autumn of 1970, the provision of shelter had no effect on stem lengths or earliness of flowering in the narcissus Golden Harvest.

Bulb yields of the tulip Rose Copland were not significantly affected by shelter. The exposure conditions in the experiments were identical with those in the strawberry experiment described above, and the results illustrate the marked differences in wind sensitivity of different crop species.

(D. K. L. MacKerron, P. D. Waister).

Seed germination and seedling emergence

Carrots

Of 50 Chantenay seedlots tested, 19 showed temperature sensitivity of germination, *i.e.* a significant reduction in laboratory germination at 10°C (G10) compared to 20°C. Seed advancement has previously been shown to increase the G10 of some temperature-sensitive seedlots, but was effective in doing this in only four of the 19 seedlots in 1971. Speed of emergence in the field was increased by seed advancement in most of the seedlots used.

Temperature sensitivity of germination was investigated in relation to seed anatomy. Fixing seeds overnight in 1% mercuric chloride solution induces or reveals differences between seedlots in the extent to which the embryo fills the embryo-cavity in the endosperm. Temperature sensitivity did not occur in a seedlot with a mean embryo/cavity length ratio (ECR) of greater than approximately 0.7. Below this value there appeared to be two populations of seedlots–those in which temperature sensitivity increased linearly with decrease in ECR, and those in which there was a range of ECR values but no temperature sensitivity. Seed maturity or seed deterioration after harvest may explain the differences.

Seed of carrot (captan dressed) was sown on 20 weekly occasions from 9 March. Four carrot seedlots were used and differences in seed quality resulted in varying levels of emergence throughout the year. Emergence of all the seedlots was affected by the formation of a soil cap in April and by a warm, very dry spell in June. However, in one seedlot emergence levels of greater than 65% were recorded on 14 occasions distributed throughout the experiment. During this time the mean soil temperature between sowing and half emergence increased from approximately 7°C in March to 22°C in July. Using such a seedlot it may be possible to obtain predictable levels of emergence from almost any sowing date if the effect of moisture stress and soil capping can be modified (*e.g.* by the use of a soil mulch). Speed of emergence (expressed as the reciprocal of time to half emergence) was linearly related to mean soil temperature between sowing and emergence except under very dry conditions. After making allowances for these conditions, the correlation coefficients for the relationship in the separate seedlots were greater than 0.97. There was a similar form of relationship between rate of germination and temperature in the laboratory when two seedlots were germinated at a range of constant temperatures (8° to 23°C or 26°C) and the correlation coefficients were in excess of 0.99.

Beet

The field emergence of beetroot from thiram-soaked clusters, sown on 20 occasions from 16 March, was generally more variable than that of carrots and there was particularly poor emergence from the first 6 sowings. As with the carrots, rate of emergence was linearly related to mean soil temperature between sowing and half emergence, but again there was more variability than in the case of carrots ($r=0.94$ for beetroot). It is possible that varying levels of soil moisture affected both the final level and speed of emergence more in beetroot than in carrots.

The striking linear relationships found between rates of germination and field emergence and temperature suggests that physical rather than chemical processes within the seeds may dominate in controlling germination and emergence over the range of temperatures found in the field in east Scotland.

Mulching effects on emergence

A bitumen mulch applied to the soil surface can affect soil conditions by preventing wind-blow, the formation of a soil cap and excessive moisture loss; there is also an effect on soil temperature. All these factors can affect germination and emergence in the field. In order to study a number of these factors at different times of the year carrot seed was sown on 4 occasions (April-July) into plots that were either left untreated, or were covered with a bitumen mulch immediately after sowing. The emergence percentages on the control plots for the four sowings were 21, 42, 53 and 52% respectively and for the bitumen-treated plots 43, 54, 55 and 52% respectively. The higher level of emergence of the bitumen-treated plots from the April sowing was due to the prevention of a soil cap which formed on the unmulched plots. Modification of the soil environment to allow more uniform levels of emergence throughout the year could be an advantage if less expensive soil mulching materials can be developed.

(T. W. Hegarty).

WEED INVESTIGATIONS

Weed competition

Competition between chickweed (*Stellaria media*) and transplanted spring cabbage from late winter until harvest (31 May) reduced total crop weight by 50% and weight of marketable heads by 66% compared with yields from totally weed-free plots. Treatment with propachlor after transplanting reduced the weed population but the very rapid spring growth of surviving chickweed resulted in a 40% reduction in total crop weight at harvest; trifluralin incorporated prior to transplanting the crop gave excellent overall weed control. Despite the presence of resistant species, ground cover by weeds in plots treated with trifluralin was only 5% at crop harvest and no crop losses were recorded. The ability of chickweed to survive the winter, and to spread rapidly in early spring at the expense of other weeds and of the crop, makes its elimination the major requirement of the weed control programme.

Raspberry canes (cv. Malling Jewel) planted on 25 March were subjected to competition from the natural weed flora for various periods during the growing season. The major species was the simazine-resistant weed, knotgrass (*Polygonum aviculare*). In plots left weedy until 1 June and kept clean thereafter, there was no adverse effect on numbers of new canes produced by the end of November but average cane length was reduced by 60%. When the weeds were left until 1 July or 1 August before removal, cane numbers were reduced by 28% and 77% respectively and average length by 60% and 53% respectively. These results clearly indicate the vulnerability of canes to competition from weeds during the first few months after planting and stress the need for the development of suitable herbicide treatments.

Herbicide development

A number of candidate herbicide treatments were evaluated on newly-planted raspberries at five locations during 1971, both for crop tolerance and for ability to control annual and perennial weeds resistant to simazine. Promising results were obtained with atrazine and bromacil at 2 and 1 lb a.i./acre respectively, sprayed overall shortly after planting. The experiments are being continued to assess any carry-over effect on crop and weed growth.

Dry weather in spring often adversely affects the performance of surface-applied residual herbicides in spring-planted raspberry and strawberry crops. One way to avoid this problem is by herbicide incorporation before crop planting. During 1971 the tolerance of both crops to trifluralin applied in this manner was evaluated. Raspberries (cv. Malling Jewel) showed no adverse effect on cane numbers or average length at 2 lb a.i./acre, but at 4 lb a.i./acre there was some reduction in cane length. Strawberries (cv. Cambridge Favourite) were a little less tolerant but in both crops excellent weed control was obtained at 1 lb a.i./acre.

In a carrot experiment, trifluralin incorporated at 1 lb a.i./acre pre-sowing gave more effective weed control under dry conditions and without adverse effect on the crop, than any of the commercially available herbicides applied to the soil surface. Metoxuron showed promise as a post-emergence treatment. The weed spectra of these two herbicides are complementary and further investigations will examine their joint use in a programme of weed control.

Soft fruit management

In an experiment planted in 1968 to examine possible competition between row cane and suckers growing in the alleys between the rows, results indicate that adverse effects of the presence of alley suckers are unlikely provided they are removed before the onset of fruit ripening. Delaying sucker removal until just before fruit picking may result in reduced yields per fruiting cane in dry seasons. (H. M. Lawson, J. S. Wiseman).

Raspberries

By subdivision of root systems it is possible to induce increases of 40% or more in the number of canes produced per unit of spawn cane. However, the individual canes so produced are weaker than those obtained from conventional methods. Attempts to strengthen cane growth by additional applications of nitrogen were not successful.

In the third cropping year of an experiment to examine the feasibility of offsetting the effects of increased row width for mechanical harvesting by increasing cane populations per row, the wide-row dense-cane system has yielded about 25% less than the conventional 6 ft spaced rows, for both Malling Jewel and Malling Promise. This is a reflection of markedly reduced yield per cane, the reasons for which may well be associated with the more favourable climate for cane pathogens in the dense rows.

Other manipulations of cultural methods for mechanical harvesting, involving various forms of biennial cropping, have not proved promising. All the indications to date are that yield potential will be reduced by the introduction of machine picking. A system of pruning to give bushy canes which could be self-supporting has also lowered yields to unacceptable levels.

Testing of a harvesting machine was continued, in co-operation with the N.I.A.E. Scottish Station. In a very wet harvest season it was possible to do little more than confirm that some further radical alterations are necessary in either the machine, in the cultivar used, or in the training method, if not in all. A wide range of cultivars and seedlings has been established in a four-acre block to test their suitability for mechanical harvesting; these include existing cultivars and new seedlings selected specifically for fruit abscission characteristics.

In co-operation with the National Fruit Trials, Brogdale, a new cultivar trial was established. It includes the new S.H.R.I. cultivar, Glen Clova, two from East Malling Research Station, Malling Orion and Malling Admiral, as well as thirteen new seedlings from the two institutes. Marked differences in vigour, in both cane numbers and extension growth, are already apparent.

As a means of measuring the extent to which present row spacing fails to exploit available land, raspberries were planted at spacings down to 3 ft between rows in 1968. In this third cropping year yields from the 3 ft spacing were still 43% higher than in the conventional 6 ft spacing.

(M. R. Cormack, P. D. Waister).

Raspberry bud death

At intervals of 3 weeks throughout the winter of 1970-71 short pieces of cane, each bearing a bud, were cut from plants growing in the field. On each occasion samples were taken from successive positions up the canes, from base to tip. They were then incubated in petri dishes at 20–25°C for 17 days to test viability. At no time was there a significant amount of bud death.

In the spring of 1971 many plantations in Scotland showed extensive bud death but unfortunately the sampled area was exceptional in that few buds failed.

As in the previous year, spur blight (*Didymella applanata*) was recorded on most of the excised samples from which buds developed normally. The absence of any obvious link between bud death and spur blight does not rule out pathogens as causal agents (see Mycology Section report). The variability of cane and bud death found between canes on the same stool and between canes of closely adjacent stools, is more suggestive of pathogen attack than of direct damage attributable to an environmental factor, such as low winter temperatures. (D. T. Mason).

Storage and transport of raspberries

Co-operative work with the A.R.C. Food Research Institute, Norwich, confirmed more extensively, last year's findings which indicated the feasibility of transporting raspberries by road to markets in the south of England. A field cooler designed by F.R.I. was used to remove field heat from 400 lb batches of fruit which were then transported in a cooled container, to markets some 450 miles away. Fruit sold 68 hours after picking was in readily saleable condition. Problems of scale will be examined when full commercial container-loads are transported south in future years.

The success of fungicides used in the field to control *Botrytis* is usually measured either in terms of absolute yield of healthy fruit or percentage of mouldy fruit at harvest. However, for raspberries transported to distant markets, the length of time during which the fruit remains in marketable condition is critical. Shelf-life tests at 21°C were conducted on fruit from plots not given any fungicide treatment. Samples picked at mid-season developed mould growth more quickly than those harvested early or late in the season, contrary to previous years' results where the rapidity of deterioration increased throughout the season. Three sprays of benomyl at 12-day intervals from the 3 June delayed the onset of visible mould growth at 21°C giving samples an additional shelf-life of one day. Similarly timed sprays of dichlozoline were less effective.

The most frequent cause of termination of storage life is the appearance of one or two mouldy berries per punnet, not deterioration of the whole sample. It is not yet clear whether the mouldy berries arising in samples from sprayed treatments are those missed by the fungicide in the field or are those which are physically damaged or otherwise rendered particularly prone to attack by a fungus. (D. T. Mason, A. W. Tomalin[1], A. Farrimond[1]).

Strawberries

A cultivar screen based on four-plant units has shown some interesting examples of adaptability among the 180 cultivars obtained from widely

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

differing climatic areas. Within the highest yielding group of 20, there are cultivars bred in New York State, California, Missouri and France, as well as in Britain. Further observations on the most promising will be made in 20 plant units established this year.

In association with the National Fruit Trials, Brogdale, a trial of 5 cultivars and 7 new seedlings from British breeders has been planted.

Once-over harvesting of Cambridge Favourite, to simulate machine picking, depressed yield of marketable fruit by 22% compared with normal hand-picking. This single harvest was taken 10 days after the start of the hand-picking treatment. The timing is critical, as delay of a few days markedly increases the percentage of over-ripe or mouldy fruit, even in this cultivar which is considered to 'hold' well.

In spacing experiments planted in 1970, yields from Merton Princess and Cambridge Favourite grown as spaced plants were higher at 9 in and 3 in within-row spacing than at the conventional 18 in. The object of this work is to assess the degree of control of fruit size possible by manipulation of plant population. In this first full cropping year spacing has not significantly affected the berry size of Cambridge Favourite, but the 3 in spacing of Merton Princess has reduced size by about 15% compared with the normal 18 in spacing.

A similar spacing experiment has been established with Crusader and Talisman to find whether reduction in vigour caused by between-plant competition can substitute for the defoliation normally necessary for these cultivars. This response will not be measurable until 1972, but yield and fruit size data were available in 1971. As with Merton Princess and Cambridge Favourite, closer spacing increased yields but in neither was fruit size affected. The mean yield increases for all 4 cultivars grown as spaced plants (as opposed to matted rows) were 42% and 49% for the 9 in and 3 in spacings, respectively. When grown as matted rows, closer planting of Merton Princess and Cambridge Favourite did not give a yield advantage.

(M. R. Cormack, P. D. Waister).

Strawberry crown death

Cambridge Favourite grown in the east of Scotland suffers from a necrosis of the pith sometimes followed by death of the crowns. The disorder is sporadic, varying in intensity from plantation to plantation. A survey of injury was undertaken in 68 plantations in 1968 and 1969, and at the same time information was collected on soil and climatic conditions, and growers were questioned about cultural methods. The incidence of crown death varied from nil to 88%. Analysis of the results shows no strong common factor among the plantations suffering heaviest damage. Trends towards greater damage have been shown with increasing distance from the coast, on particular soil types, or following inadequate nutritional régimes, and possibly with misuse of herbicides. Older plantations show a greater incidence than young. This multiplicity of possible factors, together with the association with *Fusarium avenaceum* (see Mycology Section report), suggest that the

condition may occur wherever environmental and cultural methods produce metabolic changes predisposing the plant to infection. Susceptibility does not appear to be merely due to general lack of plant vigour.

(D. T. Mason).

Vaccinium species

Added impetus has been given to the work on highbush blueberries (*Vaccinium corymbosum*) by the establishment this year of the first two field scale plantations of this crop on farms in Scotland. In an experiment comparing methods of adjusting pH, applications of either sulphur or peat produced increases in total extension growth (number of new whips multiplied by length) of 300% and 330% respectively. The present pH levels are 4.9 for sulphur, 5.3 for peat, and 5.9 for the untreated control.

Cultivar trials and observation plots are growing satisfactorily but are not yet old enough to produce meaningful yield results.

The observation beds of cranberries (*Vaccinium macrocarpum*) established in 1968 have yielded very poorly this year, apparently as a result of excessive vegetative growth. Measures are being taken to control this vigour.

(M. R. Cormack, P. D. Waister).

VEGETABLE CROPS

Brussels sprouts

Ten cultivars differing in one character or another were each grown at spacings of 20×79 in, 20×20 in and 20×5 in. The cultivars were selected on the basis of certain known characteristics such as number of sprouts/plant, maturity, stem length and leafiness. Each spacing/cultivar combination was harvested on three occasions although results from only two harvests are so far available.

Maximum marketable yield was obtained from the intermediate spacing for each cultivar when harvested in November and also in January, with the exceptions of Early Half Tall and Rollo which gave their maximum yields for both harvests at the closest and widest spacings respectively. Extremes of differences found in the magnitude of response to population between cultivars are exemplified by Indra and Rollo. When harvested in January, yields for Rollo were 5.8, 5.4 and 5.4 tons/acre, and for Indra were 5.2, 10.3 and 7.9 tons/acre, for the three spacings respectively. Detailed analyses of the results are required before the significance of this type of response may be evaluated. The object of this work is to determine the way in which yield components differ in different genotypes, and the nature of the responses to changes in cultural method.

Calabrese

As in the case of blueberries, work on calabrese is designed to aid commercial exploitation of a new crop for Scotland. Mechanical harvesting appears to be feasible, judging from experience with close-grown crops in beds this year, cut with a prototype harvester. Programming of the crop to give an extended harvest season with once-over picking requires knowledge of the effects of sowing date and population on rate of maturation. With the cultivar Harvester, the number of days to maturity from each of four sowing dates, 8 April, 6 May, 3 June and 1 July, were 90, 70, 74 and 67 days respectively. A late sowing on 29 July virtually failed because of delayed maturation and low quality spears. Varying populations within a range from 3 to 18 plants/sq ft had no effect on maturity date.

Attempts to obtain early crops by overwintering, using 19 cultivars, were successful but the winter was so atypically mild that the results are of questionable significance.

A direct-drilled cultivar trial was thinned to give a spacing of 24×6 in. Green Comet yielded 9.2 tons/acre of high quality spears. Higher yields, of about 11 tons/acre, were obtained from Coastal, Topper 43 and Hybrid 8392, but these were of lower quality.

Grown at a close spacing of 8×2 in for once-over mechanical harvesting, only three cultivars appeared to have potential. Harvester yielded 2.1 tons/acre, Hybrid 8383 2.0 tons, and Green Comet 2.3 tons. Their periods to maturity were 81, 92 and 99 days from a 15 April sowing.

The very large yield difference between the high and low populations is in part attributable to the harvesting of secondary spears from the hand-harvested, wide-spaced plants. However, even after adjusting for this, with all cultivars tested this year there was an appreciable drop in yield when plants were close-spaced for mechanical harvesting of small spears.

Cauliflowers

The range of curd sizes required for different markets is wide, and information is lacking on cultivar response to control of curd diameter by change in plant population. Two cultivars were chosen to represent marked genotype differences: Finney's 110, with little leaf and Kangaroo with large, long leaves. Both have similar curd diameters when grown at wide spacing.

Five populations varying from 0.18 to 4 plants/sq ft were used (the normal commercial population in Scotland is equivalent to approximately 0.20–0.25 plants/sq ft). When grown at a square spacing Finney's 110 gave a peak yield of 13.0 tons/acre at 1 plant/sq ft compared with only 7.2 tons at 0.25 plants/sq ft. The corresponding mean curd diameters were 4.8 in and 5.5 in. The yield of Kangaroo was similar to that of Finney's 110 at the lowest population of 0.18 plants/sq ft (approximately 3.5 tons/acre) but was only 4.4 tons/acre at 1 plant/sq ft. Curd diameter of Kangaroo was 5.0 in and 4.0 in at the 0.18 and 1 plant/sq ft spacing respectively. The large difference in yield between the cultivars at the close spacing was associated with reduction in the number of plants of Kangaroo which succeeded in producing curds.

Red beet

This is potentially an important processing crop in Scotland. The problem of production is not so much that of achieving high yields per acre but of

arranging for the produce to be of the right size grade distribution, and available over a long processing season. The two main grades required are $\frac{3}{4}$–$1\frac{1}{2}$ in and greater than 2 in.

Manipulation of sowing dates and plant populations of the cultivar Avonearly gave a range of harvest dates from 21 July to 11 November. With storage the season could be extended to April or May. No combination of treatments gave a yield of 'baby beet' ($\frac{3}{4}$–$1\frac{1}{2}$ in) greater than 4.4 tons/acre. The maximum total yields and maximum yields of beet greater than 2 in diameter were obtained from the lowest population of 4 plants per sq ft. From successive sowings on 19 April, 10 May, 1 June, 22 June and 12 July this treatment yielded 32.0, 26.0, 23.0, 17.0 and 5.4 tons/acre respectively.

Much of the investigational work on the relationship between population and yield of beet has been carried out using a wide bed with close rows. Since harvesting is easier from 'mini-beds' about 9 in wide at 25–30 in centres, comparisons of yield for the two systems were made. Populations achieved were 17 plants/sq ft in the mini-beds and 20 plants/sq ft in the wide beds. Levels of nitrogen application imposed on each of these treatments were 200, 400 and 600 units/acre. Averaged over the nitrogen treatments, the total yield and yield of baby beet were 17.5 and 3.8 tons/acre for the mini-beds and 18.0 and 3.3 tons/acre for the wide beds.

Effects of nitrogen on yield were more marked for the mini-beds than for wide beds. Total yields from the mini-beds with 200, 400 and 600 units were 15, 18 and 20 tons/acre respectively and for the wide beds all were similar with 18 tons/acre.

Vining peas

To establish the characters in vining peas which lead to desirable attributes of yield and maturity, three cultivars of markedly different habit were grown at four populations. Green Shaft was selected because it has a greater than average number of ovules per pod, whilst bearing generally two pods/node; Skagit for its multipodded habit whilst producing an average number of ovules per pod, and Fridol because it produced relatively small peas. The yield of the cultivar Skagit at tenderometer 100 reached a peak at about 4 plants/sq ft and fell steeply with further rise in population. Green Shaft and Fridol showed much lower sensitivity to change in population and yields were at a maximum between populations of 6 and 9 plants/sq ft. Analysis of the relationship between yield and the components of yield such as number of pods/plant, number of ovules per pod, number of tillers per plant and ovule size, has yet to be completed.

Tulips

There is growing interest in tulip production in Scotland and earlier work at Mylnefield has indicated that growth and yield of dry bulbs in eastern Scotland should compare favourably with that in England. As doubt has been expressed about the suitability of Scottish-grown bulbs for early forcing, a programme has been started to examine the performance of Scottish-grown bulbs when forced for the Christmas trade.

Three cultivars amenable to early forcing, Paul Richter, Merry Widow (Lustige Witwe) and Mirjoran, were harvested in the first week of July, preconditioned at 30°C for 7 days, then at 20°C until one week after inflorescence initiation was completed (stage G), followed by 6 weeks at 9.5°C. After boxing, the bulbs were stored at 9.5°C until housed. When the three cultivars were housed on 16 November, Paul Richter and Mirjoran reached 50% flower stage by 21 December, and Merry Widow by 25 December. A fortnight's delay in housing postponed flowering by only 2 days in Paul Richter and Merry Widow, and by 5 days in Mirjoran.

Miscellaneous

Results of short term experiments not included here will be reported in the Institute Association Bulletin. Topics include broad bean cultivar testing, the effects of applications of common salt on the yield of red beet, population and cultivar trials on cylindrical beet, and drying methods for dried pea production. (R. Thompson, H. Taylor).

STATISTICS AND COMPUTING

Twenty-nine people have discussed statistical or computational problems, and 27 have used the computing facilities. Analysis of variance was carried out on 3,279 variates, a 12% increase on last year; 65 jobs involved regression analysis and some 20 other programs were used either regularly or on an exploratory basis. Both analysis of variance and regression are now covered by suitable programs whose use has become routine for many projects. Urgent attention is being given to the provision of something intermediate between the desk calculator and the elaborate coding and slow turn-round of the computing service. The delays and frustrations of a postal service have not prevented several members of staff from writing their own programs. The staff of the Edinburgh Regional Computing Centre are thanked for advice and assistance on numerous occasions.

The series of genetic programs was extended by a program to fit constants to plant breeding data. This permits assessment of general combining abilities and gives some indications of specific combining abilities of parents represented by irregular numbers of crosses and seedlings. It is being used to evaluate differences in performance of identical strawberry breeding material at Auchincruive and at Mylnefield. Another program which may be used to screen hypotheses about the genetic control of a character and the constitution of parents prints out, for an observed segregation, a list of two-class genetic ratios and the chi square for deviation from each. It has found a place in study of disease resistance, where segregations are not clear cut and recognition may depend on the method of assessment. (P. B. Topham).

CORMACK, M. R. (1971). Highbush blueberries. *Scott. Agric.* **50**, 171–175.

CORMACK, M. R. (1972). Prospects for highbush blueberries in Britain. *Comml. Grow.* **No. 3971**, 234, 235 and 242.

HEGARTY, T. W. (1972). Temperature relations of germination in the field. *Proc. 19th Easter Sch. agric. Sci. Univ. Nott.* 1972 (in press).

(The effects of temperature on percentage and rate of germination and field emergence of carrots are described. Soil temperatures within the range normally occurring during the sowing period need not affect the final percentage emergence if a temperature insensitive seed lot is selected. Linear relationships found to exist in the laboratory between rate of germination and temperature were also found in the field between rate of emergence and mean soil temperature).

LAWSON, H. M. (1972). Weed competition in transplanted spring cabbage. *Weed Res.* **12**, 254–267.

(Experiments on the timing of removal of weeds in transplanted spring cabbage showed that the presence of weeds during autumn and winter had no effect on crop growth provided they were removed before the onset of rapid growth of crop and weeds in early spring. Weeds left beyond this time competed with the crop, resulting in smaller marketable heads. Increasingly severe competition affected internal head quality, reduced the numbers of plants producing heads and resulted in the death of a proportion of the crop plants. The main weed species responsible for crop loss was chickweed (*Stellaria media*), which survived winter frost and grew away rapidly in early spring to fill all available ground space, dominating the weed flora and shading the crop foliage.

Comparison between cropped and uncropped plots showed that the crop itself exerted considerable competitive pressure on the growth and development of weeds).

LAWSON, H. M. (1972). Herbicide management. *Agriculture Lond.* **79, No. 4**, 175–180.

LAWSON, H. M. and WAISTER, P. D. (1972). The response to nitrogen of a raspberry plantation under contrasting systems of management for weed and sucker control. *Hort. Res.* **12**, 43–55.

(The response of a raspberry plantation (cv. Malling Jewel) to two rates of application of nitrogen was found to be independent of whether soil management systems involved regular or minimal cultivation. Extra nitrogen promoted cane production but this was increasingly offset by reduced yield per fruiting cane as the plantation matured, until in the final two years yield per plot was significantly reduced. Lower yield per cane on plots receiving additional nitrogen was associated both with increased cane death and with reduced yield per unit length of live cane).

LAWSON, H. M. and WAISTER, P. D. (1972). The effects of soil cultivation techniques on the growth and yield of the raspberry crop. *Weed Res.* **12**, 96–106.

(Five management systems for the control of weed and sucker growth were compared over 8 years in a plantation of raspberries (*Rubus idaeus*) grown on the stool system. Traditional intensive cultivations consistently produced the tallest cane, which contributed to that treatment outyielding all others for the first 5 cropping years. Reduced cultivation systems, involving rotary cultivation and hoeing, or simazine and hoeing, outyielded non-cultivation systems which depended on herbicides alone. Lower numbers of fruiting canes, as well as poorer cane quality on non-cultivated plots, were associated with failure to remove raspberry sucker growth between the stools during the growing season on these plots. The introduction of mechanical removal of between-stool growth considerably improved the yield of one uncultivated treatment.

Possible beneficial effects of cultivation included the improvement of cane growth by ridging the crop, the concentration of crop growth in the stool itself by regular pruning of extension growth into the alleys and between the stools, and the prevention of competition between fruiting cane and suckers growing outside the stool area.

Analysis of the component operations of the old system shows that their useful features can be incorporated into modern systems of mechanised plantation management which depend largely upon herbicides for weed control).

THOMPSON, R. (1971). Carrot storage using forced air ventilation. *Proc. Symp.* on *Vegetable Storage. Association of Applied Biologists, November 1970.*

THOMPSON, R. (1972). Mini-carrots. *Scott. Agric.* **51**, 308–312.

THOMPSON, R. and TAYLOR, H. (1971). Mylnefield puts focus on low-cost cropping. *Comml. Grow.* **No. 3946**, 239–240.

WAISTER, P. D. (1971). Wind shelters improve soft fruit yields. *The Grower* **75**, 1358, 1360.

WAISTER, P. D. (1971). Shelters give strawberry yields a 78 per cent boost. *The Grower* 75, 1473, 1474.

WAISTER, P. D. (1971). Cutting the wind speed by half. *The Grower* **76**, 267, 268.

WAISTER, P. D. (1971). Raspberry harvester works, but . . . . *Arable Farmer* **6, No. 1**, 32–33.

WAISTER, P. D. (1972). Wind as a limitation on the growth and yield of strawberries. *J. Hort. Sci.* **47**, 411–418.

(Reduction in mean wind speed from 1.6 m/s to 1.1 m/s produced a mean increase of 56% in the yield of the strawberry Cambridge Favourite over a three year cropping period. Variation in response from year to year was appreciable and appeared to be linked to the wind conditions in the previous growing season.

Extensive bruising of leaves in exposed plots was recorded and this appeared to be a more likely reason for growth depression than indirect effects of exposure via alteration in plant temperature or soil water balance. Earliness of cropping was virtually unaffected by reduction in wind speed.

Shelter improved not only the total yield but also the regularity of yield from year to year. The exposed plots showed variation from 9.8 to 15.8 t/ha, compared with 16.6 to 19.1 t/ha in the sheltered plots).

WAISTER, P. D. and CORMACK, M. R. (1972). Growing Scots raspberries to suit the machine. *Comml. Grow.* **No. 3970**, 205, 206.

Plant Breeding

D. L. JENNINGS

A highlight of the year was the Eucarpia symposium on strawberry breedin held in July at the West of Scotland Unit, and attended by over 4 scientists representing 8 countries. Dr R. S. Bringhurst of California an Dr G. Staudt of Germany were invited guests and we are indebted to th Agricultural Research Council for providing funds to meet their expense H. J. Gooding was responsible for most of the organisation of the meetin and read a paper dealing with field resistance to red core disease. Anothe Eucarpia function in which we were involved was the Sixth Congress a Cambridge held in July; five members of the Section attended.

A. B. Wills accepted an invitation to read a paper at a meeting of th European Molecular Biology Association held in Rome in November, an funds provided by the S.H.R.I. Association enabled him to visit centres o Horticultural Research near Versailles, France, in July. Four members of th Section attended a Brassica Breeders' Conference at Southport, contributin papers on incompatibility, cytogenetics and the analysis of seed isoenzymes and our work on Brassica breeding was also the subject of an exhibit at th Chelsea Flower Show. I accepted an invitation to attend a Program Revie Conference on cassava at the Centro Internacional de Agricultura Tropical Colombia.

P. Smith was appointed to assist A. B. Wills on the resignation of B. M Henley. Mrs J. Lawson, a postgraduate student from Newcastle University worked with the Brassica group for 6 weeks, and M. J. Rafferty, a 'sandwich course' student from the West of Scotland College of Agriculture, spen three months in the Section.

At the West of Scotland Unit, a new Dutch Light House was erected an is proving invaluable for holding our large collection of breeding materials.

BEAN

Field trials of white-seeded stringless lines were continued and selection made for improved suitability for canning and for machine harvesting. Tw advanced selections were entered for Plant Breeders' Rights and N.I.A.B trials, and both are being multiplied by N.S.D.O. with a view to release Single plant selections were made from plots of anthracnose-resistant line being grown to test their suitability for machine harvesting and for quick freezing. (A. J. Redfern).

BLACK CURRANT

The first crop was obtained in 1971 from clones included in trials at Ludding-ton Experimental Horticulture Station and the National Fruit Trials, Brogdale in 1970. Several selections from the cross (Consort × Magnus) × (Brödtorp × Janslunda) showed considerable promise, combining high yields with large fruit size and an upright growth habit. Fruit samples of two of them were tested by Beecham Products Ltd. for their suitability for juice production, and both were found to produce juices somewhat lower in ascorbic acid content and of less true black currant flavour than Baldwin. Their derivation from Consort, which is hybrid between *Ribes nigrum* and *R. ussuriense*, may be the reason for this.

Resistance to leaf spot and American gooseberry mildew

Progenies combining sources of leaf spot resistance derived from *R. dikuscha* or *R. nigrum sibiricum* carried their first crop in 1971. The *R. dikuscha* progenies and a family of complex origin derived from *R. nigrum*, *R. bracteosum* and a Ribesia sp segregated for plants bearing sporulating or non-sporulating lesions on their non-senescing leaves. Many segregates also showed the *R. nigrum* type of resistance, i.e., sporulating lesions occurred but defoliation was not premature, but it was not possible to separate the two forms of resistance accurately because of the unusually dry late summer. Several selections combined productivity with disease resistance but only a few of these had the necessary upright growth habit. Several progenies also combined two sources of resistance to American gooseberry mildew, one from *R. dikuscha* and one from *R. nigrum*.

Resistance to gall mite and reversion virus

R. ussuriense and the *R. nigrum sibiricum* cultivars Rus and Narjadnaja were still free of galled buds and mites in 1971 after growing for 4 years adjacent to infested bushes. The *R. nigrum sibiricum* cultivars Vistavotnaja and Gornoaltajszkaja were also free from galling, but live mites were occasionally found in normal buds. Symptoms of reversion were observed in six-year-old plants of *R. ussuriense* and in two-year-old plants of Golubka flowering for the first time. The original mother plants of Golubka remained symptom-free, however, as did established plants of Rus and Narjadnaja. Scions of the latter cultivars were therefore grafted onto healthy indicator plants of Baldwin to see if they carry reversion virus. (M. M. Anderson).

BRASSICAS

Incompatibility

Fluorescence microscope analyses of the S-alleles present in breeding lines were continued, but greater emphasis was placed on studies of partial self-compatibility, since this is an important factor associated with breakdown in the control of seed production for F_1 hybrid cultivars of Brussels sprout.

Self-compatibility was studied in two large groups of plants. The first wa chosen from five closely related inbred lines in which all the plants were homozygous for the S_5 incompatibility allele. The level of self-compatibility of each plant was tested on at least three occasions and the results indicate that there were overall differences in the degree of self-compatibility betwee the five lines. However, in any single test interpretation was complicated b considerable variation in the numbers of pollen tubes penetrating selfe styles, both within lines and individual plants. The second group of plant were inbred lines derived from crosses between related plants of known self-compatibility and all carrying the allele S_{45}. Fewer pollen tubes than expecte penetrated the styles in out-crossing tests, but differences in self-compatibilit levels between the lines were apparent and, as with the first group of plants the results are not easily explicable.

Further experiments were done to study the observed within-plan variations in self-compatibility. It was not possible to relate variations i self-compatibility to plant age or to flower position, but it appeared that self-compatibility increased with the age of individual flowers, being highest i 5 to 6 day-old flowers. This was particularly marked in the more self-compatible plants. (J. R. T. Hodgkin).

Production of potential parthenogenetic autodiploids

The 1970 Report recorded an attempt to produce totally homozygous plant (autodiploids) by pollinating plants of *B. oleracea* with *B. campestris*, sinc this procedure is known to give maternal-type progenies. The seed parent were all known to be heterozygous for their S-alleles and for a gene giving glossy foliage. A total of 32 seedlings were obtained and grown to maturity in 1971. They were all diploid *B. oleracea*; 21 were normal and 11 glossy-leaved individuals and nine of them were found to be heterozygous at the S-locus. The normal-leaved plants were selfed and 14 of the 21 progenie segregated for glossy foliage. The seeds must therefore have arisen by some procedure other than doubling of the egg nucleus, so alternative methods of producing homozygous plants are now being considered. Attempts were also made to use the same procedure to produce 'autodiploids' from commercial lines of Brussels sprouts, but 6,000 pollinations yielded only 12 seeds and in view of the results described, the investigation was discontinued.

(J. R. T. Hodgkin, A. J. Redfern).

Serology of incompatibility

Antisera were raised in eight rabbits, seven to stigmatic extracts and one to a pollen extract. Brussels sprout, cabbage and kale plants homozygous for their S-alleles were used as sources of stigma tissue; four alleles were involved. S_{23} (high dominance), S_{15} (low dominance) and S_{45} and S_2 (intermediate dominance). Marrow-stem kale carrying S_{23} provided the pollen source. The antisera were tested against homologous and non-homologous stigma extracts by double diffusion in agar gels but no S-allele specific band was found in any of the absorbed antisera. Another antiserum, made here in 1970 by Dr Nasrallah, gave specific identity reactions against S_{45} and the allele designated S_{D7} by N.V.R.S.

Rabbits varied greatly in their sensitivity to stigma extracts. None of them produced high titres to any component of the unpurified extract and some produced no reaction at all below a serum dilution of a half. The development of titre to plant proteins is now being investigated to determine the optimum injection schedule and time required for maximum titre to be reached. Attempts are also being made to raise antisera in rabbits of a different breed.

(M. Sedgley).

Genetics of B. oleracea

Linkage tests were made on 37 gene combinations in progenies flowering during 1971. Thirty-two combinations showed no clear evidence of linkage, but crinkly petal (*cp-1*), white petal (*Wh*) and glossy foliage (*gl-b*) appeared to be linked in a group of F_2 families. There was high winter mortality among the glossy plants and a significant deficiency of them at flowering time, but significant chi^2 values were obtained for linkage between *cp-1* and *gl-b* (2.0% level) and between *cp-1* and *Wh* (5.0% level). Chi^2 for *gl-b* and *Wh* linkage was not significant. A further group of backcross families segregated *cp-1* and *Wh* but not *gl-b*. These did not show linkage.

Several related progenies segregated for the intense form of anthocyanin pigmentation derived from marrow-stem kale (A^{MK}) or Shetland cabbage (A^{SC}), together with anther spot (*As*). Some among these also segregated for *cp-1*. The data indicated linkage only between A^{MK} and *As*, with $6.5 \mp 2.8\%$ recombination. However other families showed anomalous joint segregation of *A* and *As*, with disturbed *As*/*as* ratios. Joint segregation and disturbed ratios would both be explained if a third gene, epistatic to *As*, was also segregating, and there was evidence that such a gene was linked to A^{MK} and *As* in families derived from marrow-stem kale, but not to A^{SC} and *As* in families derived from Shetland cabbage. In an independently derived back-cross family segregating for hairy leaf (*Hr*) and *cp-1*, *Hr* segregated approximately 1 *Hr* to 3 hr instead of 1:1 as expected. This result is also explained if another gene epistatic to *Hr* and tightly linked to *cp-1* was segregating.

Among novel phenotypes observed for the first time in 1971 was retarded development (*rd*), where *rd* seedlings grew initially at a markedly slow rate and had narrow, pointed leaves. Later growth was more normal but *rd* plants were still recognisable 12 weeks after germination. The condition was not associated with change of chromosome number. Semi-dwarf (*sd*) types also occurred and both *rd* and *sd* forms arose in lines derived from a common parent grown from gamma-irradiated seed. Progeny of this plant segregated *cp-2*, a floral deformity resembling crinkly petal. Although *rd* and *sd* each gave 3:1 segregation their joint segregation in F_2 was 2:1:1:0. Analysis of seed numbers per pod in these and unrelated families gave no evidence to suggest the presence of an inversion.

Altogether the segregations of some 56 pairs of seedling characters were analysed for linkage in 1971 progenies. Significant chi^2 values were calculated

for *gl-c–sd-1* (1%), *gl-c–c* (0.1%), *gl-y–a* (2%), *pg-y–sd-3* (1%), *gl-c–a* (1%) and *Hr-y–al*-3 (0.25%). These families are expected to show segregation of several floral genes when flowering occurs in 1972. (A. B. Wills, P. Smith).

BRUSSELS SPROUTS

Inbreeding and selection of superior glossy foliage lines was continued and hybrids between these and with certain normal foliage lines were produced by hand pollination. Similar hybrid combinations were grown in field observation plots to determine their range of type and quality, mildew susceptibility, and suitability for processing and machine harvesting. Extensive bird damage to emerging seedlings precluded their inclusion in a replicated trial, but the hybrids showed substantial agronomic improvement due to continued selection within the glossy parent lines.

The parent lines of Gleneagles were reselected for increased height. This material will also be used to select plants which are homozygous for incompatibility alleles, because the original selections were made before their S-allele constitution had been determined. The proportion of sibs in hybrid seed is however still at an acceptable level. (A. J. Redfern).

N.V.R.S./S.H.R.I. Co-operative project

Seed was produced from 50 crosses between 10 inbred lines developed by the S.H.R.I. and five lines developed by the N.V.R.S., who also made a series of crosses. The progenies will be grown during 1972 in similar trials at both centres. (J. R. T. Hodgkin).

CABBAGE

The low seed production of the savoyed inbred parent line of Celtic Cross cabbage was investigated. It was found not to be due to low self-fertility, since similar seed yields were obtained from selfing and from outcrossing, so improvement will be sought by reselecting within the line. (A. J. Redfern).

RASPBERRY

Bad weather during the summer months made the assessment of fruit qualities in breeding material more than usually difficult. Suitability for machine harvest was again the main criterion for selection, and promising material has been propagated for further observation prior to it being considered for inclusion in the National Fruit Trials. In a trial of earlier selections a high incidence of cane disease, caused apparently by *Fusarium avenaceum* (see Mycology report), rendered yield data meaningless. Material in this trial varied in susceptibility, however, and one selection showed considerable resistance. Control of the disease by breeding is therefore a possibility.

Additional selections apparently resistant to the beetle *Byturus tomentosus* were obtained in a family obtained by selfing second-backcross material

derived from *Rubus phoenicolasius*. The presence of resistance was judged by refusal of beetles to feed normally when caged on small plants, and confirmation will be sought in further tests in which they will be caged on flower buds and open flowers. However, the resistance level of this generation is probably inferior to that of *R. phoenicolasius* itself, and so the resistant selections are being crossed with F_1 hybrids of the cross to concentrate resistance genes.

Hardiness

Studies were continued to obtain more information on the importance of early cane dormancy and low water content for determining hardiness. It was found that canes of several very hardy selections ceased to grow in early August and entered their rest period in early September, whereas canes of selections of only average hardiness continued growth until late August and entered their rest period correspondingly later. Certain selections which are prone to winter injury continued to grow throughout September and did not enter their rest period until November. Early entry into rest period was usually but not always associated with a rapid reduction in water content by early November, when the first frosts usually occur. The results suggest that physiological changes which occur before early August considerably influence cane hardiness, and that measurement of cane growth which occurs after this time may aid the recognition of hardy segregates. This idea is now being tested. It was also found that the timing of these changes was influenced by the age of the plants and by premature defoliation in early September.

(D. L. Jennings, B. M. M. Tulloch, E. Carmichael).

STRAWBERRY

It is expected that imports of early strawberries from southern Europe will increase and lead to greater emphasis being placed on late production in Britain, and also that once-over machine harvesters will be developed. Particular attention is therefore being given to selection for late-fruiting types and for types suitable for once-over harvest. One late-fruiting selection produced 66% of its crop between 15 July and 6 August, compared to only 20% for Cambridge Favourite. Yields from single and multiple harvests were compared in another trial on red core infected land, the once-over harvest being taken when the majority of secondary fruits were at least two-thirds ripe. This stage occurred 9 and 14 days after the commencement of conventional harvesting in Marmion and Cambridge Favourite respectively, and at this harvest Marmion yielded 78% of its crop (99 cwts/acre) and Cambridge Favourite 80% (73 cwts/acre).

The laboratory device developed to test for capacity to withstand transportation has proved an efficient means of screening selections. Four selections from one family withstood shaking significantly better than Cambridge Favourite, and one of the five submitted to the National Fruit

Trials also showed special merit in these tests with evidence of good resistance to bruising and to *Botrytis*.

In the experiment to study environmental effects on 400 seedlings in identical plantings at Auchincruive and Invergowrie, the Invergowrie plants attained a much larger size in 1971, in spite of their slower establishment. Truss numbers were higher than in 1970 but the Auchincruive mean of 0.9 trusses per crown was again about 30% higher than that of the Invergowrie plants. Two progenies of 53Q13, a *Fragaria virginiana* derivative, produced the largest plants and the highest mean numbers of trusses per plant and per crown at both sites.

Disease resistance

Crown rot, caused by *Phytophthora cactorum*, is widespread in Europe and has been found in both field and glasshouse plants at Auchincruive. Thirty cultivars, including Marmion, Merton Dawn, Montrose, Belrubi, Ostara, Repita and Tamella were found to be susceptible, and so were certain progenies derived from Talisman and Glasa. However, a controlled inoculation test revealed a degree of resistance in Cambridge Favourite and Templar.

Progeny tests showed that the kind of field resistance shown by 53Q13 to *Phytophthora fragariae*, where the red stele symptom is restricted to the root tips, is inherited with partial dominance. Even in the progeny of 53Q13 with Glasa, an extremely susceptible cultivar, the mean resistance was not significantly lower than that of 53Q13. A significant correlation was found between the mean phenotypic scores of parents for resistance and estimates of their general combining ability for this character, indicating that additive gene effects are of major importance.

(H. J. Gooding, K. C. McConnell, P. R. Irons).

PUBLICATIONS

ANDERSON, M. M. (1972). Resistance to black currant leaf spot (*Pseudopeziza ribis*) in crosses between *Ribes dikuscha* and *R. nigrum*. *Euphytica* (in press).

(When progenies of the cross *Ribes dikuscha* × *R. nigrum* were exposed to field infection by *Pseudopeziza ribis* a proportion bore only restricted, non-sporulating lesions on their leaves and rarely showed premature defoliation. The segregation observed is explained if resistance is controlled by two complementary genes, Pr1 and Pr2, the *R. dikuscha* parent being heterozygous for both of them and some of the *R. nigrum* parents carrying one, also in the heterozygous state).

JENNINGS, D. L. (1971). Some genetic factors affecting the development of endocarp, endosperm and embryo in raspberries. *New Phytol.* **70**, 885–895.

(The sizes and shapes of different parts of pyrenes obtained from two diallel crosses of raspberry were influenced both by maternal effects and by interaction effects involving maternal and genetic factors. In one diallel, interactions with maternal factors were large but considerably reduced by applying auxin to the developing fruits. In the other, maternal effects were more important and maternal interaction effects less so. Application of auxin to the fruits reduced endosperm or embryo size in some crosses and increased it in others. It is postulated that these responses were related to the endogenous content of growth substances, negative responses indicating their presence in supra-optimal concentration, and that variations in the responses provide clues to the physiological factors which govern successful pyrene development).

JENNINGS, D. L. (1971). Some genetic factors affecting seedling emergence in raspberries. *New Phytol.* **70**, 1103–1110.

(The emergence of raspberry seedlings derived from two diallel crosses was studied. In one diallel, emergence was poor and the variations present were largely determined by maternal effects. In the other it was better and the largest variations were determined by inbreeding depression effects. In most cases maternal effects on emergence were negatively correlated with maternal effects on endosperm size, while inbreeding effects were associated with reductions in embryo size. It is concluded that the factors which determined seedling emergence would tend to maintain heterozygosity and should therefore be regarded as part of the breeding system).

JENNINGS, D. L. (1972). Aberrant segregation of a gene in the raspberry and its association with effects on seed development. *Heredity* **29**, 83–90.

(Causes of aberrant segregation of gene *S* in the raspberry were investigated in several series of crosses. Pollen parents usually had more influence on segregation than seed parents, but the aberrant segregation was probably due to post-fertilization effects. There was a difference in the seedling emergence time of the alternative phenotypes and failure to emerge probably caused aberrant segregation in some crosses. Variation in seed dormancy was correlated with variation in endosperm size and there was evidence that gene *S* affected the latter. Aberrant ratios associated with the use of Burnetholm as pollen parent were due to other causes. They were improved by dilution of the pollen which probably reduced competition between pollen tubes of alternative genotype).

Mycology

R. A. FOX

During the past year there have been several changes in the staff; J. M. Duncan joined us in October to work on problems in red core and Georgina M. Laing was appointed to assist him in November; Marilyn Smith became Mrs Davidson in September and we were sorry when she left at the end of February 1972. Mrs Isobel Anderson, who joined the Institute in November 1963, left at the end of March and I am sure that our regret is shared by many junior members of staff throughout the Institute whom she helped when they first arrived.

In February E. Patricia Dashwood attended the Federation of British Plant Pathologists Symposium on 'Potato Diseases' and read a paper written jointly with me, entitled 'Potato Gangrene; some aspects of association with plants other than the potato,' and M. C. M. Pérombelon read a paper on 'Some lesser known factors involved in the rotting of potato stems and tubers.' In July I was invited to read a paper on 'Host-pathogen inter-relationships' in the Symposium on 'Plant Root Systems in Health and Disease,' organised by the Association of Applied Biologists for its Residential Meeting in Dundee. In September W. R. Jarvis and I attended the First International Mycological Congress at Exeter and presented papers entitled, respectively, 'Spore dispersal in *Botrytis cinerea*' and 'Potato Gangrene; infection of symptomless alternative hosts.' At a meeting of the Federation of British Plant Pathologists in November J. G. Harrison and I presented papers on, respectively, 'Hollow heart of peas, some causes and effects,' and '*Armillaria mellea* as problem of plantations in tropical rain forest lowlands.'

M. Pérombelon was invited to the Third International Conference on Plant Pathogenic Bacteria at Wageningen in April and read a paper on 'A quantitative method for assessing virulence of *Erwinia carotovora* var. *carotovora* and *E. carotovora* var. *atroseptica* and susceptibility to rotting of potato tuber tissue.' D. A. Perry attended the Sixteenth International Seed Testing Congress in Washington, D.C. from 7–12 June and presented a paper entitled 'Principles for the development of Seed Vigour Tests.' Following the Congress he visited centres of seed research at the U.S.D.A., Beltsville and at East Lansing, Michigan and Geneva, New York. In September I made a brief consultancy visit to the South East State of Nigeria. I was also invited by the American Phytopathological Society to be a member of a Panel of Consultant Scientists to advise on plant pathological problems arising from the military use of herbicides.

In November I attended a three-week course on Organisation and Staff Management at the Civil Service College, Sunningdale. W. R. Jarvis accepted an invitation to be an Editor for Horticultural Research for 1972 onwards.

Of particluar interest in the past year was the finding by W. R. Jarvis and A. J. Hargreaves of the association between *Fusarium avenaceum* and the now defined 'die-back' condition of raspberry bud death and lateral wilt. Common to much of our work are problems relating to the survival of soil-borne pathogens from which are evolving common interests in the effects of soil temperature and moisture stress on pathogenesis, factors which also have an important bearing on the seed establishment studies of D. A. Perry and J. G. Harrison. Another important link lies in the field of latency and symptom expression where the biochemical and physiological skills currently available to us may limit advances.

We have pleasure in acknowledging assistance in identifying fungi given by C. Booth and B. C. Sutton, Commonwealth Mycological Institute and R. Watling, Royal Botanic Garden, Edinburgh.

RED CORE OF STRAWBERRY

In examining factors influencing field resistance, roots of plants of different cultivars, as far as possible comparable in size and age, were inoculated with a standard zoospore suspension (5,000 zoospores/ml) and incubated at 16°C. Although there was variation between experiments, some cultivars (Cambridge Rival, Cambridge Vigour and Templar) and seedlings were significantly less susceptible in all experiments than Cambridge Favourite which was used as a standard; others, including Crusader, Marmion and Talisman, were significantly less susceptible in the majority of experiments but equally susceptible in others.

Varying the concentration of zoospores (200; 500; 1,000; 5,000; and 17,500 zoospores/ml) did not significantly affect the percentage number of diseased roots nor change the ranking order of a limited number of cultivars which had previously shown significant differences in susceptibility when inoculated with 5,000 zoospores/ml.

To examine seasonal fluctuations in the development of red core in infested soil, healthy runners of Merton Princess were planted on 15 April 1970 and samples lifted at 33-day intervals until 4 May 1971. For comparison, a second series of runners from the same stock was planted at intervals of 33 days from 15 April until 6 October; each batch of plants except the first was root-pruned and grown on in a glasshouse to induce newly formed main roots prior to planting. The series was continued from 10 November 1970 until 30 March 1971 by planting runners formed in the autumn of 1970. No infection occurred in either series in the first three samples lifted on 19 May, 23 June and 28 July. Thereafter plants of the first series showed increasing severity of disease with time and were always more severely affected than those which had been in the soil for only 33 days. The highest mean percentage number of diseased roots was 67 (after 349 days) in the first series and

22 (after 33 days) in the second. Fluctuations in the percentage number of diseased roots in the second series seemed to relate to rainfall alone and there was no indication that soil infectivity varied appreciably between 28 July 1970 and 4 May 1971. The relatively high percentage number of roots infected in the short periods of 33 days suggests that inoculum in the soil may be of equal importance to secondary infections.

To test the feasibility of detecting *Phytophthora fragariae* by baiting with a susceptible cultivar, an infested site of approximately 0.25 of an acre was sampled by soil auger. Random samples of 7, 10, 14 and 21 cores were combined and planted with healthy runners of Glasa. The plants were watered twice daily, kept in a glasshouse with a mean temperature of 21°C, and examined after 5 weeks. In one experiment the fungus was detected only in the 14 and 21 core samples, but in another experiment also in 7, 10 and 14 cores. Dilution of the soil samples with equal parts of autoclaved vermiculite did not decrease the sensitivity of the test but it improved the soil as a rooting medium. (I. G. Montgomerie, D. M. Kennedy).

An alternative technique of detecting *P. fragariae* in soil was developed in which excised roots of susceptible cultivars were placed in soil/water mixtures in petri dishes. Symptoms developed quickly and the red steles contained numerous oospores typical of the fungus.

Of the many media tested, isolates of *P. fragariae* produced oospores on French bean agar. However, only one isolate produced sufficient numbers of oospores for studies on their germination, longevity and infectivity. In attempts to develop selective media the fungus was tolerant of the antibiotics Vancomycin and Polymixin (anti-bacterial), Pimaricin and Nystatin (anti-fungal), and of the fungicide benomyl. (J. M. Duncan).

The cultivar Merton Princess was planted on 17 April 1970 in a well-drained infested site to compare raised rows (100 mm), ridges (300 mm) and two concentrations (1750 ppm and 1000 ppm) of Dexon applied at different times. In samples examined in April 1971, the lowest percentage number of diseased roots was from plots treated with Dexon (1750 ppm) applied as a drench at planting and from plants grown on ridges. Significant decreases in the disease were also obtained by Dexon (1000 ppm) applied as a drench either at planting or in August 1970. There were large but not significant differences between treatments in fruit yield in 1971.

(I. G. Montgomerie, D. M. Kennedy).

INTERNAL NECROSIS OF STRAWBERRY CROWNS

In eastern Scotland many plantations of Cambridge Favourite are affected by death of the crowns (see this Report p. 29) and the internal tissue, diffusely mottled brown pink, consistently yields *Fusarium avenaceum*. As in raspberry bud death and lateral wilt, this fungus is often associated with *Alternaria ? tenuis*, *Phoma* spp (particularly *P. exigua* var. *exigua* and *P. eupyrena*) and *Coniothyrium fuckelii*. *F. avenaceum* was also isolated from roots of affected plants. Inoculations have been made to overwintering plants for evaluation in the spring and attempts are being made to correlate the occurrence of this disease with factors of plantation management. *Coniothyrium fragariae* was also isolated from necrotic crown tissue and this is believed to be a new British Record. (W. R. Jarvis and A. J. Hargreaves).

STAMEN BLIGHT OF RASPBERRY

Increasing from 2 to 4 days the time that a film of water was maintained around axillary buds of Malling Jewel after inoculation, doubled the percentage number of diseased inflorescences. Inoculation of Malling Exploit, Malling Jewel, Glen Clova, Lloyd George, Malling Landmark, Malling M, Malling Promise, Norfolk Giant and Malling Enterprise resulted in 27, 25, 21, 18, 14, 9, 5, 5, and 5% diseased inflorescences respectively.

(I. G. Montgomerie).

RASPBERRY WILT AND BUD FAILURE

Lateral buds of raspberry killed by winter and spring frosts tend to open slightly. Those killed by fungi remain tightly closed and *Fusarium avenaceum* has been consistently isolated from them, and, less frequently, *Alternaria ? tenuis*, *Phoma* spp (especially *P. exigua* var. *exigua* and *P. eupyrena*) and *Coniothyrium fuckelii* but never *Didymella applaanata*, nor are such dead buds necessarily associated with spur blight lesions. Many laterals wilt suddenly at any time from emergence to full fruiting and again *F. avenaceum* and the other fungi, except *D. applanata*, were consistently associated with them. The symptoms accord well with vascular blocking because usually single canes from a stool, or the laterals on only one side of a cane wilt and, occasionally, only half-leaflets show typical inter-veinal necrosis. Sporodochia of *F. avenaceum* were frequent on affected canes, and macroconidia were found in rain-splash droplets. Mass root inoculation with macroconidia caused a rapid wilting of potted plants and potometer measurements indicated impeded water flow. Cell-free culture filtrates also induced wilting although the symptoms were somewhat different. Inoculations of buds, stems and roots have been made on overwintering plants for evaluation in the spring.

Both raspberry and strawberry isolates of *F. avenaceum* (characterised *inter alia* by lack of chlamydospores) readily formed what appeared to be survival structures when macroconidia and hyphae were allowed to dry on glass slides which were then buried in field soil. These structures, smaller and thinner-walled than chlamydospores in other species of *Fusarium*, have remained viable for six months when buried 50–100 mm in arable soil in the field. The autecology of *F. avenaceum* in raspberry plantations is being investigated together with the epidemiology of the disease complex.

(W. R. Jarvis and A. J. Hargreaves).

NARCISSUS SMOULDER

The addition to the water tank of dichlofluanid, formaldehyde and benomyl (all at 100 ppm) increased, whereas sodium metabisulphate (1%) and benomyl (250 ppm) considerably decreased flowering from narcissus bulbs (cv. Golden Harvest) when compared with a standard hot water treatment (44.4°C for 3 hr). All treatments, done in 1969, reduced flowering in 1970 compared with an unheated check, but fumigating bulbs with sulphur dioxide or dibromotetrachloroethane had no effect. In the second cropping year (1971), there were no significant differences in flowering or in bulb yield and in both years the incidence of smoulder (*Botryotinia narcissicola*) was very low and the treatments showed no significant differences in its control.

Roguing infected plots and flower removal (the flower stalk stumps being believed to be a route for bulb infection) had no effect on the incidence of the disease in bulbs planted in 1969 and harvested in 1972.

(W. R. Jarvis).

PHOTOTROPISM IN BOTRYTIS CINEREA

When cultures of *B. cinerea* were incubated in near-u.v. light to induce sporulation, the conidiophores were phototropic and they could be induced to change their direction of growth by turning the plates. As is the case with negative phototropism of germ tubes the effect was greatest at approx. 420 nm. It is interesting that in one organism near-uv.light induces both positive and negative phototropism with maxima at similar wave lengths.

(W. R. Jarvis).

PLANT ESTABLISHMENT STUDIES

Twelve lines of monogerm, pelleted seed of 4 commercial cultivars of sugar beet were sown on 15 March and 19 April to investigate the effect of high soil moisture on seed establishment. The first sowing received 1 in (25.4 mm) water on each of 6 days after sowing, and the second received a total of 5 in (127.0 mm) during the 4 days after sowing. A second factor of seed bed compaction was imposed immediately after the second sowing using a heavy roller. In the first sowing, high soil moisture reduced emergence from 65% to 40% and there was a significant interaction between seed lots and irrigation. In the second sowing irrigation alone reduced emergence from 70% to 63% and seed bed compaction had similar effects. Emergence in the compacted plots receiving water was 60% compared with 74% in the untreated plots showing that the treatments were additive in their effects.

Eight commercial samples of barley, Golden Promise, and of oats, Aster, were sown on seven occasions at weekly intervals commencing 24 March. Average laboratory germination of the barley samples was 95% and mean emergence over the seven sowings was 87%. Emergence was unaffected by soil temperature but was reduced when a period of moisture stress followed sowing on 8 April. Emergence of the oat seed was similar to barley.

To obtain information on the possible effects of poor establishment on barley yield the following seed rates were sown in a randomised block design within the farm barley crop:–140 (normal farm weight), 280, 70 and 35 lb/acre (157, 314, 78 and 39 kg/ha). Populations established were 384, 755, 205 and 104 plants/m^2 respectively, which were close to those expected from the sowing rate, and yields were 43.7, 42.4, 38.2 and 38.0 cwt/acre (5.49, 5.32, 4.80 and 4.77 tonnes/ha). A 50% reduction in plant population below that predicted by the normal sowing rate to 140 lb/acre (157 kg/ha) resulted in a yield depreciation of 12.6%. (D. A. Perry and J. G. Harrison).

HOLLOW HEART OF PEAS

In further experiments to determine the cause of hollow heart, a seed lot which ripened in the glasshouse, when ambient air temperatures up to 43.5°C were recorded, had temperatures within the pods up to 5.5°C higher than ambient. Sixty-five percent of the seeds were affected by hollow heart but 99% were viable; other seeds harvested later and earlier in the year when temperatures were lower were not as severly affected.

A growth and germination inhibitor associated with hollow heart affected tissue was shown to be heat labile and was lost on dialysis, while a weaker inhibitor found in normal cotyledon tissue was unaffected by heat.

(J. G. Harrison).

CAVITY SPOT OF CARROTS

Analyses of soil samples taken from a survey of cavity spot (referred to in the 1970 Annual Report) failed to reveal any associations between the levels of available soil K, Ca, Mg or the ratios between them and the incidence of the disorder.

Carrots were sown in field trials on 14 April, 4 and 26 May on a farm with a history of severe cavity spot outbreaks. The incidence of affected roots increased with successive harvests on 23 September, 10 November and 8 December from the first two sowing dates, but declined with the third sowing, possibly because of a different size distribution of roots on the harvest dates; there was no consistent differences in cavity spot between seed rates of 9 and 2 lb/acre (10.1 and 2.25 kg/ha).

A trial containing 11 stocks of Chantenay types and representatives of Berlikum, Amsterdam Forcing, Nantes, Autumn King, Imperator, Feonia and Danvers groups showed that no stocks were immune from the disorder. Differences between stocks were significant at the 5% level with Imperator, Feonia and Danvers cultivars showing least cavity spot. When these results were combined with those from two additional sites in England, the incidence of the disorder was found to be uniform throughout Chantenay stocks.

Cavity spot was found on roots grown in the glasshouse in pots containing soil taken from the site of the field experiments. Increasing the soil K level from 127 ppm to 434 ppm by adding K_2SO_4 increased the roots affected from 52% to 79% whereas the addition of equal volumes of peat reduced it to 20%. Applications of high levels of N, B, Mn, and Mg had no effect. Pots with waterlogged soil, due to impeded drainage, had more affected roots than freely-drained pots. (D. A. Perry and J. G. Harrison).

BACTERIAL SOFT ROT AND BLACKLEG OF POTATO

Erwinia carotovora was detected in the vascular ring of most tubers of Majestic harvested at fortnightly intervals from June to September 1970 from plants with blackleg symptoms, but not in tubers from healthy plants. When planted the following year the incidence of blackleg was 6% and 2% among plants grown from tubers from infected and healthy parents respectively, showing that vascular ring contamination was relatively unimportant. In contrast the importance of surface inoculum was demonstrated by abrading apparently healthy tubers in sand slurries containing varying numbers of cells of *Erwinia carotovora* var. *atroseptica*. Blackleg incidence in the crop was then related to the numbers of bacteria in the slurries.

The susceptibility of 9 cultivars was compared in an experiment by planting seed, surface inoculated with sand slurries, and making monthly counts of plants with blackleg. There were differences between cultivars in the rate of appearance of the disease and in the total number of affected plants. The inclusion of failure to emerge as evidence of infection gave similar totals for all the cultivars except for Majestic which showed the highest number of affected plants throughout the experiment.

Examination of groundkeepers again showed that most were contaminated by *E. carotovora* and that large numbers can survive through five years cropping with cereals. Moreover, there was little change in the numbers found when re-examining the same fields in two successive years. Particular care was taken to pick up all tubers from the 1971 commercial crop harvested with an elevator digger. Nevertheless, after the field had been harrowed, sample plots indicated that approx. 12,000 tubers/acre (30,000/ha) remained on the surface, mostly chats, with a further 38,000/acre (94,000/ha) in the first 200 mm of soil of which 20% were seed size or greater. Only those on the surface were killed by frost in November.

Previous experiments showed large discrepancies between the length of time for which *E. carotovora* survived when added to soil in the field and in the same soil kept in the laboratory at temperatures corresponding to the meteorological records for July and August at 100 mm and 200 mm depth in the soil. These discrepancies were resolved by using temperature cycles in the laboratory similar to those recorded continuously in drills in the potato field. Thus population numbers of *E. carotovora* var. *atroseptica* fell from 10^6/ml to an undetectable level within 10 days both in the field and in the same soil in the laboratory when subjected to daily temperature cycles with a maximum of 24°C for 4 hr and a minimum of 12°C for 8 hr.

A quantal assay was used to determine the susceptibility to rotting of fully turgid discs cut from tubers of Majestic, inoculated with *E. carotovora* var. *carotovora* and *E. carotovora* var. *atroseptica* and then incubated for 3 days at 100% r.h. Both organisms induced the same amount of rotting at 5°C and at 25°C. Under aerobic conditions the ED50 value corresponded to 10^7 cells per disc but under anaerobic conditions it fell to an indicated value of only one cell. At intermediate temperatures, however, tuber tissue was more susceptible to rotting under anaerobic than aerobic conditions and var. *carotovora* induced more rotting than var. *atroseptica*. When uninoculated whole tubers were incubated at 25°C and their surface kept wet by wrapping them in moist paper towels, extensive rotting occurred only under anaerobic conditions but there was little or no rotting when the surfaces were dry. In general, the greater the water deficit of tuber tissue the longer it took for the initiation of rots which became extensive only if the tissue was fully turgid.

Under anaerobic conditions other pectolytic bacteria were isolated from rotting tubers, namely, *Bacillus polymyxa* and *Clostridium* spp. which have also been found, although less frequently, in naturally rotting tubers.

(M. C. M. Pérombelon and R. Lowe).

GANGRENE OF POTATO

Tubers of Majestic were sampled at 10-day intervals from a field experiment, surface disinfected or not, given standard wounds and then stored at approx. 3°C. Some samples which had been disinfected developed more gangrene lesions than those which had not been so treated. The lesions presumably originated from infections sufficiently deep-seated to escape disinfection. Similar anomalies followed tuber fumigation with sulphur dioxide, which increased the amount of tuber blight, and heat treatment, which increased the incidence of gangrene. Such results might be explained by postulating that any form of disinfection may have destroyed at least part of the tuber-plane flora antagonistic to tuber pathogens but the latter observation still poses a problem since the temperature regimes used were lethal to the pathogen *Phoma exigua* var. *foveata* in culture.

Barley plants growing adjacent to or 1 m from 12 first generation potato groundkeepers were examined for the presence of *P. exigua* var. *foveata* by inserting surface sterilised roots and stem pieces into potato tubers. Two sites were negative; of the 10 remaining 5, 3 and 2 were positive 1 m from, adjacent to, and both 1 m from and adjacent to the groundkeepers, respectively, only one of which, however, yielded var. *foveata*. Similarly, only one of 24 fourth generation groundkeepers yielded var. *foveata* though *Phoma exigua* var. *exigua* was often obtained from them. Because infected plants usually have no symptoms, the efficiency of detecting the pathogen is low, being limited by the number of samples which can be plated or inserted into baits; moreover, var. *foveata* is readily overgrown by common contaminants.

When barley plants were grown in soils amended with different levels of var. *foveata* inoculum in the greenhouse the rate of recovery of the fungus

from roots decreased with time, while the soil population, as assessed with tuber baits, either remained steady or increased. If the fungus was largely limited to the outer cells of the roots, as suggested in preliminary experiments using labelled inoculum, and these died, then the fungus would probably be killed by the mercuric chloride or sodium hypochlorite solutions used for surface disinfection. In contrast, if the dead cells were sloughed off, or the roots decayed, the mycelium within them would maintain or increase the soil population as detected by baiting. The role of var. *foveata* as a non-pathogenic parasite in a wide range of potential alternative hosts cannot be satisfactorily evaluated until the techniques for quantifying soil populations are improved. Promising results have been obtained with Most Probable Number procedures using sand or sterilised soil rather than liquids for serially diluting soil samples, and potato tuber discs, variously treated with bacteriocides and fungicides, as baits.

Spores from pycnidia developing on stems can form a major part of the inoculum at harvest, and thus stem as well as tuber susceptibility should be of importance to the plant breeder. Most tests reported elsewhere concern tubers alone and further, they are usually done with massive inocula of standard laboratory media. Experiments in which the fungus was grown on a basic mineral salts medium containing glucose and asparagine in varying amounts to give a range of C:N ratios and using minute glass fibre inocula, showed that increasing the carbohydrate concentration decreased pathogenicity and that this loss, beyond a certain point, was not off-set by increasing the nitrogen level to decrease the C:N ratio. Pycnidial production usually decreased on complex media containing customary amounts, e.g. 2%, of readily available carbohydrate. Stem inoculation experiments confirmed that tuber susceptibility was not necessarily related to that of other plant parts. For example, whilst the tubers of Record are relatively resistant to gangrene their stems were among the most susceptible of the cultivars tested.

(R. A. Fox, E. Patricia Dashwood and H. M. Wilson).

PUBLICATIONS

FOX, R. A. and DASHWOOD, E. Patricia (1972). Potato gangrene: potential problems and harvest timing. *Scott. Agric.* **51**, 372–376.

(A popular account of the potential problems posed by alternative hosts of the gangrene fungus *Phoma exigua* var. *foveata* found among common crops and weed species and of the effects of harvesting practices on disease incidence).

HARGREAVES, A. J. and JARVIS, W. R. (1972). Raspberry bud death and lateral wilt. *Scott. Agric.* **51**, 384–387. (A popular account).

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JARVIS, W. R. (1972). Phototropism in *Botrytis cinerea*. *Trans. Brit. mycol. Soc.* **58**, 526–527.

(The conidiophores of *B. cinerea* are positively phototropic in near-u.v. light (ca 420 nm) while germ tubes in the same light are negatively phototropic).

JARVIS, W. R. and HARGREAVES, A. J. (1972). *Coniothyrium fragariae* on strawberry in Scotland. *Pl. Path.* **21**, 47.

(A brief record of the occurence of *C. Frageriae*, believed to be a new British record).

JARVIS, W. R. and HARGREAVES, A. J. (1972). Raspberry bud death and lateral wilt associated with *Fusarium avenaceum*. *Pl. Path.* **21**, 48.

(A brief and preliminary record of the etiology of the disease).

JARVIS, W. R. and HAWTHORNE, B. T. (1972)[1]. *Sclerotinia minor* on lettuce: progress of an epidemic. *Ann. appl. Biol.* **70**, 207–214.

(Analyses of disease progress curves of lettuce drop, caused by *Sclerotinia minor*, indicate that early-infected plants sometimes provide inocula for later secondary spread within the crop, there sometimes being evidence of plant-to-plant spread. It is suggested that primary infections are attributable to aerially dispersed ascospores, produced by apothecia from germinating sclerotia, which are soil-borne, and that secondary plant-to-plant spread is associated with mycelial inocula).

MONTGOMERIE, Isabel G. and KENNEDY, Diana M. (1972). Evaluation of three fungicides and one systemic insecticide for control of red core of strawberry. *Pl. Path.* **21**, 35–37.

(The prophylactic properties of Bayer 22555 (1000 ppm a.i.), benomyl (333 ppm and 1000 ppm a.i.), Fun 52.133 (160 ppm and 320 ppm a.i.), and the insecticide Du Pont 1410 (20 ppm and 80 ppm a.i.) were assessed in a pot experiment using pure culture inoculum of *Phytophthora fragariae*. Bayer 22555 applied either as a drench or as a dust resulted in a significant decrease in the percentages of infected roots. The effects with and differences between the other chemicals were not significant).

MONTGOMERIE, Isabel G. and KENNEDY, Diana M. (1972). Race and pathogenicity of *Phytophthora fragariae* from a red core outbreak in Hampshire. *Pl. Path.* **21**, 38–40.

(Twenty-three pure culture isolates of *Phytophthora fragariae* were obtained from cultivars Cambridge Favourite, Cambridge Rival, Gorella and Redgauntlet which had become infected at one site in Hampshire. All were race B66–11. When four isolates were compared, there was no evidence that they had been selected for pathogenicity towards their source cultivar).

PÉROMBELON, M. C. M. (1971). A quantal method for determining population number of *Erwinia carotovora* var. *carotovora* and *E. carotovora* var. *atroseptica* in soils and plant material. *J. appl. Bact.* **34**, 793–798.

(A quantal method, based on the maximum likelihood method, was found especially suitable for estimating low population densities of *E. carotovora* in soils and plant material. Replicated defined areas of a solid semi-selective medium with a pectate overlayer are inoculated dropwise from serial dilutions of the test material. The presence or absence of 1 or more of the characteristic deep cavities formed by *E. carotovora* colonies in the pectate layer is the basis of the quantal count from which population estimates can be derived).

PÉROMBELON, M. C. M. (1972). A quantitative method for assessing virulence of *Erwinia carotovora* var. *carotovora* var. *atroseptica* and susceptibility to rotting of potato tuber tissue. *Proc. Third Int. Conf. Pl. Path. Bact., Wageningen*, 1971, pp. 209–303. PUDOC, Wageningen, 368p.

(A quantal assay is described which enables the quantifying of both virulence of *E. carotovora* on potato tuber tissue and susceptibility to rotting of the latter under

[1]The second author is a staff member of the D.S.I.R., Auckland, New Zealand, where the work reported in this paper was done.

various environmental conditions imposed before and after inoculation. Thin tuber tissue discs are inoculated with serial dilutions of the test organism. The subsequent soft rotting or not of the discs at each dose level is the basis of the quantal counts which after transformation into probits, allow the determination of the ED 50 from a dose-response curve).

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Virology

B. D. HARRISON

Colin Cadman's death deprived us not only of our Director but also of a generous and imaginative friend and colleague, who headed the Virology Section from its establishment until 1965. This is no place to describe his contribution to science and to horticulture but perhaps simply to mention some of the qualities that enabled him to set such a fine example as a research worker and colleague–dedication, persistence in unravelling difficult problems, delight in discovery, interest in the wider implications of research, and unselfishness.

Among the scientific staff, Aileen A. Crockatt left and H. Barker was appointed. Of the assistant staff D. Donald left, Agnes Lowson transferred from the Crops Research Section to the Virology Section and Jean Seal was appointed. Two visiting workers arrived, S. El Nagar from the United Arab Republic and T. Yamamoto, whose stay was unexpectedly cut short, from Japan. J. I. Cooper was awarded the degree of Doctor of Philosophy of the University of St. Andrews.

In June, B. D. Harrison and A. F. Murant participated in the international Congress of Virology at Budapest, and J. I. Cooper read a paper at the Wageningen meeting of the European Association for Potato Research.

This year further progress was made in the characterization of raspberry viruses, and the control methods developed for two soil-borne potato viruses are nearing the point at which we think they can be justified economically. Research on multicomponent viruses has continued, with increasing emphasis on the genetic control of their biological properties.

Our laboratory work was aided by the purchase of an automatic liquid scintillation counter and a recording spectrophotometer.

MULTICOMPONENT VIRUSES

Separation of components of tobacco rattle virus

Centrifugation in reverse concentration gradients of polyethylene glycol was assessed as a method for separation of the two nucleoprotein components of tobacco rattle virus. Electron microscopy indicated that the fractions were of high purity, but infectivity tests showed that the short particle fraction contained more long particles than did preparations of short particles obtained by conventional sucrose density-gradient centrifugation.

(D. J. Robinson).

Tobacco rattle virus protein

The size of the polypeptide contained in particles of tobacco rattle virus changed during storage of virus preparations, as a result of microbial action. Fresh preparations of strains CAM and PRN had similar size proteins of 28,500 daltons whereas in aged preparations the size was 24,000 daltons. Fresh preparations of other isolates of tobacco rattle virus also had a protein of about 28,000 daltons but the protein of isolates of pea early-browning virus was about 24,000 daltons. With strain CAM the change in protein size during storage appears to result from a few polypeptide cleavages and can be imitated in part using papain, although trypsin and chymotrypsin had no effect. Treatment of strain CAM with papain or papain plus 2-mercaptoethanol did not, however, diminish the specific infectivity of preparations. Moreover, storage conditions which converted the protein of CAM into the lower molecular weight form did not affect the sedimentation coefficients of long or short particles, the total particle width or core diameter, buoyant density in caesium chloride, or the susceptibility of infectivity to ribonuclease or heat inactivation. Evidently the structure of the intact virus particle does not require an intact polypeptide subunit, and the subunit is functional when broken into at least two parts. Some of the variation in protein molecular weight estimates for tobacco rattle virus may be caused by the use of virus preparations in which polypeptide cleavage has occurred.

(M. A. Mayo, J. I. Cooper).

No free N-terminal amino acid residue was detected in the protein of strain CAM by the fluorodinitrobenzene technique. This was true both of the 28,000 daltons protein of fresh virus and of the 24,000 daltons protein of virus after storage. This suggests that the N-terminal portion of the protein is not removed by the polypeptide cleavage that occurs on storage.

(D. J. Robinson).

Behaviour of the defective form of tobacco rattle virus

Unlike strain CAM, the previously described defective isolate CAM/DF produces large spreading, necrotic lesions on inoculated leaves of Xanthi-nc tobacco whereas White Burley tobacco reacts similarly to both. Also, CAM produced large discrete lesions in cotyledons of Lockie's Perfection cucumber, which are not infected by CAM/DF.

(D. J. Robinson, M. A. Mayo).

Isolate CAM/DF produced neither local lesions nor phenol-extractable infectivity in *Chenopodium amaranticolor* at 28°C. At 20°C many lesions and much infective material appeared; on transferring these plants to 28°C, the amount of phenol-extractable infectivity decreased rapidly. However, plants kept at 28°C for as long as 7 days after inoculation were still capable of producing a few lesions when transferred to 20°C. Ribonuclease activity in leaves of *C. amaranticolor* grown at 28°C was only 1.8 times that in plants

grown at 20°C, an increase which seems insufficient to account for the dramatic decline in concentration of infective RNA.

About ten times as much infectivity was obtained from CAM/DF-infected leaves by extraction with phenol as by extraction in pH 8 phosphate buffer containing bentonite (30 mg/ml). Bentonite+buffer did not give appreciably more infectivity than buffer alone; nor did addition of bentonite during phenol extraction result in any improvement. (D. J. Robinson).

Mutants of tobacco rattle virus

A start was made on the preparation of a series of temperature-sensitive mutants of tobacco rattle virus, in the belief that analysis of these will lead to an understanding of the functions required by the virus for successful infection of its hosts. Nitrous acid at pH 6 was chosen as mutagen. This reagent inactivates both purified virus (CAM strain) and its isolated nucleic acid with apparently first-order kinetics, although the rate of reaction with whole virus is about seven times as rapid as with RNA.

Single lesions were picked from *C. amaranticolor* inoculated with mutagen-treated virus plus enough untreated short virus particles to ensure that most lesions contained virus nucleoprotein. These isolates were tested for temperature-sensitive behaviour and, when this was observed, were cloned by two further single lesion isolations. Two mutants were obtained, code named N8 and N10. Both produce many local lesions on *C. amaranticolor* at 20°C, but very few at 30°C. N8 grows to high yield in *Nicotiana clevelandii* at 20°C, but only to about 3% of this at 30°C. N10 seems to grow normally at 30°C in *N. clevelandii*, but not in *C. amaranticolor*. No difference has been observed between either mutant and the wild-type virus in host range or symptoms on glasshouse grown plants, heat stability in sap or particle morphology.

Unsuccessful attempts were made to obtain mutants from virus grown in the presence of 5-fluorouracil. (D. J. Robinson).

RNA of raspberry ringspot virus

Purified preparations of the virus contain three components with different sedimentation coefficients: T(52*S*), M(92*S*) and B(130*S*). Of the two RNA-containing components, particles of M contain one RNA molecule of 1.4×10^6 daltons (RNA-1); some B particles contain one molecule of 2.4×10^6 daltons (RNA-2) and others contain RNA-1 molecules. That there are two molecules of RNA-1 in some B particles was indicated by the results of experiments in which virus preparations were irradiated with ultraviolet light. Irradiation apparently caused bonding between RNA molecules. Thus in polyacrylamide gel electrophoresis, RNA-1 from u.v.-irradiated B particles behaved predominantly as dimers, whereas the electrophoretic behaviour of RNA-1 from u.v.-irradiated M particles was unchanged. RNA extracted from virus preparations is single-stranded, and showed about 20% hyperchromicity in 0.1 M sodium phosphate at pH 7, indicating about 40% base pairing.

When T, M and B particles were separated, only B particles were infective, but infectivity was increased by adding excess M particles. When RNA obtained from purified virus was fractionated by density gradient centrifugation or by polyacrylamide gel electrophoresis, preparations of RNA-2 were infective but those of RNA-1 were not. RNA-1 from either M or B particles increased infectivity when added to RNA-2. This effect of RNA-1 was abolished by ultraviolet irradiation and was not mimicked by yeast RNA. These results suggest that both RNA-1 and RNA-2 carry genetic information.

Similar experiments indicate that tobacco ringspot virus has two functional species of RNA, with sizes close to those of raspberry ringspot virus.

(B. D. Harrison, M. A. Mayo, A. F. Murant, R. A. Goold, H. Barker).

Cherry leaf roll virus

Purified preparations of the golden elderberry strain of cherry leaf roll virus contain two isometric nucleoprotein components with sedimentation coefficients of 115*S* and 128*S*. The specific infectivity of these components was decreased when they were separated but was restored when they were remixed, indicating that both are needed for maximum infectivity. Polyacrylamide gel electrophoresis of the protein and nucleic acid of each component indicated that both contained a single polypeptide species, of about 54,000 daltons, but that the 128*S* component contained a RNA molecule of molecular weight 2.4×10^6 whereas the 115*S* component contained one of 2.1×10^6 daltons. (A. T. Jones, M. A. Mayo).

ELECTRON MICROSCOPY

Aphid heads

As a preliminary to studying the mechanism of virus transmission by aphids, by means of electron microscopy, the structure of the heads of virus-free *Myzus persicae* was examined. Many of the structures reported in work done by light microscopy were examined in greater detail. The salivary pump has a valve on its afferent duct but none was seen between the pump and the outlet to the salivary canal within the maxillary stylets. Unbranched flexuous rods about 200×23 nm were commonly found in the lumen of the salivary syringe, associated with the wall, but were not seen elsewhere. The tendon, which is attached to the food pump at the hypopharynx and acts as an anchor for the food pump dilator muscles, proved to be a complex structure. It has 10 to 13 approximately vertical branches which, like the main part of the tendon, each have a narrow central canal. This system of canals apparently connects with the lumen of the food pump. Some of the dilator muscles are anchored to each tendon branch. At the stylet tips, the food and salivary channels come together to form a common cavity for the last 2 to 3 μm of the maxillary stylets. (I. M. Roberts, A. Kinninmonth).

The salivary syringe of a few aphids carrying potato virus Y contained particles resembling those of the virus.

(B. D. Harrison, I. M. Roberts, A. Kinninmonth).

Tulip halo necrosis virus

The incidence of the disease associated with this virus in a field stock of the cultivar Andes grown on a local bulb farm showed no sign of diminishing over a period of 3 years. Also, whereas some of the diseased plants of this stock contained tobacco necrosis virus when tested in previous years, this virus was not detected in any of the fifty diseased plants tested during 1971. Another stock of Andes, imported from the Netherlands and grown in sterilized potting mixture, contained a few diseased plants from which isolates of a virus similar to, but even more unstable than, tulip halo necrosis virus were obtained. These isolates behaved like tulip halo necrosis virus in experimental hosts but the tulips from which they were obtained showed pale green or necrotic rings on the leaves. Attempts failed to transmit tulip halo necrosis virus by inoculation of sap to plants of Andes, Apeldoorn and Princess Beatrix.

Further attempts to purify the virus met with limited success. Two agents, 0.05M 2,3 -dimercapto-1-propanol and 2% thioglycerol, were found to stabilize infectivity in sap extracts but neither was better than either 0.01 M dithiothreitol or 0.2M 2-mercaptoethanol, and 2% thioglycerol was toxic to *Chenopodium quinoa* assay plants. The most effective stabilizing agents were those which produced the lowest redox potentials in sap extracts. When extracts containing a stabilizing agent were kept at room temperature, infectivity first increased and then decreased. These changes were not necessarily accompanied by changes either in redox potential or in pH of the extracts.

When sap was shaken with water-saturated trichlorotrifluoroethane the aqueous phase was more infective than preparations of other kinds. After ultracentrifugation followed by rate centrifugation in sucrose density gradients, infectivity was found to sediment slightly faster than that of tomato bushy stunt virus. This suggests the virus is not a free nucleic acid, but the particles of the virus were not identified by electron microscopy.

(W. P. Mowat).

Tomato bushy stunt virus

The tulip and the type isolates of the virus produced identical effects in the tulip cultivars Princess Beatrix, Korneforos and Apeldoorn. The leaf symptoms produced were indistinguishable from those caused by tobacco necrosis virus but the symptoms in petals differed according to the causal virus.

Attempts to transmit viruses to tulip usually give at best a low percentage of infection. However, some improvement seems to result from the use of a coarser grade of abrasive than is normally used to assist infection. Thus with Apeldoorn, of 38 plants inoculated with one or other strains of tomato bushy stunt virus and 19 inoculated with tobacco necrosis virus the respective numbers of plants which became infected were 7 and 3 using 300-mesh and 2 and 0 using 600-mesh Carborundum. (W. P. Mowat).

Meristem-tip culture

Twenty-five plantlets derived from meristem tips of Double White narcissus are now in their fourth growth cycle since transfer from culture tubes to pots. Of the 19 tested, 11 seem to be free from sap-transmissible viruses. Preliminary trials of a rapid method of propagation are underway, with the aim of finding a reliable technique before the first of the virus-free bulbs are large enough for further multiplication.

Of 64 plantlets of bulbous iris produced from meristem tips and potted, 12 were large enough to test for viruses by inoculation of sap to indicator plants and examination of plantlet extracts in the electron microscope. Two plantlets, one of Wedgewood and one of Van Vliet seem to be virus-free.

(J. Chambers).

RASPBERRY VIRUSES AND DISORDERS

A new strain of raspberry bushy dwarf virus

A virus from *Rubus* that occurs in low concentration in plants and is transmissible with difficulty by inoculation of sap is code-named 611V. It is serologically related to, but distinguishable from, the type culture of raspberry bushy dwarf virus. The virus was transmitted to *Chenopodium quinoa* test plants from three of six *Rubus occidentalis* plants previously grafted with tissue from Glen Clova raspberry but not from control *R. occidentalis* plants, and has never been found in this species in other experiments. Repeated attempts to transmit 611V directly from the Glen Clova raspberry plants failed. However, tissue from these plants, as well as from *R. occidentalis* and *C. quinoa* plants containing 611V, all induced leaf mottling and death of shoot tips when grafted to *Rubus henryi*. Thus the virus probably occurs in Glen Clova raspberry but the possibility that it is seed-borne in *R. occidentalis* cannot be excluded. Like raspberry bushy dwarf virus, it can infect symptomlessly several species in the families Solanaceae, Amaranthaceae and Compositae and it caused symptoms in some species of *Chenopodium* and *Vigna*. 611V is more difficult to transmit than the type culture of raspberry bushy dwarf virus and it has a dilution end-point in *C. quinoa* sap between 10^{-1} and 10^{-2}.

(A. T. Jones, A. F. Murant).

Spread of raspberry viruses

Present information suggests that the spread of an aphid-borne mosaic disease in Glen Clova raspberry is relatively slow in the East of Scotland (fewer than 1% new infections per year). However, graft transmission tests to Glen Clova indicator plants showed that almost 100% of Malling Jewel plants contain the virus after three years in the field, although they show no symptoms of infection. Factors that may affect the rate of spread of the virus in these two cultivars are being studied.

A field experiment was begun in 1971 to discover how well raspberry plants resistant to the aphid *Amphorophora rubi* also resist infection with aphid-borne viruses. Two virus-free *A. rubi*-resistant raspberry selections, Malling Orion and 888/49, and four aphid-susceptible cultivars, Norfolk Giant, Glen Clova, Malling Jewel and Lloyd George, were planted in the presence and absence of Malling Jewel infector plants. Preliminary results indicate that the cultivars can be ranked for aphid susceptibility in the order given above, with Malling Orion and 888/49, as expected, highly resistant and Lloyd George the most susceptible. However, later in the season the lower leaves of the two *A. rubi*-resistant selections were colonized by *Aphis idaei*. First results from virus-testing show that the numbers of plants infected with viruses graft-transmissible to *Rubus henryi* reflect the degree of infestation by *A. rubi*.

(A. T. Jones, A. F. Murant).

Crumbly fruit disorder in Norfolk Giant raspberry

A crumbly fruit condition was reported in 1970 in a high proportion of plants of some stocks of Norfolk Giant raspberry derived from virus-tested material released by the Institute. Apart from the fruit abnormality the plants were virus-free and seemed in other respects true to type. In spring 1971, examination of the eight virus-free foundation stock plants of Norfolk Giant held at the Institute showed that six plants produced normal fruit when selfed but two produced severely crumbly fruits because of inadequate drupelet set. Although 25% of the pollen grains produced by affected plants were abortive, sufficient normal grains were produced to ensure adequate pollination, so that some other factor(s), possibly abortion of ovules, must be involved. No virus transmissible mechanically or by grafting was detected in affected plants and the condition is thought to arise by mutation in vegetative tissues. Observations on virus-tested stool canes of other cultivars showed that no stock had more than 3% of crumbly-fruited plants but most contained a small proportion. Thus with any cultivar there is a risk that a crumbly-fruited mutant may be inadvertently selected when the mother plants are divided in the normal course of propagation. A routine test of the fruiting characteristics of progeny from each mother plant has therefore been introduced. This, although time-consuming and costly, should ensure the withdrawal of any affected stocks before they leave the Institute.

(A. F. Murant, J. Chambers, with D. L. Jennings, Plant Breeding, and J. Cantwell, Glasshouse).

POTATO VIRUSES

Reactions of new potato selections

In collaborative field trials with T. W. Davidson, Scottish Plant Breeding Station, Pentlandfield, 215 advanced selections were tested for susceptibility to tobacco rattle virus at one site and to potato mop-top virus at three other sites.

(J. I. Cooper).

Tobacco rattle virus

Further evidence was obtained of the importance of soil water in the transmission of TRV by *Trichodorus* nematodes. Pentland Dell plants were grown in boxes of virus-infested soil kept (a) wet (6–10 cm Hg) for 90 days; (b) dry (20–30 cm Hg) for 90 days; (c) wet for 42 days then dry; and (d) dry for 42 days then wet. The incidences of tuber spraing caused by TRV were 17, 0, 4 and 4% respectively. The tubers became infected with TRV only when the soil was wet, infection occurring in both first and second halves of the cropping period. The treatments did not greatly affect the numbers of *Trichodorus* but the incidence of spraing was inversely related to that of common scab.

Observations were continued on plots treated with D-D nematicide at 100 or 200 lb/acre (112 or 224 kg/ha) in either spring or autumn before planting potatoes. In the second year after treating a sandy soil, plots that had received D-D at 200 lb/acre in autumn yielded the least spraing, about 1% of the amount in control plots. However, by the time the crop was harvested, the numbers of *Trichodorus* in the treated plots had reached 10% of the numbers in control ones. Because the effects of nematicides persist for only a limited period, it may be best to aim at control in only the first year after treatment. In these circumstances systemic nematicides, such as methomyl, have advantages. Methomyl gives reasonable control of spraing, is easy to apply and gives some control of potato aphids.

(J. I. Cooper, B. D. Harrison).

Potato mop-top virus

The tubers of 39 Arran Pilot stocks of grades 'A' and 'F.S.' grown in 1971 were examined for symptoms of primary infection with PMTV. Seventeen stocks were free of symptoms but 7 contained more than 10% of affected tubers. In large tubers, the symptoms occurred less frequently at the heel end than in smaller ones. This suggests that the tuber tissue is less readily infected as it ages, an effect similar to that found by others in work on the potato common scab organism. Subjecting spraing-affected Arran Pilot tubers to a cycle of high and low temperature to induce an additional arc of spraing caused by PMTV did not alter the proportion (52%) that produced plants with haulm symptoms, as compared with tubers stored at constant low temperature throughout. PMTV was transmitted from Arran Pilot to Arran Pilot but not to Pentland Dell by core grafting of tubers.

Applying zinc sulphate to increase the zinc content of PMTV-infested soil from 2 to 270 ppm decreased the spraing incidence in the subsequent potato crop from 28% to 8%. Applying zinc frit to increase the soil zinc to 340 ppm and the soil boron from 2 to 58 ppm decreased spraing to 11%. But although the main effect of zinc frit is therefore attributable to its zinc content, boron may have some activity. Applying borax to increase soil boron from 3 to 65 ppm decreased spraing from 33% to 21%. At these levels boron is very phytotoxic whereas zinc is not. On virus-free land, 100 ppm zinc decreased

the weight of tubers produced by 11% whereas 18 ppm of boron decreased it by 52%.

In pot experiments with PMTV-infested soil, a heavy application of benomyl (2g per kg soil) decreased spraing from 13% to 0% but half this amount had no effect. In a field experiment, applying benomyl (7 lb/acre) to the potato drills before planting had no effect on spraing incidence (37%).

PMTV, purified from inoculated leaves of Xanthi-nc tobacco by extraction in 0.5M borate buffer (pH 9) followed by two cycles of differential centrifugation, was applied to sucrose density gradients containing 0.1–0.5% Fenopon T73. Infectivity mostly sedimented at more than 300*S* but some sedimented between 150 and 300*S*. The virus particles were of two predominant lengths. Of 414 particles measured from electron micrographs, 217 were 100 to 150 nm long and 46 were from 225 to 275 nm. Although at least some of the longer particles may be dimers of the shorter ones, infectivity seemed to be associated with the longer particles. Virus preparations reacted with an antiserum to soil-borne wheat mosaic virus.

A virus isolate obtained from Peruvian tubers of the cultivar Renacimiento through the co-operation of E. R. French, Lima, Peru and E. L. Calvert, Belfast, was identified as PMTV. It produced typical symptoms in test plants and these contained particles indistinguishable by electron microscopy from those of PMTV. We think that PMTV probably came from South or Central America to Europe with the potato. (J. I. Cooper, B. D. Harrison).

VIRUSES OF UMBELLIFEROUS PLANTS

The aphid *Cavariella aegopodii* transmits parsnip yellow fleck virus and its helper, anthriscus yellows virus, sporadically or not at all during the winter months. The transmission rate is improved by illuminating the source and test plants but no condition has yet been found in which the complex is transmitted as efficiently and reliably as in the summer. Sometimes only one virus of the complex is acquired and transmitted to test plants from *Anthriscus sylvestris* source plants that contain both. Anthriscus yellows virus was acquired in less than 3 hr and inoculated in 2 min feeding on chervil (*Anthriscus cerefolium*). It did not infect any of the non-umbelliferous plants tested. In addition to previously recorded hosts, *Scandix pecten-veneris* was found to be susceptible to both anthriscus yellows and parsnip yellow fleck viruses. (S. El Nagar, A. F. Murant).

Of several viruses transmitted by aphids (*Cavariella pastinacae* and *C. theobaldi*) from wild *Heracleum sphondylium*, one code-named HV2 infects several species of umbelliferous and non-umbelliferous plants. In *Chenopodium quinoa* sap it loses infectivity when diluted to 10^{-4} to 10^{-5}, stored for 3–4 days at 18°C or heated for 10 min at 45–50°C. It has very flexuous filamentous particles about 750 nm long, containing RNA. In negatively

stained preparations the particles, which show obvious striations, resemble those of beet yellows, apple chlorotic leafspot and apple stem grooving viruses. (A. F. Murant, R. A. Goold).

The multiplication of carrot mottle virus was studied in *Nicotiana clevelandii* plants kept in growth chambers at 17°C and illuminated (4000 lux) for 8 hr per day. Samples were collected at intervals from systemically infected leaves. Extracts containing virus were made in phosphate buffer, pH 7; extracts containing infective virus RNA were made by a phenol method. The infectivity of phosphate buffer extracts was greatest 9 days after the plants were inoculated, and then gradually declined. By contrast, the infectivity of phenol extracts peaked after 7 days and then rapidly declined; the infectivity of phenol extracts after 7 days was much greater than that of phosphate extracts after 9 days. In early stages of infection, the infective material therefore seems mostly to be sensitive to leaf ribonuclease; later it becomes ribonuclease-resistant and survives extraction in phosphate buffer, pH 7, but is more difficult to extract by the phenol method. In further experiments, ribonuclease-sensitive infectivity was extracted from leaves using tris-HCl buffer at pH values (8 or 9) at which leaf ribonuclease is largely inactive. As with phenol extracts, the proportion of this kind of infectivity, relative to that extractable in phosphate buffer of pH 7, peaked at 7 days and declined rapidly thereafter. (A. F. Murant, R. A. Goold).

Parsnip mosaic virus, a member of the potato virus Y group, infects several species in the family Umbelliferae and some in the Chenopodiaceae and Amaranthaceae. Another member of the potato virus Y group, celery mosaic virus, was once thought to infect only umbelliferous plants, but there are recent reports of strains, some distantly serologically related to the type strain, that infect *Chenopodium* species. This prompted a re-investigation of the possible relationship between celery mosaic and parsnip mosaic viruses. No relationship was detected, using antisera to celery mosaic virus kindly provided by J. F. Shepard, Bozeman, Montana and R. R. Frost, Manchester, or antisera to variants from parsley and poison hemlock kindly provided by R. N. Campbell, Davis, California.
(A. F. Murant, R. A. Goold).

MISCELLANEOUS VIRUSES

Broad bean wilt virus

In gel-diffusion serological tests, broad bean wilt virus, tropaeolum ringspot virus and the parsley virus 3 isolate of nasturtium ringspot virus were serologically indistinguishable when tested against antiserum to the parsley isolate kindly provided by J. A. Frowd, Wellesbourne. All three viruses should therefore be regarded as strains of broad bean wilt virus.
(A. F. Murant, R. A. Goold).

Elderberry latent virus

The virus from elder, previously code-named elderberry virus B, induced a symptomless infection when returned to virus-free elder and is now called elderberry latent virus. Further studies on this virus have shown that it contains about 22% single-stranded RNA of estimated molecular weight 1.6×10^6, and a single major protein species of 40,000 molecular weight. Although the two are serologically unrelated, the virus resembles tomato bushy stunt virus in these and other respects, but it has a smaller sedimentation coefficient. This discrepancy may reflect differences in arrangement of polypeptides in the particle. (M. A. Mayo, A. T. Jones).

Elm mottle virus

A virus consistently obtained from elm (*Ulmus glabra*), showing ringspot and mottling symptoms of the leaves, reacted with antiserum to elm mottle virus kindly supplied by K. Schmelzer, Aschersleben, German Democratic Republic. The virus was transmitted to a wide range of herbaceous species by inoculation of sap, but infected most symptomlessly. In *Chenopodium quinoa* sap the virus lost infectivity when diluted to 10^{-3} to 10^{-4}, heated 10 min at 55–60°C or stored for 2 weeks at 18°C. Partially purified preparations formed two incompletely separated light-scattering zones when centrifuged in sucrose density gradients, and infectivity was associated with these zones. They contained numerous quasi-spherical particles about 30 nm in diameter.
(A. T. Jones).

PUBLICATIONS

BARNETT, O. W. and MURANT, A. F. (1971). Differential hosts and some properties of raspberry bushy dwarf virus. *Annls Phytopath.* Numéro hors série, 129–139.

(Raspberry bushy dwarf virus (RBDV) and apple chlorotic leaf spot virus (CLSV) produce somewhat similar symptoms in some herbaceous test plants and have been reported to be serologically related. Apple stem grooving virus (ASGB) is not related to CLSV but has similar filamentous particles. RBDV was compared with CLSV and ASGV for host range and symptom production in 77 herbaceous plant species in 13 families.

RBDV infected 55 species in 12 families, most of them symptomlessly. *Chenopodium quinoa* was the best species for propagating the virus and *Phaseolus vulgaris* for local lesion assay. CLSV infected only 18 species in 7 families; although in many hosts it caused symptoms like those caused by RBDV, many differences were found. *Beta vulgaris* (sugar beet) became infected systemically with CLSV but only locally with RBDV, and *Nicotiana clevelandii* and *N. tabacum* cv. Xanthi-nc became infected (locally and systemically respectively) with RBDV, but not with CLSV. ASGV infected 37 spp in 9 families. Of several hosts not previously reported, few showed symptoms of infection. CLSV infected *Lagenaria siceraria* cv. Hundredweight systemically whereas ASGV infected only the inoculated leaves, and this plant was used to separate CLSV from ASGV.

RBDV also differs from CLSV and ASGV in having isometric particles about 33 nm in diameter. The three are serologically unrelated.

BROWN, F. and HARRISON, B. D. (1972). Bridging groups of viruses; virus affinity and host diversity. *Int. Virol. 2, 2nd int. Congr. Virol., Budapest, 1971*, 257–264.

(Summary of a symposium in which the possible affinities between viruses infecting bacteria, flowering plants, fungi, invertebrates and vertebrates were examined).

COOPER, J. I. (1971). Soil treatments for the control of potato mop-top virus and tobacco rattle virus (spraing) in potato. *Potato Research* **14**, 239.

(An abstract summarizing results of recent work at the Scottish Horticultural Research Institute).

COOPER, J. I. (1972). The behaviour of tobacco rattle virus in potato and some properties of the virus. PH.D. Thesis, University of St. Andrews.

COOPER, J. I. and THOMAS, P. R. (1971). Chemical treatment of soil to prevent transmission of tobacco rattle virus to potatoes by *Trichodorus* spp. *Ann. appl. Biol.* **69**, 23–34.

(Of the chemicals tested in field experiments at two sites on sandy soil in Scotland, D-D (dichloropropane-dichloropropene) applied before planting at 200 or 400 lb/acre (224 or 448 kg/ha) gave the best control of potato spraing disease caused by tobacco rattle virus (TRV); it almost eliminated the disease in the first year and greatly decreased the incidence in the second. Application in the autumn was more effective than in the spring.

Methomyl at 8 lb/acre (9 kg/ha) and dazomet at 150 lb/acre (168 kg/ha) greatly decreased the spread of TRV in the first year after treatment, but not in the second. These effects were closely related to the nematicidal effects of the chemicals on the nematode vectors (*Trichodorus* spp), except that methomyl controlled virus spread more effectively than it killed *Trichodorus*. When data from plots treated with methomyl are excluded, spraing incidence was more closely correlated with the numbers of *Trichodorus* found in May than in September. In general, the infectivity of soil, estimated by infection of cucumber bait seedlings with TRV in pot tests, paralleled the incidence of spraing, but bait cucumber roots were infected more readily than potato tubers.

Application of D-D at 200 lb/acre (224 kg/ha) is probably worthwhile economically when potato cultivars that are susceptible and sensitive to TRV are to be grown on land infested with the virus).

HARRISON, B. D. (1972). Some recent work on fungus-transmitted and nematode-transmitted viruses. *Proc. 6th Br. Insectic. Fungic. Conf.* Vol. 3, 751–757.

(A consideration of the methods of survival and spread of fungus- and nematode-transmitted viruses, especially in potato, and of their control by chemical treatment of soil).

HARRISON, B. D. and CROCKATT, A. A. (1971). Effects of cycloheximide on the accumulation of tobacco rattle virus in leaf discs of *Nicotiana clevelandii*. *J. gen. Virol.* **12**, 183–185.

(Actinomycin D, chloramphenicol and rifampicin had little or no effect but cycloheximide (10 mg/l) almost completely inhibited virus accumulation. Thus cytoplasmic but not chloroplast ribosomes seem implicated in virus replication. Inhibition occurred at both 20°C and 28°C, and at 20°C it occurred in discs kept in either light or dark. When added at different times after inoculation, cycloheximide inhibited further accumulation of virus, but already synthesized virus was not degraded. When added 5 hr after inoculation, cycloheximide did not inhibit the accumulation of virus RNA to the same extent as that of virus nucleoprotein. Neither accumulated when the inhibitor was added before inoculation. It is suggested that virus RNA replication depends on a protein that is synthesized on cytoplasmic ribosomes earlier in infection than is the virus coat protein).

HARRISON, B. D., FINCH, J. T.[1], GIBBS, A. J.[2], HOLLINGS, M.[3], SHEPHERD, R. J.[4], VALENTA, V.[5] and WETTER, C.[6] (1971). Sixteen groups of plant viruses. *Virology* **45**, 356–363.

(The type members and main characteristics of each group are listed. The extension of this system to other plant viruses is discussed, and it is recommended that only well studied viruses should be grouped. Names are proposed for twelve of the groups: bromovirus, carlavirus, caulimovirus, comovirus, cucumovirus, nepovirus, potexvirus, potyvirus, tobamovirus, tobravirus, tombusvirus and tymovirus. It is suggested that the value of these names should be tested by using them for an experimental period).

HARRISON, B. D. and JONES, R. A. C. (1971). Factors affecting the development of spraing in potato tubers infected with potato mop-top virus. *Ann. appl. Biol.* **68**, 281–289.

(A larger proportion of tubers of Arran Pilot potato growing at the surface of soil infested with potato mop-top virus (PMTV) showed spraing symptoms (brown rings) at harvest than tubers from below the surface. Infected tubers with or without spraing developed a spraing ring when stored in darkness, first for 1–2 wk at 18°C and then for 1–2 wk at any constant temperature between 5°C and 13°C. Only a faint surface ring developed when either of these periods was decreased to 1 day; 4-day periods were needed to induce distinct symptoms. Internal tuber symptoms developed more slowly than surface symptoms, and their formation was favoured by cutting the tubers in half. Additional pigmented surface rings were produced outside the first ring by successive cycles of treatment at 18°C and 9°C. Spraing did not develop when the first stage of treatment was at 22–25°C, when the tubers were kept first at 10°C and then at 5°C, when the treatment at 5–13°C preceded that at 18°C, or when the tubers were kept at constant temperatures ranging from 5°C to 25°C.

When tubers of six potato cultivars were grown in PMTV-infested soil and then stored at temperatures designed to induce symptoms, the cultivars known to be the most susceptible in the field were those which had the greatest tendency to develop spraing during storage. When infected tubers were exposed to light, typical spraing symptoms were not induced, but greening of the tuber surface was much delayed in localized ring-shaped areas, so that pale weals appeared.

Spraing symptoms were produced, in favourable conditions, by the reaction of cells at the periphery of the PMTV-invaded zone. Internal spraing did not prevent PMTV invading tissue outside the brown arcs; its rate of spread was about 10 μm/h at 14–18°C.

JONES, A. T. (1972). Purification and properties of elderberry latent virus, one of four sap-transmissible viruses obtained from American elder (*Sambucus canadensis* L.). *Ann. appl. Biol.* **70**, 49–58.

(Cherry leaf roll, tomato black ring and two previously unrecorded viruses were obtained from *S. canadensis* plants imported from the U.S.A. Of the two newly recognised viruses one, code-named elderberry virus A, has filamentous particles *ca.* 650 × 15 nm; the other, named elderberry latent virus (ELV), was transmitted to several herbaceous species but remained symptomless in elder and most other hosts. In *Chenopodium quinoa* sap ELV lost infectivity after dilution to 10^{-5} to 10^{-6}, 10 min at 85–90°C, or 7 days at 18°C. ELV was purified from *C. quinoa* leaf extracts that were clarified with chloroform, by precipitation at pH 5 and differential centrifugation.

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[6]University of the Saarland, Saarbrücken.

Purified preparations contained numerous isometric particles *ca.* 30 nm in diameter and a few particles *ca.* 17 nm in diameter. In 0.06 M phosphate buffer, ELV sedimented as a 112*S* (calculated for infinite dilution) major component and a 48*S* minor component. ELV showed no serological relationship to 27 other isometric plant viruses. Its present cryptogram is R/1:*/*:S/S:S/*.

JONES, A. T. and MURANT, A. F. (1971). Serological relationship between cherry leaf roll, elm mosaic and golden elderberry viruses. *Ann. appl. Biol.* **69**, 11–15.

(A virus obtained from plants of *Sambucus canadensis* imported from North America and another obtained from wild plants of *Sambucus nigra* growing in Perthshire, Scotland, were serologically identical to golden elderberry virus described from North America. They were serologically related to, but distinguishable from, cherry and rhubarb isolates of cherry leaf roll virus from Europe, and elm mosaic, another virus from North America).

MAYO, M. A., MURANT, A. F. and HARRISON, B. D. (1971). New evidence on the structure of nepoviruses. *J. gen. Virol.* **12**, 175–178.

(Using polyacrylamide gel electrophoresis in neutral sodium dodecyl sulphate, raspberry ringspot virus was found to contain a single protein species of molecular weight 54,000. The weight of protein in each particle was calculated from the RNA molecular weight and the percentage RNA in the particles, and separately using the Svedberg equation, to lie in the range $3.2–3.6 \times 10^6$ daltons. Each particle therefore contains 57 to 69 polypeptides, and it is concluded that the correct value is 60. Arabis mosaic and tobacco ringspot viruses gave similar results and it is suggested that the 60-polypeptide structure may be common to all nepoviruses).

MOWAT, W. P. (1971). A new disease of tulip resembling Augusta disease. First International Symposium on Flowerbulbs, Noordwijk/Lisse, 1970. *Acta Horticulturae* No. 23, Vol. II, 283–285.

(Tobacco necrosis virus could not be detected in many diseased tulip plants that showed leaf symptoms resembling Augusta disease. From some of these plants an agent was transmitted to other plant species by inoculation of sap. In *Chenopodium quinoa* Willd. local necrotic lesions developed within 7 days after inoculation. In *Nicotiana clevelandii* Gray, local lesions appeared in 7 and systemic symptoms in about 12 days. The disease associated with this pathogen in tulip was perpetuated in bulb sizes of up to 11 cm in circumference.

The pathogen survives treatment with di-ethyl ether and remains in the supernatant fluid after centrifugation at 9,000*g* for 8 minutes, and therefore is probably a virus. It could not be routinely maintained in a glasshouse under summer conditions and is highly unstable in plant extracts. The reducing agent 2-mercaptoethanol preserves most of the infectivity of sap for about 1 hour).

MOWAT, W. P. (1971). Stabilization, culture and some properties of tulip halo necrosis virus. *Ann. appl. Biol.* **69**, 147–155.

(Tulip halo necrosis virus, obtained from tulips with leaf necrosis, is very labile in crude sap but can be transmitted consistently by inoculating *Nicotiana clevelandii* plants with extracts made in pH 8 phosphate buffer containing a stabilizing agent such as 0.2 M 2-mercaptoethanol or 0.01 M dithiothreitol. Of the fifteen species in five families of Angiosperms infected by inoculation with sap, few are suitable as sources of inoculum. Cultures of the virus can be maintained in *Nicotiana clevelandii* kept at 14°C or 18°C but not at 21°C. Infectivity can be assayed in *Chenopodium quinoa*, in which necrotic local lesions are produced. Stabilized extracts of leaves were infective at a dilution of 1/16 but rarely at 1/32, and infectivity decreased disproportionately with dilution. Infectivity of all extracts was abolished in 10 min at 50°C and of some at 45°C, but survived when extracts were clarified using diethyl ether or trichlorotrifluoroethane. The virus was not transmitted by the aphid *Myzus persicae*).

MURANT, A. F. (1972). Parsnip mosaic virus. *C.M.I./A.A.B. Descriptions of Plant Viruses*, **No. 91**.

ROBERTSON, W. M. and ROBERTS, I. M. (1972). A simple device for the bulk staining and storage of ultrathin sections on grids. *J. Microscopy* **95**, 425–428.

(For summary see Zoology Section).

Zoology

C. E. TAYLOR

Dr T. J. W. Alphey was appointed in July to undertake research on the biology of *Trichodorus* nematodes. With a grant provided by the Natural Environment Research Council, and in conjunction with the Institute of Tree Biology, Edinburgh, Dr B. Boag was appointed in October to investigate nematode parasites of woodland and forest trees and is assisted by Miss Irene Niven, who joined the Section in November. Miss Isla Suttie was appointed to the NATO-financed Scientific Assistant post in February but stayed for only a short time and she was replaced in August by Miss Sheena Morton.

In February I attended a three-week course on Personnel Management at the Civil Service College, London. During the year I paid three visits to the Laboratorio di nematologia, Bari, Italy, as a member of its Scientific Council; in September I accompanied members of the laboratory on a short tour, financed by NATO, to inspect nematode problems in citrus plantations in Sicily and in peach orchards in northern Italy. In June, at the invitation of the International Agricultural Centre and the Agricultural University, Wageningen, I gave a series of lectures, with practical demonstrations, on nematode vectors of plant viruses to students of the 7th Post-graduate Nematology Course.

Electron microscopy was interrupted for several months towards the end of the year when the building housing the electron microscope was demolished to make way for new laboratories and the instrument was re-housed in a re-furbished laboratory within the present main building. There was also some disturbance for the rest of the Section in their removal to temporary accommodation in 'Portakabins.'

NEMATOLOGY

Biology

The NATO-financed survey of the distribution of *Longidorus* and *Xiphinema* nematodes in the United Kingdom (see last year's Report) was continued and a further 621 soil samples were examined for the presence of the nematodes and tested for virus infectivity. All samples containing large to moderate populations of any *Longidorus* or *Xiphinema* species were analysed for soil particle size and the pH assessed. The survey reveals the widespread distribution of *X. diversicaudatum* which most frequently occurs in soils with a

high clay or silt content and in association with grassland or deciduous woodland, although large populations were also found in arable soils with potatoes, cereals or turnips and in coniferous woodland. The most northerly records of *X. diversicaudatum* are from the Dundee area and frequency of occurrence increases towards the south of England. Other species of *Xiphinema* rarely occur in the U.K., but some populations of *X. coxi* and *X. vuittenezi* have been found as far north as Yorkshire.

Many *Longidorus* species are widespread and abundant, compared with their restricted distribution in continental Europe. *L. elongatus* is fairly common on the moderately light soils and in the drier eastern areas of the U.K., and is the most frequently occurring *Longidorus* species in Scotland where most populations are found in association with grassland. Grassland may also be the favoured habitat for *L. leptocephalus* although this species, together with *L. goodeyi*, is usually found in heavy soils. *L. caespiticola* occurred frequently in the soil samples from England but has only occasionally been found in Scotland, mainly in the Kelso area. *L. macrosoma* was found most frequently in clay soils and in deciduous woodland in southern England, although some large populations were found in association with raspberry and permanent pasture. *L. attenuatus* is also restricted in its distribution and has so far been found mainly in the sandy soils of East Anglia.

About 40% of the soil samples contained one or more species of *Xiphinema* or *Longidorus* with about 30% of them containing known virus vectors. However, only six samples proved to be virus infective and these with viruses transmitted by *X. diversicaudatum* which was found in 108 of the soil samples. On behalf of the East of Scotland College and the Scottish Nuclear Stock Association, 87 soil samples from 32 different localities in eastern Scotland were examined for the presence of *Longidorus* or *Xiphinema* nematodes and were tested for virus infectivity. All but 16 of the samples were infested; *L. elongatus* was present in 25 of them, *L. leptocephalus* in 16, *L. goodeyi* in 3, and *X. diversicaudatum* in 5. Tomato black ring virus was transmitted in only one sample, which contained a large population of *L. elongatus*, and the remainder were free from virus infection.

(C. E. Taylor).

Trichodorus nematodes are widespread in the lightest arable soils of eastern Scotland and many populations are associated with tobacco rattle virus. There is, however, some evidence to suggest that there is a close specific association between virus and vector, with each population of a particular *Trichodorus* species transmitting only its 'local' strain of virus. This apparent specificity of transmission is being examined in the laboratory by exposing several *Trichodorus* species to three morphologically distinct strains of tobacco rattle virus.

(T. J. W. Alphey).

Nematodes and trees

In conjunction with the Institute of Tree Biology and with a grant provided by the Natural Environment Research Council, a programme of research has

been started on the biology of plant parasitic nematodes associated with forest and woodland trees. A preliminary survey of deciduous and coniferous plantations in eastern Scotland has shown that *Helicotylenchus* and *Rotylenchus* are the most commonly occurring genera, with *Tylencholaimus*, *Paratylenchus*, *Criconemoides* and *Trichodorus* occurring frequently and often in large numbers. Population dynamics and pathogenicity of selected species are being examined on a range of coniferous and deciduous hosts. (B. Boag).

Chemical control

'Vydate' (Du Pont) (S-methyl 1-(dimethyl-carbamoyl)-N(methylcarbamoyl) oxy thioformimidate) is one of several systemic nematicide/insecticides that are already available to growers or under development. The mode of action is believed to be by interference with the cholinesterase system of the nematodes which prevents them from feeding on the plants' roots but does not necessarily kill them. In laboratory experiments it has been shown that if the nematicide is applied as a spray to the foliage of cucumber plants it is not only translocated to the roots but a nematicidal exudate is released into the soil. Although 'Vydate' is commercially available only as granules for direct application to the soil, the property of translocation and release of nematicidal root exudates ensures that nematicidal action is available where it is most needed and where the plant is most vulnerable to nematode attack, i.e. at the young roots.

In pot tests, 'Vydate' 9 lb a.i./acre (10 kg a.i./ha) was as effective as D-D 393 lb/acre (440 kg/ha), dazomet 232 lb/acre (260 kg/ha) or acrylonitrile 393 lb/acre (440 kg/ha) in killing *L. elongatus* and *X. diversicaudatum* and preventing the transmission of viruses to sugar beet bait plants and strawberry plants. Quintozene 78 lb/acre (88 kg/ha) completely prevented virus transmission but killed only 85% *X. diversicaudatum* or 95% *L. elongatus* compared with 96–100% control of both species obtained with the previously mentioned nematicides; methomyl had little effect on nematode numbers but virus transmission occurred in only 3 out of 15 pots containing *L. elongatus* and 2 out of 10 containing *X. diversicaudatum* compared with 100% infection in 10 control pots of each species.

In a field experiment 'Vydate' granules were broadcast at 9 lb a.i./acre (10 kg a.i./ha) in soil with a heavy infestation of potato cyst eelworm (*Heterodera rostochiensis*, approximately 200 larvae/g soil). Arran Pilot potatoes yielded five times more in treated than in untreated plots. In soil free from the eelworm, nematicidal treatment gave no increase in yield.

An area of land in which there was no known nematode problem was treated with 'Vydate' 11 lb a.i./acre (12 kg a.i./ha) or acrylonitrile 393 lb/acre (440 kg/ha injected at 40 cm spacing) or left untreated. The replicated plots were sown with lettuce, cabbage, turnip, radish, broad bean and French bean. Yields of radish were increased by the nematicidal treatments, but there were no significant differences in the growth and yields of the other crops although there was a suggestion of reduced germination of lettuce, cabbage and turnip in the 'Vydate' treatments. (C. E. Taylor).

Electron microscopy

An examination of species of *Longidorus* has shown that the feeding apparatus is similar in each, consisting of the cuticular stylet enclosed within a guiding sheath, a guiding ring formed at the base of the stoma wall, and an odontophore formed from the peripheral cuticularisation of the most anterior part of the oesophagus. Also in each species, the guiding sheath is surrounded by an amorphus liquid tissue which connects with lobes of similar tissue situated in the hypodermal chords near the guide ring. In *L. africanus*, *L. caespiticola* and *L. macrosoma*, three sets of radial muscles are present throughout the length of the oesophagus and these are associated with stylet retractor muscles which extend from the base of the odontophore, passing between the oesophagus and the nerve ring, to their attachment on the body wall in the region of the oesophageal bulb; this arrangement of muscles is also seen in *Xiphinema*. In *L. attenuatus*, *L. elongatus*, *L. goodeyi*, *L. leptocephalus* and *L. vineacola*, radial muscles are absent from the anterior oesophagus, except for about 15μ length near the junction with the odontophore. Except for *L. elongatus*, the stylet retractor muscles are short, passing from the odontophore outside the body wall just posterior to the nerve ring; in *L. elongatus* the muscles are absent. Furthermore, in these species a band of longitudinal muscle encircles the oesophagus about half-way along its length and posteriorly it divides into four segments which then attach to the body wall; they probably function by retracting the anterior oesophagus and forming the loop but are homologous with the stylet retractor muscles.

Paralongidorous maximus is similar to *Longidorus* in the general structure of the feeding apparatus, including the presence of the amorphous liquid tissue surrounding the guiding sheath, but has large, slit-like openings to the amphidial pouches as seen in *Xiphinema*. Radial muscles are present throughout the length of the anterior oesophagus but unlike the *L. africanus* group, stylet retractor muscles are not present and instead, the retractor muscles are arranged similarly to those in the *L. attenuatus* group. A further feature in *P. maximus* is the band of muscle which encircles the anterior oesophagus at its junction with the oesophageal bulb and which presumably acts as a sphincter; in *Longidorus* this has only been found in those species without radial oesophageal muscles. (C. E. Taylor, W. M. Robertson).

ENTOMOLOGY

Raspberry beetle

The peak of raspberry beetle (*Byturus tomentosus*) emergence from the soil is usually reached just before the first open-flower stage of Malling Jewel raspberry, and in some years they may be sufficiently numerous to damage the flower buds and warrant their control at this, or at an earlier stage. However, damage to the fruit presents an annual, although variable, problem which at the present time can be met only by a protective insecticidal spray. In 1970, trials with several organophosphorous insecticides as substitutes for

DDT showed that good control of larval infestations was obtained by applications of fenitrothion (Cyanamid 50% Accothion at 15 fl oz/acre) and azinphos-methyl (Bayer 22% Gusathion at 20 fl oz/acre) at first pink-fruit stage. In 1971, trials were undertaken to find if sprays applied before flowering could give sufficient kill of adult beetles to prevent larval infestation of the fruit. Fenitrothion and azinphos-methyl sprays applied to Malling Jewel at the white-bud stage resulted respectively in 80% and 63% control of larvae compared with unsprayed controls; this relatively low level of control was probably due to invasion of the sprayed areas at the open flower stage by adult beetles migrating from unsprayed areas or from neighbouring crops. Sprays at first pink-fruit stage gave 95% control with fenitrothion but only 63% with azinphos-methyl; only slight improvements in control were obtained when the insecticides were applied at both pre-flower and first pink-fruit stages. Fruit harvested seven days after insecticidal applications at the first pink-fruit stage were found to be without taint and without any effect on flavour when canned or frozen (tests by FVPRA, Chipping Camden) or when jammed (BFMIRA, Leatherhead). Insecticidal residues on the fruit were a mean of 1.0 ppm for azinphos-methyl and 0.37 ppm for fenitrothion.

In 1971 the first flowers of Malling Jewel opened at Invergowrie on 27 May and adult beetles remained on the crop, laying eggs in the flowers or on the young fruits, until mid-June. Egg hatch started some 15 days after the beginning of egg-laying and continued up to about the first pink-fruit stage in early July. The newly hatched larvae usually tunnel into the base of the fruit plug soon after emergence from the egg, and although they may later migrate to other fruits, once within the fruit the larvae are largely protected from insecticidal sprays. Ideally an insecticidal cover is required on the fruit for the whole of the egg hatch period, which in some years may extend over a longer period than observed in 1971. In eastern Scotland it seems likely that in most years more effective control of the larvae may be obtained by spraying slightly earlier than the first pink-fruit stage, which would also decrease the insecticidal residues on the harvested fruit. This is to be examined in 1972.

(C. E. Taylor, S. C. Gordon).

Eleven *Rubus* species were tested in the laboratory as potential sources of resistance to the raspberry beetle. *R. coreanus*, *R. cockburnianus*, *R. phoenicolasius* and *R. thibetanus* all exhibited resistance in the flower buds but the beetle fed to varying degrees on the young leaves. Tests were also undertaken with plants derived from *R. phoenicolasius* x raspberry crosses and lines with varying levels of resistance have been selected for further propagation.

(S. C. Gordon with D. L. Jennings, Plant Breeding Section).

Raspberry mite

Overwintering populations of the raspberry mite (*Eriophyes gracilis*) were found in 18 out of 31 raspberry plantations surveyed in Angus, Fife and Perthshire during January and February. The mean number of mites per bud

was few, except in sheltered areas of some plantations where up to 63 mites per bud were found.

Five plantations with high infestations of overwintering mites were selected for spray trials using dicofol, endosulfan, formothion, quinomethionate and tricyclohexyltin hydroxide applied early to mid-April, soon after bud burst, and then in mid-May. Examination of the plantations during May, before the second spray application, showed evidence of widespread mite infestation of the leaves in treated and untreated plots. At fruit harvest yellow blotching of the leaves was still quite obvious, particularly on the young, current season canes although these symptoms were less extensive on plots treated with endosulfan or formothion than on unsprayed plots or the other spray treatments. Weights of 1,000 fruits were similar from all treatments, compared with differences in yield of up to 18% between sprayed and unsprayed treatments in the 1970 trials. Possibly this is accounted for by the change from warm to cool weather at the green-fruit stage and continuing through the harvest, which prevented the build-up of mite infestations on the fruits. Thus widespread yellow blotching of the leaves, indicative of heavy infestations of mites, does not necessarily give rise to damaged fruit and loss of yield. The results do not, of course, show the gradual dwarfing of canes, the damaged buds and fewer fruits per cane which are associated with heavy mite infestations persisting over many years. (S. C. Gordon).

Aphids and viruses

Stylet-borne viruses are so-called because they are believed to be carried at the tips of aphids' stylets, but such a seemingly simple relationship has yet to be proved and demonstrated as an adequate explanation of the variety of results and viewpoints that have arisen from the many years of experimentation undertaken by numerous researchers. We have approached the problem by examining the characteristics of transmission of tobacco severe etch virus (TSEV) by *Myzus persicae*, by observations of the feeding behaviour of the aphid, and by searching for sites of virus transport in the aphid by electron microscopy.

M. persicae transmitted TSEV most efficiently when allowed short (10 second) probes on infected tobacco plants and on *Nicotiana tabacum* cv. Xanthi-nc test plants. The probability of virus acquisition and transmission decreased markedly with feeding probes of more than one minute. Similar rates of transmission were obtained with adults or larvae, but transmissions were obtained in 40% of 350 tests with single starved aphids compared with 19% when they were unstarved. Up to five successive transmissions were obtained with single aphids fed for 10 seconds on infector plants, but the chances of transmission decreased by about half with each serial transfer.

Unstarved aphids usually explored the leaf surface with the distal end of the labium before inserting the stylets. Starved aphids placed on a leaf usually inserted their stylets immediately, but leaf tapping increased before each successive probe. If the labium is used to locate the grooves between the cells it follows that starved aphids are more likely to insert their stylets

through a cell than are unstarved aphids, and that the frequency of transmissions will decrease in successive transfers from plant to plant.

Electron microscopy has been confined to a study of the stylets, the cibarium (food pump) and the salivary system, as the most likely areas for the retention of viruses that are acquired and transmitted in short probes. Rod-shaped particles of 20 nm diameter have been observed in the salivary pump and canal of aphids fed on virus-infected and on healthy plants. They may be plant protein acquired from the phloem or particles produced by the aphid itself, but are not likely to be associated with virus infectivity. From an examination of the structure of the junction where the maxillae interlock and sleeve over the salivary and food canals at the tip of the hypopharynx, it is considered unlikely that virus drawn into the food channel would pass to the salivary canal. Our studies support the often-stated theory that the non-persistent viruses are retained at the stylet tips but as yet, there is not sufficient evidence to state this categorically.

(C. E. Taylor, W. M. Robertson).

Potato aphids

Investigations on the population dynamics of *Myzus persicae* completed the third and final year of the International Biological Programme. As in previous years aphids were first found on potato plants of cultivar Kerr's Pink towards the end of June and a peak population of 350 per hill was reached by early August. In each of the three years of the investigations peak populations of *M. persicae* were reached at about 590 day-degrees C after the initial infestation. Also as found in previous years, predators and parasites killed only about 2% of the aphids and the rapid reduction in numbers after the peak was partly due to emigration of winged forms but mainly to natural mortality within the populations. (C. E. Taylor).

PUBLICATIONS

ALPHEY, T. J. W.[1] (1971). Studies on the aggregation behaviour of *Nippostrongylus brasiliensis*. *Parasitology* **63**, 109–117.

(Two behaviour patterns which could bring about clumping in *N. brasiliensis* sexual attraction and thigmokinesis, were investigated. A T-tube choice-chamber to facilitate an *in vitro* study of sexual attraction was described. A method for studying aggregation was also outlined. Male *N. brasiliensis* were shown to be attracted to female worms, positive sexual attraction. Both sexes were shown to exhibit strong thigmokinetic responses, and possible functions of such behaviour were discussed).

ALPHEY, T. J. W.[1] (1972). An *in vitro* study of the effect of oxygen tension upon the motility of *Nippostrongylus brasiliensis*. *Parasitology* **64**, 181–186.

(An activity cell apparatus to facilitate quantitative measurements of motility of small nematodes in saline was described. The effects of salines with a pO_2 either greater than 120 mm Hg or less than 12 mm Hg upon the motility of adult *N. brasiliensis* females was studied. The worms were found to require an oxygen tension greater than 12 mm Hg to be able to maintain their motility).

[1]Based on work done at the Zoology Department, University College, Cardiff.

BOAG, B.[1] (1972). The incidence of helminths in the wild rabbit, *Oryctolagus cuniculus* (L.) in north east England. *J. Helminthology* **46** (in press).

(Post-mortem worm counts revealed the presence of six helminth parasites. Two of these are normally sheep parasites and constitute a new record for rabbits).

BOAG, B.[1] and THOMAS, R. J.[2] (1971). Epidemiological studies on gastro-intestinal nematodes of sheep. I. Infection patterns on clean and autumn-contaminated pasture. *Res. vet. Sci.* **12**, 132–139.

(An understanding of the epidemiology of the parasites is shown to be the key to the formulation of effective control measures which integrate strategic anthelminthic programmes and pasture management).

BOAG, B.[1] and THOMAS, R. J.[2] (1972). Epidemiological studies on gastro-intestinal nematodes of sheep. III. Control of parasitism in lambs on clean pasture. *Res. vet. Sci.* 13 (in press).

(No larval parasites were found to overwinter on autumn-contaminated pastures. Contamination from the ewe in the spring was the main source of infection occurring in lambs in August and September).

ROBERTSON, W. M. and ROBERTS, I. M. (1972). A simple device for the bulk staining and storage of ultrathin sections on grids. *J. microsc.* **95**, 425–428.

(Instructions are given for the construction of a simple holder, made from Perspex, in which the grids for electron microscopy are held in slits formed in a plastic-coated wire spring. A bulk staining technique is described).

TAYLOR, C. E. (1972). Transmission of viruses by nematodes. In *Plant Virology*: Principles and Techniques (ed. C. I. Kado and H. O. Agrawal). New York: von Nostrand Reinhold Co. (in press).

THOMAS, R. J.[1] and BOAG, B.[2] (1971). Pasture management and parasitism in the the lamb crop. *Outlook on Agriculture* **6**, 232–235.

(Overwintering larvae produced two waves of infection in the lambs but neither of these resulted from contamination laid down by the ewes).

THOMAS, R. J.[2] and BOAG, B.[1] (1972). Epidemiological studies on gastro-intestinal nematodes of sheep. II. Infection patterns on clean and summer-contaminated pasture. *Res. vet. Sci.* **13**, 61–69.

(Eight different anthelminthic programmes based on epidemiological patterns were tried. A high level of control was obtained by either giving the ewes a single dose at lambing or by dosing the lambs at weaning and moving them to clean pasture, in place of the usually recommended doses at regular two to three-weekly intervals).

[1]Based on work done at the University of Newcastle.
[2]University of Newcastle.

Scottish Horticultural Research Institute Association

The Association was formed in August 1967, to promote interchange of information between the Institute and the horticultural industry; membership is on an individual or corporate basis. The Bulletin is published at indefinite intervals but usually there are two issues per year. The articles in the Bulletin are intended to communicate the results of experimental work, sometimes at an incomplete stage, between research workers and growers, and to present papers published at symposia organised for the Association.

The following articles have been published to date:–

Bulletin No. 1 (*August, 1968*)

The quality requirements of the fruit and vegetable processing industries *by* V. D. Arthey (FVPRA, Chipping Camden), pp. 3–13.

Controlling post-harvest grey mould in soft fruit *by* W. R. Jarvis, pp. 14–16.

Selecting a system for Brussels sprout production *by* P. D. Waister, pp. 17–19.

Making effective use of contact herbicides in vegetable crops *by* H. M. Lawson, pp. 20–23.

Bulletin No. 2 (*June, 1969*)

The expansion of vegetable and soft fruit growing for processing *by* C. H. Cadman, pp. 2–7.

Potato mop-top virus, and its effects on potatoes *by* R. A. C. Jones, pp. 8–13.

Spraing disease caused by tobacco rattle virus (TRV) *by* J. I. Cooper, pp. 14–20.

Gangrene of potato *by* R. A. Fox and E. P. Dashwood, pp. 21–24.

Bacterial soft rot of potatoes *by* M. Pérombelon, pp. 25–28.

Potatoes for canning *by* P. D. Waister, pp. 29–36.

Carrots for canning *by* R. Thompson, pp. 37–44.

Practical trials of non-tillage methods of raspberry growing on a field scale *by* George Bruce (Garlowbank, Kirriemuir), pp. 45–47.

Bulletin No. 3 (*May, 1970*)

New methods of planting raspberries *by* P. D. Waister and M. R. Cormack, pp. 2–4.

Results of vegetable variety trials at S.H.R.I. *by* H. Taylor, P. D. Waister and R. Thompson, pp. 5–21.

Bulletin No. 4 (*July, 1970*)

Papers presented at a meeting of the Association on 21 January, 1970, on 'Prospects for raspberry marketing.'

Some reflections on the current situation *by* J. L. Henderson (Wemyss, Forfar), pp. 1–2.

The outlook for raspberries in the frozen food trade *by* E. Pellew-Harvey (W. B. Pellew-Harvey & Co., Grantham), pp. 3–7.

Potential demand for, and qualities of, raspberries for jam manufacture *by* J. C. Dakin (BFMIRA, Leatherhead), pp. 8–13.

The aims and objectives of the British Agricultural Export Council *by* A. E. Wilkinson (BAEC, London), pp. 14–17.

Raspberry production in Europe *by* F. A. Roach (NAAS), pp. 18–28.

A businessman's views on raspberry marketing *by* C. S. Macphie (Macphie & Co. (Produce) Ltd., Glasgow), pp. 29–37.

Bulletin No. 5 (*April, 1971*)

Alternative insecticides to DDT for the control of the raspberry beetle *by* C. E. Taylor, pp. 2–6.

The development and marketing of pesticides *by* H. M. Lawson, pp. 7–11.

Mechanical raspberry harvesting in the United States and Canada *by* D. L. Jennings, pp. 12–14.

Raspberry mechanical harvester tests 1970 *by* P. D. Waister and H. M. Ramsay (NIAE, Scottish Station), pp. 15–16.

Highbush blueberries–a potential new crop for Scotland *by* M. R. Cormack, pp. 17–18.

Results of vegetable experiments in 1969 *by* R. Thompson and H. Taylor, pp. 19–25.

Bulletin No. 6 (June, 1972)

Papers presented at a symposium on 'The efficient use of herbicides' held by the Association on 21 October 1971.

Soil conditions and the efficiency of herbicides *by* D. S. C. Erskine (The Edinburgh School of Agriculture), pp. 2–6.

Spraying machinery and herbicide application *by* H. J. Nation (NIAE, Silsoe), pp. 7–15.

Weed seeds in the soil *by* H. A. Roberts (NVRS, Wellesbourne), pp. 16–19.

The control of couch grass *by* G. W. Cussans (WRO, Yarnton, Oxford), pp. 20–25.

Herbicide management *by* H. M. Lawson, pp. 26–30.

INSTITUTES FOR AGRICULTURAL RESEARCH IN GREAT BRITAIN

The research programmes of all the research Institutes supported from public funds are co-ordinated by the Agricultural Research Council. The following is a list of Institutes. Most of them publish reports annually and details can be obtained from the Secretaries of the Institutes concerned.

A.R.C. Institutes

Animal Breeding Research Organisation	King's Buildings, West Mains Road, Edinburgh EH9 3JQ
Food Research Institute	Colney Lane, Norwich, NOR 70F
Institute of Animal Physiology	Babraham, Cambridge, CB2 4AT
Institute for Research on Animal Diseases Letcombe Laboratory	Compton, Newbury, Berks. Letcombe Regis, Wantage, Berks.
Meat Research Institute	Langford, Bristol, BS18 7DY
Poultry Research Centre	King's Buildings, West Mains Road, Edinburgh EH9 3JS
Weed Research Organisation	Begbroke Hill, Sandy Lane, Yarnton, Oxford OX5 1PF

State-aided Institutes in England and Wales

Animal Virus Research Institute	Pirbright, Woking, Surrey
East Malling Research Station	East Malling, Maidstone, Kent
Glasshouse Crops Research Institute	Worthing Road, Rustington, Littlehampton, Sussex
Grassland Research Institute	Hurley, Maidenhead, Berks SL6 5LR
Houghton Poultry Research Station	Houghton, Huntingdon PE17 2DA
John Innes Institute	Colney Lane, Norwich NOR 70F
Long Ashton Research Station	Long Ashton, Bristol BS18 9AF
National Institute of Agricultural Engineering	Wrest Park, Silsoe, Bedford
National Institute for Research in Dairying	Shinfield, Reading RG2 9AT
National Vegetable Research Station	Wellesbourne, Warwick
Plant Breeding Institute	Maris Lane, Trumpington, Cambridge CB2 2LQ
Rothamsted Experimental Station	Harpenden, Herts.
Welsh Plant Breeding Station	Plas Gogerddan, Aberystwyth, Cardiganshire SY23 3EB
Wye College, Department of Hop Research	Ashford, Kent

State-aided Institutes in Scotland

Animal Diseases Research Association	Moredun Institute, 408 Gilmerton Road, Edinburgh EH17 7JH
Hannah Dairy Research Institute	Ayr, Scotland
Hill Farming Research Organisation	29 Lauder Road, Edinburgh EH9 2JQ
Macaulay Institute for Soil Research	Craigiebuckler, Aberdeen AB9 2QJ
National Institute of Agricultural Engineering (Scottish Station)	Bush Estate, Penicuik, Midlothian
Rowett Research Institute	Bucksburn, Aberdeen AB2 9SB
Scottish Horticultural Research Institute	Invergowrie, Dundee DD2 5DA
Scottish Plant Breeding Station	Pentlandfield, Roslin, Midlothian

Meteorological Records 1971

D. K. L. MACKERRON, J. L. MILNE

MYLNEFIELD

Wind

Monthly wind-run throughout the first nine months of the year was below average, except for May. Total wind run for the year, however, was slightly above average, this being attributable to very high wind runs during November and December. A gale from WSW with gusts of up to 82 km per hour (51 mph) occurred on the 15 July and was responsible for an appreciable reduction in the quality of the first raspberry harvest which began a few days later.

Temperature

The first three and the last four months of the year were exceptionally mild, particularly December which was the warmest since our records began in 1954. In contrast, June was the coolest recorded in the Dundee area since 1928.

Rainfall

Total precipitation was the lowest recorded at Mylnefield for some years, with an abnormally light rainfall during the last five months of the year. A relatively dry period from 27 June to 20 July was followed by several days of very heavy rainfall.

Sunshine and solar radiation

Total hours of bright sunshine exceeded the 1954-1968 average by almost seventy hours. This was due to high monthly values for May and September, and in particular July which was the sunniest since 1965.

Total solar radiation was similar to that for the last two years.

AUCHINCRUIVE 1971

Month	Temperature °C: Mean of daily maxima	Mean of daily minima	Mean daily temperature at 30cm depth	Rainfall millimetres	Sunshine hours	Ground frost days
January	7.1	2.3	4.7	43.7	38	18
February	7.6	3.0	5.1	87.1	46	9
March	8.2	2.2	5.6	39.6	81	15
April	11.6	3.6	7.9	19.1	159	17
May	15.0	6.4	10.9	45.0	227	9
June	15.5	7.4	12.8	49.8	184	4
July	18.9	10.3	15.2	89.4	227	0
August	17.6	10.8	14.9	76.7	120	0
September	17.1	9.4	13.7	41.7	135	1
October	13.9	7.6	11.6	98.8	114	8
November	8.9	3.4	8.1	84.8	65	17
December	9.1	4.9	7.3	26.4	37	8
Year	12.5	5.9	9.8	702.1	1433	106

MYLNEFIELD 1971

Month	Temperature (Centigrade): Mean of daily maxima	Deviation from average*	Mean of daily minima	Deviation from average*	Accumulated Temperature Above 5.6°	Accumulated Temperature Below 5.6°	Highest Max. Temp.	Highest Max. Date	Lowest Min. Temp.	Lowest Min. Date	Soil Temperature at 30cm depth: Mean	Deviation from average*	Ground frost days	Rainfall: Millimetres	Deviation from average*	Sunshine: Hours	Deviation from average*	Solar Radiation: Mean daily radiation mW h cm^{-2}	Wind Run: Kilometres
January	6.3	+1.2	1.6	+2.1	20	68	12.2	9	−4.9	4	3.7	+1.8	22	70.0	+20.0	33	−25	45	8175
February	7.7	+2.1	2.0	+2.4	24	47	13.6	3	−3.9	16	4.4	+2.2	18	21.3	−23.2	69	−6	104	8281
March	8.7	+0.7	1.8	0.0	37	48	15.0	24	−2.2	17	4.7	+0.6	16	37.3	−9.2	108	+8	194	8998
April	10.8	−0.7	3.5	+0.2	66	16	17.2	15	1.0	17, 28	7.3	+0.4	13	63.2	+20.5	146	−14	288	9297
May	14.7	+0.8	6.0	+0.4	157	7	18.6	10	2.2	27	10.7	+0.6	3	71.3	+17.2	214	+26	454	9442
June	14.7	−2.3	7.5	−1.0	164	1	19.4	1	4.5	14	12.1	−1.5	1	54.4	+3.1	160	−16	444	7356
July	19.4	+1.3	10.7	+0.9	293	0	26.3	7	6.2	17	15.2	+0.3	0	104.1	+36.5	227	+62	498	6494
August	17.6	−0.1	10.1	+0.4	261	0	21.6	25	5.3	15	14.9	+0.4	0	51.0	−28.0	127	−19	324	5830
September	17.4	+1.5	9.4	+0.9	236	2	23.6	7	2.5	24	13.3	+0.6	2	17.5	−46.0	158	+41	285	6425
October	13.5	+0.8	6.3	+0.2	155	20	18.9	1, 2	−3.4	14	10.6	+0.9	9	47.2	−16.0	110	+17	146	8655
November	8.5	+0.2	2.3	+0.1	52	59	15.1	4	−3.9	29	6.4	+0.9	19	50.9	−10.1	73	+13	71	11096
December	9.2	+3.4	3.3	+2.9	52	37	13.8	20	−1.0	3, 24	6.1	+2.9	13	19.1	−54.6	25	−20	28	14563
Year	12.4	+0.8	5.4	+0.8	1517	305	—	—	—	—	9.1	+0.8	116	607.3	−89.7	1450	+67	—	104612

*Recorded at Mylnefield 1954-1968

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