The Scottish Horticultural Research Institute

13th Annual Report for the year 1966

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

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

Published 1967

Contents

Governing Body

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

James Brown, Esq.

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

George Bruce, Esq.

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

James Gilchrist, Esq.

Professor James S. Hall, B.SC.AGR. *Appointed* October 1966

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

Professor J. A. Macdonald, B.SC., PH.D., D.SC., F.R.S.E.

Robert S. M. Milne, Esq.

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

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

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

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

Staff

Director C. H. Cadman*, B.SC., PH.D., F.R.S.E., F.I.BIOL.

Deputy Director A. R. Wilson*, B.SC., M.S., PH.D., M.I.BIOL.

Secretary N. D. Anderson

Crops Research

Head of Section P. D. Waister*, B.SC., PH.D.
H. M. Lawson, B.SC., M.AGR.SC.
H. Taylor, N.D.H.
M. R. Cormack
E. Anne Dickie, B.SC. *Resigned* March 1967

Assistants G. G. Hutchison
C. D. Mason
J. Stoa

Mycology

Head of Section A. R. Wilson*, B.SC., M.S., PH.D., M.I.BIOL.
R. A. Fox, B.SC., B.AGR., M.I.BIOL.
W. R. Jarvis, B.SC., PH.D., D.I.C., M.I.BIOL.
Isabel G. Montgomerie, B.SC., PH.D.
D. A. Perry, B.SC., PH.D.
M. Pérombelon, B.SC., M.SC. *Appointed* May 1966
Mrs Dorothy Spencer, B.SC.
Patricia Dashwood, B.SC., M.SC. *Appointed* September 1966
R. Lowe
H. M. Wilson

Assistants D. Bain
Christine Barnett *Appointed* December 1966
T. Boyle *Appointed* January 1967
M. Dance *Resigned* December 1966
Sheila Forsyth *Appointed* July 1966
Eileen A. Jackson *Appointed* September 1966
Patricia J. Julian *Resigned* July 1966
Pamela Majer *Resigned* October 1966
Isobel G. Stockdale

Plant Breeding

Head of Section C. North*, B.SC.HORT., M.SC., PH.D., N.D.H., M.I.BIOL.
D. L. Jennings, B.SC., PH.D.
A. B. Wills, B.SC., M.S., PH.D.
H. J. V. Gledhill, B.SC., *Resigned* March 1967
M. M. Anderson, N.D.H., S.D.H., D.H.E.
W. Greta Priestley, DIP.HORT.
Pauline B. Topham, M.A., B.SC.
Barbara M. M. Tulloch, S.D.H.
E. B. Paterson

Assistants Roberta S. Archer *Resigned* October 1966
D. Bruce
Eleanor Carmichael
Joyce Walker *Appointed* June 1966
Patricia A. Wolfe-Murray *Appointed* Oct. 1966. *Resigned* March 1967

Plant Physiology

Head of Section C. G. Guttridge*, B.SC.HORT., PH.D.
J. W. Dancer, B.SC., PH.D. *Resigned* September 1966
D. T. Mason, B.SC., PH.D.
P. B. Goodwin, B.SC.AGR., M.SC., PH.D.
A. Gordon, B.SC.
H. McC. Anderson, S.D.H.

Assistants Carolyn A. Chambers
Maureen Edward
J. B. Garrie

Virology

Head of Section B. D. Harrison*, B.SC., PH.D. *Appointed* October 1966
R. M. Lister, B.SC., PH.D., DIP.AGR.SCI. *Resigned* September 1966
W. P. Mowat, B.SC., DIP.AGR.SCI.
A. F. Murant, B.SC., PH.D.
Mrs Susan Allen, B.SC., PH.D.
J. Cathro, L.I.BIOL.
J. Chambers, B.SC.
R. A. Goold
I. M. Roberts

Assistants D. E. Branney, S.D.H. *Appointed* January 1967
Margaret J. Cameron *Resigned* September 1966
W. M. Robertson

Zoology

Head of Section	C. E. Taylor*, B.SC., PH.D.
	P. R. Thomas, B.SC., M.SC., PH.D., M.I.BIOL.
	Hanne P. Holmes, B.SC., M.SC.
Assistants	Jane Bowes *Appointed* August 1966
	S. C. Gordon *Appointed* August 1966
	Winifred I. Pattullo *Resigned* April 1966

Maintenance

Head of Section	J. H. Couttie
Assistants	J. R. Caithness
	R. MacDonald
	G. Merchant
	W. Waterston
	R. G. Watson

Farm and Plantations

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

Glasshouses

Manager	J. Cantwell *Appointed* November 1966
Foreman	R. D. Taylor

Administration

Secretary	N. D. Anderson
Assistant Secretary	A. P. Thomson
	I. MacDiarmid *Resigned* July 1966
	D. L. McIntosh
	I. A. McLeish *Appointed* August 1966
Director's Secretary	Ruby B. L. McGill
	Margaret Campbell
	Joyce Doig
	Helen Moncrieff

Library

Librarian	W. Anderson, F.L.A. *Resigned* August 1966
Librarian	Mrs Heulwen Barnes, B.A. *Appointed* September 1966
Assistant	Mrs Margaret Mitchell

Visual Aids

Photographer and Met. Observer	J. Sunderland
	Maureen I. McMaster, D.A.

West of Scotland Unit (Auchincruive)

Officer-in-Charge	R. D. Reid†, O.B.E., M.SC., S.H.M. *Retired* March 1967
	H. J. Gooding, B.SC., PH.D. *Appointed* May 1966
	K. C. McConnell, S.D.H.
	W. I. A. Jack
	Susanne A. Dodd

* Honorary Lecturer in the University of St. Andrews
† Honorary Lecturer in the University of Glasgow

General Report

C. H. CADMAN

The winds of change, so evident in our last Report, have abated somewhat. Not only has the Report itself, we hope, arrived this year at a stable format to which cataloguers can safely become accustomed; staff changes too were much fewer and Governing Body committees met less frequently as a result.

We welcome a newcomer to the Governing Body in Professor James S. Hall following his appointment to the Chair of Agriculture in the University of Glasgow and the Principalship of the West of Scotland Agricultural College in succession to the late Professor D. S. Hendrie. It is with pleasure too that we record the conferment by the University of Edinburgh of the honorary degree of D.Sc. on Sir David Lowe for his many public services to agriculture and horticulture.

The retirement this year of Mr R. D. Reid after 16 years in the Institute's service and some 36 years of devotion to strawberry breeding is a loss which will be felt no less keenly by the horticultural world than by the Institute itself. Probably no public acclaim, which he now has in rich measure, will ever quite compensate either for the years of dedicated effort or for the separation from his work which age now enforces; we hope that retirement will have its compensations and that his advice will be available to us for many years to come. In May Dr H. J. Gooding was appointed to succeed Mr Reid, and the staff of the Unit and its work are now part of the Plant Breeding Section under Dr North's direction. The 'brain drain' took Mr W. Anderson, our librarian, to the Canada Agriculture Research Station, Summerland, British Columbia, and Dr R. M. Lister to the Department of Botany and Plant Pathology, Purdue University, W. Lafayette, Indiana. For each of them the decision to emigrate was a major one and we wish them well in their new surroundings. Mrs Heulwen Barnes replaced Mr Anderson and Dr B. D. Harrison returned to the Institute to become head of the Virology Section. Dr J. W. Dancer left in September to join the staff of the Department of Biological Sciences, Portsmouth College of Technology and Mr H. J. V. Gledhill's interests in statistics and computer usage, from which the Institute has benefited greatly, gained him appointment, in March, to the staff of the Computer Laboratory, Queen's College, Dundee. Mr H. M. Lawson was appointed to the Crops Research Section to take charge of work on weed control and Mr M. Pérombelon joined the Mycology Section to initiate work on bacterial soft rot of potato. Management of the glasshouse service was separated from that of the farm and plantations with the appointment, in November, of Mr J. Cantwell as Glasshouse

Manager. Mr J. I. Cooper and Mr R. A. C. Jones who, respectively, were awarded studentships by the Ministry of Agriculture, Fisheries and Food and the Potato Marketing Board, came in October to work in the Virology Section, and Mr Thor Munthe returned to Norway in February after spending 14 months with the virologists.

Money provided by the Agricultural Research Council enabled Dr D. L. Jennings to join representatives of the National Institute of Agricultural Engineering (Scottish station) and the National Farmers' Union on a visit to U.S.A. and Canada to assess raspberry harvesting equipment. By the same means, Dr C. North attended the 17th International Horticultural Congress in Washington and paid visits to research centres in the U.S.A. and Canada, Dr A. R. Wilson and Mr R. A. Fox attended the Third Triennial Conference of the European Association for Potato Research in Zürich, Switzerland, and Dr D. A. Perry visited various institutes in the Netherlands.

The Institute receives an increasing number of visitors, and contacts have been widened this year by the number of special meetings which have been arranged with the object both of gaining information about the horticultural industry and identifying problems for research. We are particularly indebted to various members of the National Agricultural Advisory Service and of the staffs of the Scottish agricultural colleges who contributed to useful meetings on problems of flower bulb production and pea-growing, and to Scottish processing firms whose representatives have helped in defining future needs for fruit and vegetable varieties for processing. An innovation this year was the setting up of a consultative committee consisting of the senior horticultural advisers of the three Scottish agricultural colleges through which we feel we now have a useful avenue of communication with both the advisory service itself and the horticultural industry. The Institute acted as host to a symposium held in July on *Botrytis* diseases of crops and to the A.R.C. Working Party on Potato Tuber diseases which met in February with a number of invited participants to discuss work on potato gangrene. Members of the local branches of the N.F.U. were invited to a meeting in July to hear about recent information on raspberry manuring.

We receive so much help from individuals, commercial firms and other organisations both at home and overseas that nothing other than a complete list would do justice by way of acknowledgment. For all of this we are grateful and in particular to Scottish Agricultural Industries Ltd. for a generous gift of money for staff welfare purposes and to the Scottish Branch of the National Farmers' Union for a contribution towards equipment used for potato investigations.

The place of research in Scottish horticulture

The re-organisation of the Institute – apparent for the first time in this Report – seems to call for some distillation of the thoughts which led to the changes made and a look towards future policy.

Research is one of those unfortunate words that has many shades of meaning. To the grower, it usually means work needed to solve immediate problems

which he himself can see and, usually, work which should be done by someone else, preferably the state. Very often this amounts to developmental work – the extension to practice of the results of scientific experiments or the application, under local conditions, of knowledge that already exists but may have been acquired elsewhere. To workers in state-aided institutes, such as ours, research means trying to discover what lies at the back of immediate problems and trying to make possible, through new knowledge, developments which industry itself cannot foresee. It is convenient to call this sort of work 'objective basic research' because it is work done for a specific purpose and not just for the acquisition of new knowledge as such. Confusion – and perhaps some disappointment – about the functioning of the Institute arises from failure to distinguish between these two broad categories of work and the difference in kind of obligation they imply.

Both Scottish horticulture and the Institute are in an odd position. On the one hand, statistics leave no doubt that, apart from the climate, there is nothing unique about horticultural cropping in Scotland, other than the growing of raspberries in which we are supreme. In other respects the industry in Scotland is similar but on a smaller scale to that south of the Border. This is not to say that potentialities for development do not exist; they obviously do, and one is heartened by the enthusiasm which is leading to expansion in the glasshouse industry, in bulb-growing and in production of nursery stock and by the encouragement by processors of the growing of new crops or increased acreages of established ones in Scotland. On the other hand, being the only state-aided institute in northern Britain concerned with horticultural crops, the Institute has a remit, and indeed a range of interests, as wide as those of four of its sister research institutes in England put together. At the same time the Institute is part of a nation-wide research service and the research it does must not only dove-tail efficiently with that of its sister institutes; it must, scientifically, be worth the money it costs to do. Research of this calibre is, of course, not limited in application to a particular territory – no research of any consequence ever is. Much of the work we have done or are doing – on plant viruses for instance or on the growth of strawberry plants – has earned us regard in many parts of the world. The stimulation to do this work may have originated from local problems which, as a result, have been solved, but the knowledge gained has contributed to biological science and the welfare of horticulture generally. In some respects, therefore, our name is something of a misnomer for, though located in Scotland, our activities recognise no national boundaries although we have certain local obligations. It is the need to identify and cater adequately for these local obligations as distinct from the broader research issues which has been difficult and has coloured thinking about future planning.

The greatest need of the horticultural industry in Scotland has for long been, and still is, for developmental work, a need emphasised by the increasing dependence of competitive ability on the efficient use of technological advancements. It has to be remembered that Scotland has no equivalent of the N.A.A.S. Experimental Horticulture Stations and that, on economic grounds, an elaborate organisation would be difficult to justify. We must therefore pool

the available resources and utilise these to best advantage. Positive steps in this direction are two. On the one hand, the Institute now has, through the consultative committee of the senior horticultural advisers, an effective link with developmental work in the agricultural colleges. On the other our contribution to this field has been strengthened by the creation of the Crops Research Section. Whilst the main research task of the Section will be investigation of the effects of environment on crop production, a topic particularly relevant to horticulture in the north, its staff has been augmented to enable it to take on developmental work in fruit and vegetable crops, in flower bulbs and, perhaps later, in nursery stock. The emphasis here will be on weed control and problems of management rather than on variety testing, and the Section's report this year provides a foretaste of this.

Our other major local obligations are towards the raspberry industry because of its importance to Scotland and, more recently, the seed potato trade for the same reason. New varieties of raspberry are urgently needed and ultimately adaptability to mechanical harvesting will have to be catered for. These needs are being met by work in the Plant Breeding Section. More research has been done on raspberry virus diseases here than at any other centre in the world but there are still problems for the Virology and Zoology Sections to solve. The need to devote resources to this research need seemed greater than the obligation to continue providing the industry with supplies of healthy stocks–a job which it is perfectly well able to do for itself. Better control of grey mould (*Botrytis cinerea*) and the prevention of post-harvest rots will certainly be one of the applications of research being done by the Mycology Section and satisfactory control of stamen blight (*Hapalosphaeria deformans*) seems within sight. On this Section also falls the main burden of work with potato tuber diseases. Damage to seed consignments by gangrene and losses in stored potatoes because of bacterial soft rot have reached proportions where it was right that the Institute should, by reason of its location and expertise, contribute to research on a crop which, in gross value of output, is worth nearly twice as much as the entire output of the horticultural industry in Scotland. All these local obligations will, therefore, continue to be met. What, then, of the rest of the research programme?

Much of it too has local application but is designed to fit a much wider context. The Virology Section, for example, has interests in viruses affecting vegetable crops, flower bulbs and other ornamentals as well as those affecting raspberry and potato. The practical objectives here are the identification and control of viruses and virus diseases. But the information is sought in ways which will help to answer the more important questions of how viruses are spread, what makes plants susceptible or resistant to infection and what factors enable viruses to multiply in and produce symptoms in the plants they infect. The Zoology Section is concerned mainly with the biology and control of nematodes and insects that transmit viruses but it also has a role to play in helping to unravel the nature of the association between viruses and vectors so that we may eventually understand how and why viruses are transmitted. The Plant Physiology Section knows a great deal about the factors controlling

flowering and runnering in strawberry and some of this knowledge has led to practical developments such as post-harvest defoliation, cold storage of runners and the use of growth inhibitors to control runnering. The research interest, however, lies in discovering the mechanisms controlling growth and flowering in plants so that we in turn may be masters of the plants we grow and not they of us. The fundamental problem that lies behind the Mycology Section's work both with potato diseases and *Botrytis* is the nature of latency – the kind of association where a pathogen lies quiescent in its host until conditions enable it to become aggressive. What are these conditions? If we knew we should be better able to design measures to prevent the aggression. Plant breeding in state-aided institutes is at something of a cross-roads because the impact of the 1964 Seeds and Plant Varieties Act is still unpredictable. As there is virtually no commercial breeding of soft fruits in this country it is quite clear that the industry is dependent on institutes such as ours for the production of new varieties of raspberry, strawberry and blackcurrant. We are deeply conscious of this obligation but plant breeding is a slow business at any time and the demands of the industry fluctuate much more widely and rapidly than it is within the power of plant breeders to match. The breeding of vegetable and some other kinds of horticultural crops is being done by commercial firms with greater resources than state-aided institutes whose function then would seem to lie in producing new material and devising new techniques rather than competing in the production of new varieties. However, breeding programmes cannot be changed overnight and much of the Institute's present programme is committed to the production of varieties. The advantage we have is that of working under climatic conditions marginal for many crops, so that adaptation to northerly conditions is likely to ensure high performance elsewhere.

Our critics may complain of unrealism – stuffiness in the mouths of some – but we believe our programme is soundly based and that our new organisation is well fitted to keep a balance between more obvious and immediate needs and longer term research which, in the end, may have the greater impact. Patience is an essential ingredient of research for, blinding though the progress of science may be, miracles are still unperformable and the seasons still control the growth of plants as effectively for the research worker as for the grower.

Farm, Plantations and Glasshouses

L. S. GRAY

Farming years at the Institute tend to be remembered for their berry seasons because this is the time of year when organisation and patience are at a premium and the weather is all important. The summer, or at least what there was of it, promised well: fruit picking at least began in dry weather and losses from grey mould were small this year but, in common with other growers, we are finding casual labour for harvesting increasingly difficult to come by. As the weather records show, 1966 was a wet, dull and cold year. We were fortunate in making good progress with field work in the dry weather in March and May for rainfall in April and June was the heaviest since records began in 1954.

We have followed the popular trend in cereals by increasing our barley acreage–we grew 85 acres this year–at the expense of other crops. But this is partly for convenience because of the difficulty of finding crops remunerative to grow that can be used to fill out fields partly occupied by experimental crops. The crop yielded 35 cwt./acre and about one-third of this was sold for malting. Twelve acres of wheat, 7½ of oats and 10 of potatoes made up the rest of the farm crops. Wheat yielded poorly at 25 cwt./acre; the oats, intended for combine harvesting, yielded well (1.75 tons/acre) but proved something of an embarrassment because of ripening much later than the other cereals. Our potato field adjoined the main Dundee-Perth road so it was fortunate that the single pre-emergence application of linuron and paraquat provided a striking demonstration of efficient weed control.

As announced in the previous Report, the new strawberry variety Crusader was released in 1966 and some 56,000 runners were distributed, mainly to growers in the United Kingdom and Eire last April. Distribution to growers in England, Wales and N. Ireland was handled for us by the Nuclear Stocks Association and small lots were sent to various overseas research centres for experimental purposes.

Fruit-picking began with strawberries on 4 July–raspberries followed a week later–and was blessed with good weather to start with but the second half of the season was very wet. The yields–12.5 tons of strawberries, 17.5 of raspberries and 6 of blackcurrants–were close to those of last year. It was a poor year for tree fruit; there was too little sun to 'finish' the apples well, the trees were battered by gales and much of the crop blown off. The weather records provide a salutary reminder that in these parts we often have more wind in one month than more favoured parts of the country get in twelve.

Carrots, cabbage and Brussels sprouts were the only vegetable crops grown on any scale. Regretfully we have decided to abandon carrots as a farm crop

because our land is only marginally suitable. Difficulties of disposing of the crop this year were increased by the low yield of canning-size roots and a market saturated with ware. Cabbage of the Amager and Winter Pride types were grown for experimental clamping and yielded some 25 tons. The crop of Brussels sprouts–4½ tons–was marketed locally.

Three new glasshouses, equipped with thermostatically controlled heating and ventilation, for use by the Plant Physiology Section, were completed and four new dutch light houses erected for the Plant Breeding Section. These last permitted the clearance of older structures from the glasshouse site preparatory to re-organisation of the entire area. Drainage is becoming a problem on various parts of the farm and the development of wet spots seems likely to call not only for immediate remedial measures but some long term policy for field drainage.

Crops Research

P. D. WAISTER

The Section came into being in April 1966 and its two main functions are to examine aspects of the effects of environment on crop growth, and to develop and integrate research findings into crop management systems. The first of these is a new venture and, although some exploratory work has been done and some of the necessary equipment purchased or constructed, developments depend on the availability of time and new staff appointments. The second function is, in part, a continuation of activities of the former Departments of Pomology and Vegetable Crops. Work on weed control is now in the hands of H. M. Lawson who was appointed in September 1966 to the post vacated by R. J. Stephens. The objectives here are to investigate new methods of weed control and their utilisation in horticultural practice, and to examine the performance of herbicides under north British conditions. Extensive screening of new chemicals is not intended as this is well catered for by other organisations. Field experimentation with fruit and vegetable crops will shortly become the province of a new member of staff. This year's programme was largely dictated by that of preceding years but has provided a breathing space in which to take stock and to analyse and interpret previous experiments before starting new ones. In the field of raspberry nutrition, several responses require further investigation; for instance, the depressing effect of heavy applications of ammonium sulphate on yield of raspberry plantations after the fourth year from planting, the improvement in yield (persisting over several years) following green manuring, and the reduction in yield associated with dressings of farmyard manure. With vegetable crops, the emphasis has previously been on variety testing. Greater prominence will be given to work on cultural techniques to ensure maximum use of both existing and new plant material.

CROP ENVIRONMENT

Shelter belts of varying plant arrangement and botanical composition have been planted at the Institute over a 13-year period. Most are oriented north/south to give shelter from the west and south-west winds. Surveys made, with the aid of small portable anemometers, showed that the most satisfactory type of break, judged on rate of growth, land occupied and sheltering effect, is composed of a row of *Cupressocyparis leylandii* alternating with *Pinus nigra var. calabrica*, separated from a row of hybrid poplar (*Populus tacamahaca x trichocarpa*) by a 15 ft. roadway. Within-row spacing is 7 ft. Planted in 1959, these trees now average 26, 12 and 30 ft. (*Cupressocyparis*, *Pinus* and *Populus*

respectively). Measurement of wind speed when the wind was normal to the break, with the poplars in leaf, showed more than 50% reduction at 5 ft. above soil surface for a distance of 130 ft. from the belt.

A collection of vegetables was irrigated whenever soil moisture tension reached 30 cm. mercury at 4 in. depth as recorded by tensiometers located in peas. This crop was selected for its rapid attainment of ground cover. The treatment was not replicated, but no differences in growth or development were recorded between the irrigated block and the non-irrigated blocks on either side. Rainfall in 1966 was well-distributed and only three irrigations were necessary. Observational work of this nature will continue each year to arrive at an estimate of the extent of depression in crop yields due to shortage of soil-moisture. In the past no quantitative estimate has been possible, though moisture shortage has been suspected as a cause of year-to-year variation in crop yield at the Institute.

Both wind and soil moisture may influence crop growth in Scotland, but their effects are not as severely limiting as are those of temperature and radiation levels, at least in horticultural areas. Both raspberries and strawberries suffer winter injury, and reference is made to hardiness assessments of raspberries in the report of the Plant Breeding Section. Little is known about the specific environmental conditions leading to winter injury, and this will be one of the first objectives in the development of the work on crop environment. (P. D. Waister).

WEED CONTROL

Raspberries

The experiment combining herbicide treatments, cultural methods and two levels of nitrogenous fertiliser is now entering its fifth growing season. Results in 1964 showed that traditional methods of cultivation–where the stools are 'furred up' by drawing a shallow plough furrow towards the row, and weeds and suckers are controlled by hoeing and by rotary cultivation of the alleyways–were more productive than management systems where the cultivations did not involve furring up or those where cultivation was eliminated through the use of herbicides. Differences in yield resulted from differences in numbers of canes that fruited. Losses over winter were greatest on plots which had not received the traditional cultivations. Possibly the extra support given by furring up may reduce wind damage to young canes in the first year or two of establishment. In 1965 yields placed the management systems into three categories. The traditional cultivations were still giving the highest yields; next came two systems in which suckers in the alleyways and both suckers and weeds between the stools were controlled by hoeing and weeds in the alleyways controlled either by rotary cultivation or by means of simazine. Treatments involving no cultivations of any kind (simazine plus paraquat and paraquat alone) produced the lowest yields. In 1966 traditional cultivations and those involving dutch hoeing plus rotary cultivation or simazine did not differ significantly, but these treatments all significantly outyielded all the non-cultivation treatments.

On a cumulative yield basis over the three years, the traditional cultivation system is still slightly ahead of all other treatments. Of particular interest is the increasing yield superiority of plots where weeds and suckers are controlled by simazine plus dutch hoeing over those where control is by simazine supplemented by paraquat. Two of the non-cultivation management systems involve annual top dressing with the equivalent of 10 tons of well rotted farmyard manure per acre. So far this has had no significant effect on yield.

In terms of weed control, systems involving the use of simazine stand out because they give control of weeds throughout the year, whereas cultivation or paraquat treatment ceases just before picking and cannot be continued into the autumn because of obstruction by untied new canes. As a result, these plots have a good cover of weeds by late autumn. Otherwise, provided each treatment is carried out from early spring onwards in a timely manner, weed competition should not be a factor affecting growth or yield. Perennial weeds are not a problem in this experiment so far.

They are a severe problem on the site of another trial begun in 1964, where simazine, atrazine and bromacil at 2 lb. a.i./acre and chlorthiamid at 4 lb. a.i./acre are compared with each other and with a control treatment involving only dutch hoeing for weed and sucker control. The herbicides are applied overall in spring before suckers emerge. Suckers in the alleys of the herbicide plots are removed either by mowing or with paraquat. By late summer 1966 average ground cover by perennials – mostly coltsfoot – on the untreated plots was 43%. Plots treated with simazine averaged 15%, atrazine 6%, chlorthiamid 5% and bromacil 1%. Perennials are virtually the only weeds on the herbicide plots. By contrast, the control plots required a constant battle against annuals and perennials until harvest time and thereafter became smothered in weeds because of obstruction to hoeing by fallen new cane. Results in 1965 showed no significant differences between treatments in yield or vigour of cane. In 1966, however, all herbicide treatments yielded less fruit than the control treatment, four of them significantly so at the 5% level. Differences between the herbicide treatments were not significant so that the higher yield from the control plots may result from differences between the two systems of management and not from any effect of the herbicides as such. In view of the improved weed control obtained with atrazine, chlorthiamid and in particular bromacil, it is encouraging that these materials applied three seasons running have not adversely affected growth or yield of Malling Jewel in comparison with the standard simazine treatment.

A new experiment, begun in 1966 on a well-established plantation of Malling Promise (planted 1961), is designed to test the tolerance of the crop to dosage rates of chlorthiamid likely to be used for perennial weed control in established plantations. Three dosage rates (equivalent to 6, 8 and 10 lb. a.i./acre) are being evaluated against a hand-weeded control treatment. The treatments are applied in spring, before sucker-emergence, to a 1 ft. band on either side of the row. Weeds and suckers in the alleys are controlled by rotary cultivation in spring followed by application of paraquat/diquat. The experiment includes a comparison of the effects of applying the treatments once, two years

running and three years running on the yield and vigour of the crop. Treatments in 1966 had no effect on fruit yields, but the 10 lb. a.i./acre dosage rate of chlorthiamid somewhat reduced the total new growth produced in 1966. Average cane length was unaffected. There was still ample cane available for tying in after thinning, and no differences between treatments were apparent from counts made in February of cane tied in. It remains to be seen whether yield from this new cane is affected.

Strawberries

The trial planted in 1963 to compare the effects of traditional cultivation–rotary cultivation and hand-hoeing–with those of herbicide treatment (chloroxuron initially, with simazine thereafter) was terminated after the 1966 harvest. No significant differences in yield were found at any harvest during the life of the crop. In another trial, bromacil, at ½ lb. a.i./acre applied in spring and autumn, controlled weeds better than comparable applications of simazine at 1 lb./acre and had no adverse effect on yield. Elsewhere, bromacil at 1 lb./acre applied soon after planting killed a high percentage of the crop. The safety margin of this product is therefore not very wide on strawberries, but the outstanding control of annual and perennial weeds makes it worth further investigation.

Potatoes

In association with the A.R.C. Weed Research Organisation the effects of timing of application of linuron and paraquat on the potato crop were investigated. The effect of post-emergence application was of particular importance because of the reported use of these materials in this manner by farmers. Results showed that yield at four dates of harvesting, ranging from the equivalent of early potato lifting to late maincrop lifting was significantly reduced when linuron at ¾ or 1½ lb. a.i./acre was applied at 25% emergence as an alternative to paraquat/diquat applied just pre-emergence. This was mainly because of a reduction in the numbers of tubers per plant rather than a reduction in tuber size at any date of harvesting. Compared with the control (paraquat/diquat pre-emergence) treatment with paraquat at 50-70% emergence reduced yield drastically at the first date of harvesting, but the crop recovered sufficiently for yields at later harvest dates to differ little from those of the control plots. Reductions in both numbers and size of tubers were responsible for the low yield at the first harvest date. Thereafter tuber size was very close to that on the control plots, while tuber numbers were still significantly lower at the second date, although not at later dates.

In this trial, therefore, linuron applied post-emergence even at ¾ lb. a.i./acre decreased yields at all dates of harvesting and cannot be recommended as a commercial practice. However, since 50-70% emergence is well beyond the stage at which paraquat is likely to be applied in commercial practice, it is possible that main crop potatoes might recover almost completely from paraquat applied just post-emergence. The risk is probably too great with early potatoes.

Cabbage
Several herbicides were evaluated for control of weeds in direct-drilled cabbage. The most promising were trifluralin at 1 lb. a.i./acre incorporated to 2 in. depth pre-sowing and CP 31393 at 6 lb. formulation per acre. However, the resistance of fumitory, groundsel and shepherd's purse to trifluralin meant that this, the best treatment, was effective for only some six weeks after sowing. Where these weeds are important it may be necessary to use a post-emergence herbicide or cultivation to supplement pre-emergence herbicides. The herbicide plots became so smothered in weeds that only the control plots, which were dutch hoed, produced marketable heads.

Swede turnips
Trifluralin at 1 lb. a.i./acre incorporated to 1 in. depth pre-sowing gave the best weed control but a proportion of the harvested roots were severely malformed. A commercial mixture of CDEC and chlorpropham (JMS 6), applied pre-emergence, checked the growth of the young plants and resulted in a significant depression in yield relative to the hand-weeded control treatment. Of the materials which did not affect crop yield, the most promising was CP31393 at 6 lb. product/acre. Nitrofen applied pre- or post-emergence was unsatisfactory and failed to control chickweed.

Red beet
A preliminary trial to evaluate possible herbicides for weed control in 'baby' beet showed that none of the herbicides used decreased yields significantly. Lenacil at 1 lb. a.i./acre and Herbon Gold at 10 pt./acre applied pre-emergence gave the most effective control of weeds. Pyrazon at 3 lb. a.i./acre and endothal/propham (Murbetex) at 21 pt./acre did not control fumitory, fat hen or chickweed. (H. M. Lawson, P. D. Waister, E. A. Dickie, J. Stoa).

FIELD EXPERIMENTATION

VEGETABLE CROPS

Beetroot
With seed sown in mid-May, increasing the plant population from 17 to 23 per sq. ft. did not affect the yield of 'baby' beet ($\frac{3}{4}$-$1\frac{1}{2}$ in. diam.)–which remained constant at 5.3 tons per acre–but it halved the total yield of roots. Sowing in early June gave comparable yields of 'baby' beet but a decreased total yield. Plant establishment was poor in mid-May, very good in early June when rainfall was more abundant, and poor again in late June. A processor's assessment indicated that the earliest sowing gave the highest quality roots. Yields of 'baby' beet are likely to be lower than yields of maincrop roots, but low yields in this experiment were possibly due to inadequate applications of nitrogenous fertiliser.

Brussels sprouts
Two performance trials were made with differing systems of plant raising:

these comprised outdoor sowing in spring, and sowing under glass in February and planting outdoors in April. Of the fourteen varieties compared in the first of these, the Dutch F_1 hybrid Peer Gynt yielded best (5.8 tons/acre) and produced an early and exceptionally uniform crop of sprouts closely spaced on the plant stem. The SHRI F_1 hybrid No. 9 came second and produced the fewest blown sprouts. The sprouts were very firm, dark-coloured and easily picked from the stem but the proportion of rotten ones was rather high. The F_1 hybrid Norga I produced a high proportion of blown sprouts. Of the nine varieties raised from seed sown under glass, Norga I and Irish Elegance yielded best (6.7 tons/acre). Roem van Kloosterburen also yielded well and produced smooth sprouts widely spaced on tall stems, but had a tendency to bolt as did the SHRI F_1 hybrid No. 9. A high proportion of plants of Cambridge Special and Avoncross bolted and these are probably unsuitable varieties for raising early under glass.

A third variety trial compared autumn-sown and spring-sown plants of twelve varieties. Rejecting bolting plants (7-10%) prior to transplanting, autumn-sown Avoncross and Roem van Kloosterburen yielded 8.2 and 7.1 tons/acre of reasonably dark-green sprouts. Several varieties produced no bolters when autumn-sown, whereas Cambridge Special, Sherrardian and Jade Cross produced many and are probably unsuitable for mid-August sowing. On average, yields from non-bolting varieties sown in mid-August were 30% higher than those from plants grown from seed sown outdoors in late March.

In unreplicated observation plots sown outdoors in spring, several F_1 hybrid stocks from Gebroeder Sluis cropped at 7 tons/acre. The sprouts of the early stock UT 7 were very firm though rather pale in colour; WM 5 was slightly later in cropping and produced taller plants and small dark green sprouts.

Plant spacing affected the yield of small sprouts ($\frac{3}{4}$-$1\frac{1}{8}$ in. diam.) suitable for quick-freezing in a trial where eight varieties were compared at square spacings of $2\frac{1}{2}$, 2 and $1\frac{1}{2}$ ft. With all varieties, the closest plant spacing gave the maximum yield of small sprouts. The SHRI F_1 hybrid No. 9 gave the heaviest yield of freezing-grade sprouts, 4.7 tons/acre. The Dutch F_1 hybrid Peer Gynt, spaced at $1\frac{1}{2}$ ft., gave the heaviest yield at a single harvest, 9.2 tons/acre. Most of this yield was too large for freezing, indicating that, for the production of small sprouts, plants of this variety might require even closer spacing. As plant spacing decreased, the percentage of blown and rotten sprouts also decreased. Straighter plant stems were another result of close spacing.

Cabbage

The SHRI No. 5429 was the only one of nine winter cabbage stocks which survived the winter of 1965/66 to give a good crop of heads in mid-March. In the mild winter of 1966/67, many varieties survived well up to mid-January. The SHRI F_1 hybrid produced very uniform heads with none of the purple colour of January King. The autumn-heading variety Badger Shipper showed

a high degree of resistance to the strain of club root present in heavily infected soil at Markinch, Fife. The winter cabbages January King, Winter Pride and SHRI F_1 hybrid were sown mid-April, early May and late May and transplanted to spacings of 2, 1½ and 1 ft. square. When sown in mid-April and spaced at 1½ ft. both Winter Pride and the SHRI F_1 hybrid produced 19 tons/acre of good marketable heads. From later sowings, marketable size was attained only at 2 ft. square planting. Winter Pride and January King could not be sown later than early May, whereas the SHRI F_1 stock produced marketable heads from the late May sowing date. Dusting cabbage heads with either TCNB or dicloran before clamping in November decreased the losses from rotting, assessed when the clamps were examined in March.

Calabrese

On a single cutting date the variety Early Spartan gave a yield of marketable primary heads equivalent to 1.1 tons/acre. Because of variability in maturity date, only 36% of the plants were cut at this single harvest.

Cauliflower

Date of harvesting of the winter cauliflower variety St. George was little affected by time of sowing. The latest sowing date (31 May) gave the greatest number of plants that survived the winter and the heaviest yield of first class curds. At the request of the Horticulture Committee of the Scottish Agricultural Improvement Council a trial of twenty stocks of early summer cauliflower was grown. Assuming earliness to be of primary importance, followed by yield of large curds, the two varieties that performed best were Malina and Delta.

Celery

In co-operation with the National Institute of Agricultural Botany the performance of eighteen stocks of green and self-blanching celery was compared. The variety Greensleeves produced a heavy crop of relatively stringless stalks of good flavour. Of the self-blanching types, Lathom Blanching was the only one that combined yield with quality. In this trial both the average plant weight of 0.9 lb. and general quality were low, suggesting that greater attention to fertiliser treatment is required.

French beans

In a trial comparing nine varieties of stringless French beans, Glencarse gave the heaviest yield and earliest crop, followed by Glamis and Prelude. The other varieties in the trial matured too late to produce a worthwhile crop. At a single harvest ⅛ acre of the varieties Glencarse and Glamis yielded at the rate of 3½ tons/acre of marketable pods. Spraying with dichlofluanid three times during the flowering period halved the number of pods affected by *Botrytis cinerea* but this fungicide has not yet been cleared for commercial use on French beans.

Peas

In an autumn-sown trial grown in co-operation with the N.I.A.B., only Austrian Maple and one other stock survived the winter. Though the crop was a failure, NVRS No. 4 (60/22) with only 12% of the plants surviving, reached a suitable maturity for quick-freezing four or five days earlier than Kelvedon Wonder sown on 8 March.

Swede turnips

When six varieties of Swede, sown at the end of April, were thinned to several spacings in rows 2 ft. apart, the closest spacing (5 in.) gave the heaviest yield of roots 4 to 6 in. diam., the grade required for culinary purposes. Danestone, a white-fleshed variety, yielded the heaviest crop in this grade, equivalent to 39 tons/acre. The yellow-fleshed variety Acme also cropped heavily. The skin colour of both these varieties was even and showed very little speckling at the neck.

Sweet corn

Eleven varieties of sweet corn were sown under glass in late April and planted outside at the end of May at 2 ft. x 1 ft. spacing. The varieties Spring Gold, followed a few days later by Earliking, produced crops of 0.9 and 0.6 ears per plant (19,500 and 13,500 ears/acre) of uniformly set, high quality ears, which is equivalent to yields of 4.1 and 3.6 tons/acre respectively. (H. Taylor, C. D. Mason).

FRUIT CROPS

Top fruit

A severe gale on 6 September caused considerable damage, blowing off a large proportion of the crop and causing some serious branch breakages, mostly in the new extension to the variety collection, where shelter is poor. Because of lack of sunshine towards the end of the season, the fruit did not 'finish' well, although the grassed-down plantations were better in this respect.

The trial of ten rootstocks of the Malling and Malling Merton series, carrying three varieties, indicates that rootstock influence on growth and cropping is similar to that in the south of England. M XXV, MM 109 and MM 104 are the most vigorous, and slowest to come into cropping, while M VII is the least vigorous. MM 106 and MM 111 are proving the most productive with regard to yield and M IV the least.

In the trial of four North American varieties on four Malling Merton rootstocks, all the trees, with the exception of Lobo, made satisfactory growth. The most vigorous variety on all rootstocks is Lawfam, followed closely by Hume, although their growth habits are very different. Hume produces few very strong and upright extension shoots while Lawfam has a spreading habit and a proliferation of shoots. Cortland and Lobo are of approximately the same vigour, but while Cortland has a good growth habit, Lobo produces severely distorted new growth. The fruit of Lobo too is misshapen, although

colour, flavour and texture are good. Cropping is very light as yet, but so far Cortland has produced the heaviest yield and Lawfam the lightest and well below the others. MM 106 is the most productive stock followed by MM 111 with MM 109 and MM 104 somewhat lower. The fillers in this trial, on M 1X, are beginning to crop well. Milton was the heaviest yielder this year, and good crops of high quality fruit were produced by McIntosh Cornell, Double Red McIntosh, Golden Delicious, McIntosh Rodgers and McIntosh Summerland. The very vigorous variety Bancroft shows a strong tendency towards biennial bearing.

Raspberries

The factorial nutritional experiment planted in 1957 to study the effects of three levels each of nitrogen, phosphorus, potassium and farmyard manure on the growth and yields of the varieties Lloyd George, Malling Exploit and Norfolk Giant was completed after the 1965 harvest and the data are being analysed. The plantation, however, was retained in order to continue studies of the effects of manurial treatments on cane hardiness, an account of which may be found in the Plant Breeding Section's report.

The plots of the experiment planted in 1958 to compare combinations of eight pre-planting soil preparations and eight post-planting manurial treatments were split in 1966 and only one half received the regular annual treatment, the other half being left untreated. This experiment has completed the function for which it was originally intended and the accumulated data are being analysed. The interest now lies in the effects of the split-plot treatment on growth and yield.

Although the raspberry variety trial planted in 1960, at the request of the Horticulture Committee of the Scottish Agricultural Improvement Council has completed its planned span of life, it is still in a healthy condition and is being retained for further use. The 1966 cropping figures show a mean yield of nearly 4½ tons/acre. East Malling Seedling 69/139 produced the heaviest yield at nearly 5½ tons/acre, compared with 3½ tons from Malling Jewel, and just under 3 tons/acre from Malling Enterprise, the poorest cropper in the trial.

The variety trial planted in 1952 cropped rather better than in 1965, with Malling Promise, Malling Jewel, Malling Exploit and Norfolk Giant all yielding over 4 tons/acre. The lowest yield was from Malling Enterprise (2½ tons/acre) with Lloyd George only slightly better. Both these varieties are severely affected by virus disease. With the exception of Malling Jewel and Malling Enterprise, the low nitrogen plots produced a higher yield than the high nitrogen plots.

A trial of fungicide spray treatments for the control of *Botrytis cinerea* was carried out on a three-year-old block of Malling Exploit. High and low pressure applications of dichlofluanid, difolatan and captan were made at a rate of 200 gal./acre at seven-day intervals, the first being three days after the first blossoms opened. The mean yield of each treatment was better than that of the unsprayed control, but, probably due to uneven cane production in the plantation, the differences were not significant.

To assess the effects of treatments on latent infection, plugs taken from samples of apparently healthy fruit were incubated and counts of primary infections made. Difolatan applied at high pressure gave a significantly better control of infection than the other fungicides. There were no significant differences between the other fungicides, although dichlofluanid applied at high pressure showed a significant improvement on the unsprayed control.

Strawberries

The second phase of the strawberry defoliation experiment planned by the Horticulture Committee of the Scottish Agricultural Improvement Council was completed in 1966 when the second pairs of blocks, planted in 1962, were fruited for the last time and crown counts made on each plant. The remaining third of the experiment, planted in 1963, was divided finally into quarter plots, and defoliation treatments applied after harvest. The effects of defoliation on inflorescence numbers and yield in 1966 again showed the importance of correct timing of the treatments. It appears that the sooner defoliation is carried out after picking is finished, the better, and in 1965, should have been on or before August 13. The timing of defoliations, however, appears to have no effect on crown numbers, although differences due to defoliation histories were recorded.

The third in a series of S.A.I.C. Horticulture Committee experiments to assess the performance of runner plants planted out from cold storage on three different dates was fruited for the last time in 1966. Planting dates were 15 April, 29 May and 30 June, 1964, and half the plants were deblossomed that year. All plots cropped well, with the yield from the deblossomed ones being the heavier. The deblossomed plots improved in yield with later planting, while the reverse was true of the plots not deblossomed. The fruits produced by the deblossomed treatments were larger than the others.

1966 yield records from a defoliation experiment with Templar planted in 1962 showed that, although there was some indication that the earliest defoliated plots suffered less of a set-back than the later defoliated plots, the undefoliated controls produced the highest yields. The variety cropped quite well, however, producing an average of over 5½ tons/acre. In a variety trial planted in 1964 all varieties cropped well, the heaviest yield being from Redgauntlet at nearly 7 tons/acre. Talisman and Cambridge Favourite cropped at 6½ tons, A41 at 6⅓ tons, Crusader at over 6 tons and Templar at 5⅓ tons. The effect of defoliation on all but Cambridge Favourite was to increase yield and this reflected the pattern set by inflorescence counts.

The influence of fungicide spray pressure was examined in an experiment on field control of *Botrytis cinerea* in the variety Templar. Two fungicides, dichlofluanid and captan were each applied at pressures of 50 p.s.i. and 300 p.s.i. The rate of application was the same in all cases at 200 gal./acre of a solution recommended by the manufacturers. Dichlofluanid at both high and low pressures showed a significant reduction on the incidence of *Botrytis* compared with the unsprayed control. There were, however, no significant differences between the fungicides. The yields followed the pattern set by

infection incidence figures, although the differences were not significant. This lack of significance may be due to the fact that 1966 was a season in which *Botrytis* caused relatively little damage, possibly due to the dry weather at flowering time and through most of the harvesting period.

Blueberries

Eight varieties of American highbush blueberry, Berkeley, Bluecrop, Blueray, Burlington, Collins, Coville, Earliblue and Jersey were fruited outdoors in pots for the first time in 1966. Fruit of good size and quality was produced, the picking season starting on the 16 August and finishing on 19 September. From a processing point of view the season of this crop is convenient, coming as it does towards the end of the raspberry harvest. (M. R. Cormack, G. G. Hutchison).

A note on crop yield figures

The presentation of crop yield figures from small experimental plots on a weight-per-acre basis is often criticised as being unrealistic. While this may be so for agricultural crops it is much less so for intensively-grown horticultural crops, where growers' yields should approximate more closely to those obtained from experimental plots.

In this report experimental yields have been given on a rate-per-acre basis in the belief that this enables a grower to judge the potential for a crop and to measure his crop performance against it. It also assists the reader in assessing the validity of the results. Treatment differences may be significant statistically, but are less convincing if the overall crop was a near-failure for causes unconnected with treatments, a fact which is obscured by publishing relative yields.

Among the reasons for the superiority of experiment yields over growers' yields are the exclusion of headland areas from calculations of plot yields, avoidance of inferior sites, better plant stands, and more complete picking of produce. If a correction for harvested area is made and there are still large differences between field yields and plot yields, the conclusion must be that field soils, cultural techniques, or harvesting method could be improved. How far this is possible may be a problem for the research worker. How far it is economically justifiable is a decision for the grower. (P. D. Waister).

Mycology

A. R. WILSON

The past year has again been one of expansion both in the staff and the research activities of the Section. M. Pérombelon joined us in May 1966 from the Mauritius Sugar Industry Research Institute to work on the blackleg/soft rot complex in potatoes with particular reference to the factors involved in soft rot breakdown in store. Before taking up his duties here he spent three weeks at the D.A.F.S. Agricultural Scientific Services Laboratories, East Craigs, Edinburgh to gain experience in working with soft rotting coliform bacteria. We are grateful to the Director, Dr D. W. Williams, and to Dr D. C. Graham for the facilities provided. R. Lowe was appointed Assistant Experimental Officer in June 1966, to assist me in a joint project with the A.R.C. Ditton Laboratory on the sugar content of Record potatoes in relation to the requirements of the processing industry; he was replaced as Scientific Assistant by Sheila Forsyth. Patricia Dashwood joined the staff as an Assistant Experimental Officer in September 1966, to assist R. A. Fox with his work on potato gangrene. Other changes in the Scientific Assistant staff occurred during the year; Patricia Julian and Pamela Majer resigned in July and October 1966 respectively and Eileen Jackson, Christine Barnett and T. Boyle were appointed in September and December 1966 and January 1967 respectively.

During the summer of 1966 we were fortunate to have as a guest worker Dr Halina Borecka from the Instytut Sadownictwa, Skierniewice, Poland, who spent two months with W. R. Jarvis working on problems in grey mould of strawberries. She had been awarded a Filewicz Bursary by the Polish Government and came under the auspices of the British Council. Dr Borecka became a very active and popular member of staff and we were very sorry to lose her when her visit came to an end in July.

We congratulate Dr J. S. W. Dickens, who worked under the joint supervision of Dr Nicolson of Queen's College and myself from 1961-64, on the award of the degree of Ph.D. (St. Andrews) for his thesis 'Stamen blight of Raspberry.'

Our joint Seminars with the Botany Department of Queen's College, now in their fifth year, continued to provide a useful focus for the discussion of current research problems and we are most grateful to Dr Nicolson and his staff for their support.

In July 1966, 32 workers from seven countries met here for four days to discuss the biology of diseases caused by species of *Botrytis*. The proceedings, which are unpublished, were informal and provoked lively discussions. New contacts were established and we hope that our visitors benefited as much

from the very free interchange of ideas and information as we did. We are indebted to the Warden and Staff of West Park Hall, Queen's College for the excellent domestic arrangements.

In February 1967 the Institute and Section were glad to act as hosts to a meeting of U.K. workers on potato gangrene, sponsored by the Working Party on Tuber Diseases of the A.R.C. Technical Committee on Potato Problems; we were particularly glad that Mylnefield was selected as the venue for this meeting in view of the greatly increased interest of the Section in potato pathology in general and gangrene in particular.

Travel grants from the Agricultural Research Council and the Potato Marketing Board enabled R. A. Fox, Mrs Dorothy Spencer and myself to attend the Third Triennial Conference of the European Association for Potato Research in Zürich in September 1966. At the General Meeting which followed the Conference, I was re-elected Vice-President of the Association for a fourth term of three years.

A travel grant from the Agricultural Research Council enabled D. A. Perry to visit various Institutes in Wageningen in June 1966, including the Government Seed Testing Station (R.P.v.Z.) and the Institute of Phytopathological Research (I.P.O.).

In conclusion, I should like to express our thanks to the many people, in addition to those mentioned by name in the text of this Report, who gave facilities and advice to the Section, and who supplied samples of fungicides, seeds and other materials.

GREY MOULD OF SOFT FRUIT

Susceptibility of strawberry flowers and fruit to B. cinerea

Infection of strawberry flowers results either in a blossom blight, or in the establishment of symptomless latent infection. In six varieties of strawberry, the incidence of blossom blight was significantly higher ($P<0.01$), and the lesions more severe when flowers were inoculated at the fully-open stage, both in a controlled environment (20°C. and about 95% R.H.) and in the field, irrespective of whether the inoculum was a spore suspension or dry spores. Green buds were relatively resistant to infection in the context of blossom blight, while white buds and old flowers at petal fall were moderately susceptible.

In the field, the incidence of lesions on the flower (usually the calyx) in 1966 varied from 56.5% in Royal Sovereign, through Crusader, Cambridge Favourite, Templar, Talisman to 22.3% in Redgauntlet. The incidence of lesions on the ripe receptacle, determined after storage for one day (so as to assess fully the incidence of latent infection), was again highest when inoculations had been made at the open flower stage, and least at the green bud stage, while white buds and old flowers were intermediate. The incidence of receptacle lesions varied from 22.3% in Royal Sovereign to 1.2% in Templar, and there was no correlation between the incidence of blossom blight and the incidence of receptacle lesions in the same flowers.

Senescing strawberry flower parts stimulate spore germination; nectar, containing 9% total sugars, greatly stimulated germination, as did, in decreasing order, intact anthers, dehisced anthers, and pollen grains. The stimulative effect of anthers varied from flower to flower, and between anthers at a comparable stage of development from the same flower.

Ripe fruits were significantly more susceptible to artificial infections than immature ones and significant differences in the growth rate of the fungus occurred in different varieties which could neither be correlated with the incidence of the disease in the field, nor with the concentration of calcium, total nitrogen, potassium, magnesium or sodium in the fruit. (W. R. Jarvis, H. Borecka).

Spray timing

The timing of spray programmes during flowering and fruiting of strawberries and raspberries has been largely empirical and the terminology used to characterise the progress of flowering of the crop as a whole is often fairly meaningless; stages described as 'early flowering,' and full bloom' and 'petal fall' are very difficult to recognise in the field. Detailed counts throughout two seasons of the relative proportions of flowers in seven arbitrary stages (green buds, white buds, open flowers, old flowers at petal fall, green fruit, white-pink fruit and ripe fruit), in a number of strawberry and raspberry varieties have confirmed the imprecision of this terminology. No clear demarcations or maxima occur, and it is concluded that the only satisfactory way of expressing progress of flowering is in terms of % flowering, here defined as the proportion of opened buds. Frequency distribution curves for the various stages show wide differences between varieties in rates of flower development, and, within varieties, smaller differences between seasons and localities.

In an attempt to improve the efficiency of spraying programmes, a method has been devised of calculating spray schedules from flower stage distribution patterns and expressing the results in terms of % flowering. This method of deriving spray schedules has yet to be tested over a number of seasons and in a number of localities, but the results so far suggest that once a schedule has been established for a particular variety it can be followed in other seasons and localities without serious error. The flowering pattern relative to % flowering probably remains essentially the same, although it may be expanded or contracted or displaced in time. The discrepancies resulting from adherence to given % flowering points may be no more than two or three days from the required points on frequency distribution curves for susceptible flowers, and smaller than errors imposed, for example, by inability to spray in bad weather. As in present programmes, these new schedules may be modified by economic and such other considerations as the dubious value of spraying in very dry periods and avoidance of unacceptable fungicide residues.

The extent to which inflorescences are exposed outside the leaf canopy has an important effect on coverage by fungicides as well as on flower microclimate. This is particularly so in strawberries; in 1964, maximum exposure occurred 10-14 days before the median flowering date (at which the incidence

of susceptible flower stages is highest) in most strawberry varieties, the point in flowering at maximum exposure varying from 11.5% in Cambridge Rearguard to 42.5% in Cambridge Favourite. There was a seasonal difference which could well be a nutritional effect. (W. R. Jarvis).

STAMEN BLIGHT OF RASPBERRY

Over 88% of diseased canes in observation plots of Malling Jewel in 1966 were carried on stools which had borne diseased canes the previous year; the remainder were on stools next to these. The results of field experiments indicate that dispersal of spores of the pathogen (*Hapalosphaeria deformans*) by rain is effective over only relatively short distances though this could be sufficient to result in spread from one row to the next, particularly in a mature plantation. By the time the flowers open, most of the spores formed in pycnidia within the anthers have been extruded and are available for dispersal. Observations on one plantation of Malling Jewel in 1966 showed that large quantities of spores were available for dispersal from about 20 June onwards; periods of actual dispersal were determined by rainfall and the numbers trapped after 22 June quickly decreased to a low level which remained constant up to 25 July when the experiment ended. Failure to eradicate the disease by removing diseased flowers or cutting back the fruiting canes to a foot or so above soil level before flowering, appears to result either from the production of diseased inflorescences from lower nodes late in July or from spores shed after flowers have opened and before these have been removed. Over 80% of diseased inflorescences in Malling Jewel occur on the lower and middle sections of canes. It is not entirely clear why this is so but the explanation may lie in the time of emergence and rate of growth of young canes in relation to the period of maximum spore dispersal.

Artificial infection of axillary buds, hitherto not achieved, was successful in 12% of inoculations in the glasshouse and 7% in the field; both spore suspensions and diseased flowers were effective. When buds were examined 17 days after inoculation, clumps of ungerminated spores were found between the bud scales but no spores or hyphae were seen internal to this. Susceptibility of axillary buds to infection is being examined in relation to their development and to varietal susceptibility. So far there is no evidence for the idea that the raspberry mite (*Eriophyes gracilis*) acts as a vector in bud infection. Likewise no evidence has been obtained that *H. deformans* from wild blackberry (*Rubus fruticosus*) can infect raspberry (*R. idaeus* var. Malling Jewel).

Captan, at a concentration of 1½ lb. wettable powder (50% captan)/100 gal. (0.075% a.i.), was sprayed to run off young green canes of Malling Jewel on 17 and 24 June or 15 and 23 July 1965. The June treatment reduced the percentage of diseased inflorescences from 7.29 (1965) to 1.16 (1966), and that in July from 8.55 to 1.65; in the unsprayed control plots the comparable figures were 7.79 and 6.51. The differences between sprayed and unsprayed plots are significant and indicate that spraying with captan offers a promising means of controlling the disease.

Acknowledgment is made of the help given by Mr D. H. Turner, East of Scotland College of Agriculture in the fungicide applications in the captan trial, of the co-operation of Mr G. Bruce and Mr A. W. Bruce of Pathhead Farm, Kirriemuir where the trial was sited and of the advice on layout and statistical analysis of Dr M. R. Sampford, A.R.C. Unit of Statistics, Edinburgh. (I. G. Montgomerie).

COLD STORAGE OF STRAWBERRY RUNNERS[1]

More rotting occurred in Cambridge Favourite where the temperature during storage fluctuated above, rather than below, 0°C. It was known that degeneration of tissues in the rootstock is responsible for the death of runners either before or after planting. Fungi were isolated from transverse sections of rootstocks taken from samples stored under both environments, at intervals up to 10 months. Those fungi most frequently isolated were, one of three sterile fungi, *Cylindrocarpon radicicola* and a *Pythium* sp. Only the last two, together with a *Gloesporium* sp., were more frequently associated with the poor storage environment and of these, only the *Pythium* sp. was isolated at each sampling date. Other fungi, not particularly associated with either storage environment, and found with varying frequency, were *Botrytis cinerea*, *Fusarium avenaceum*, *Fusarium* sp., *Gnomonia fructicola*, *Penicillium* sp., *Rhizoctonia solani* and two other sterile fungi.

The help given by Dr Q. D. MacGarvie, D.A.F.S., Agricultural Scientific Services, East Craigs, Edinburgh, now at the Agricultural Institute, Oakpark, Eire, in identifying these fungi is gratefully acknowledged. (I. G. Montgomerie).

RED CORE OF STRAWBERRY

Seven strawberry varieties or seedlings were inoculated with a zoospore suspension of a highly pathogenic race of *Phytophthora fragariae* and an assessment made 14 days later of the length of root invaded by the fungus. Penetration was greatest in Huxley decreasing progressively in Little Scarlet, 52AC18, Oberschlesien, 53Q13, Perle de Prague and Auchincruive No. 6. Whether these differences are related to field resistance is unknown. (I. G. Montgomerie, K. C. McConnell, W. I. A. Jack).

GANGRENE OF POTATO

Isolations were made from lesions in 129 tubers selected from 83 stocks of Scottish seed potatoes, representing 41 varieties, which had been grown on many different sites and soil types. No fungi were obtained from six lesions, mixtures of various species from 14, *Phoma solanicola* from two, and *Phoma*

[1] An account of experimental work with fungicides and other treatments is given in the report of the Physiology Section (p. 54).

foveata[1] from 107. Nearly one-third of the total tubers (38) were selected because they had lesions of the shallow type known as skin necrosis; no fungi were isolated from five of these, various species from nine, *P. solanicola* from one and *P. foveata* from 23. Tissue from lesions in 100 tubers which had yielded *P. foveata* were examined microscopically. Duplicate sections indicated that lesions characteristically possessed (57) or lacked (43) thick-walled resting mycelium, usually darkly pigmented; some cells, being swollen, could be described as chlamydospores.

The anthraquinone pigments produced *in vitro* by *P. foveata* when first isolated, and which then readily distinguish it from allied species of *Phoma*, have not yet been detected in infected tissue. Pigment production is not a constant character of the fungus and isolates differ in the readiness with which they may lose or regain their capacity for pigment production during continued sub-culturing; these variations are themselves erratic and, so far, appear to have no particular physiological significance. Some isolates, in dual culture, readily grow towards each other, but others show mutual inhibition even, in some cases, when obtained from different parts of the same lesions, suggesting that there may be physiological races of the pathogen.

Although *P. foveata* can grow quite profusely over glass for up to 2 cm. from a food base, it has not been observed to grow through soil and only traces of mycelium have been found on the periderm above lesions in infected tubers. Under experimental conditions known to favour infection, contact infection from an established lesion to an adjacent healthy tuber has not been proved. These observations suggest that growth of the pathogen is inhibited by the general soil microflora and by that of the tuberplane, in turn suggesting that conditions permitting growth and establishment in the periderm of the infective propagule may be very critical.

Five varieties representing very susceptible, susceptible, intermediate, resistant, or very resistant categories were grown in four replicates in a randomised block. Tubers were harvested by hand at 10-day intervals from early August until late October and compared for their reactions to two methods of infection; by brief immersion in dilute mixed homogenates prepared from four isolates of *P. foveata* and by inserting a macerated mixture of the same isolates in small standard wounds. The observed responses, when compared between varieties, within varieties and with time, were, broadly, of increasing resistance with increasing age. Within this broad framework there was, however, a complex pattern which will require much further work before it can be understood. In brief, there appear to be three main zones of reaction; first, the periderm and a layer of cells up to 2 mm. deep behind it; second, a layer 1 to 6 mm. deep behind the first zone; third, the rest of the interior of the tuber. The resistance or susceptibility of these zones may vary between varieties at a given time and within a given variety with time. Support for these concepts

[1] Use of the specific epithets *foveata* and *solanicola* does not imply acceptance of their taxonomic validity.

was obtained using three varieties, when small inocula were applied to unwounded tubers or inserted into standard wounds of different depths.

Different cultural practices were compared for their effects on tuber susceptibility to gangrene using the two infection methods noted above. Three haulm treatments, followed by three intervals before harvesting, were used at two times in the growing season in a randomised split-plot experiment. In comparison with no treatment, killing the haulm by acid early in the season decreased tuber susceptibility, the benefit tending to increase somewhat with the increasing interval before harvesting; in contrast haulm pulling heightened susceptibility. No consistent effects were observed when these treatments were compared later in the season. (R. A. Fox, P. Dashwood).

BLACK SCURF ON POTATO[1]

Growth of *Rhizoctonia solani* on the surface of tubers in a field experiment, where black scurf-infected seed tubers had been planted, was not evident until plants were 14 weeks old. Sclerotia were first detected 17 weeks after planting, but only on a small number of tubers which had ceased to enlarge. Mycelial investment of tuber surfaces continued to increase up to the time of haulm destruction, though few additional sclerotia were formed. After haulm destruction the number of tubers bearing sclerotia, the numbers of sclerotia on them, and the density of mycelial investment, all increased. Three factors affected these increases; the timing and type of haulm treatment, and the interval between treatment and harvesting.

Sclerotia were found on fewer tubers where the haulm had been pulled than where it had been left untouched or burnt down with acid. If treatments were applied to haulms in a vigorous state of growth, early in the season, more infection was recorded in acid-sprayed plots than in those which were left untouched. Where haulms had begun to senesce by the time of treatment, the reverse situation was true. The longer the tubers remained in the soil after haulm destruction the greater the proportion with sclerotia on them. Spatial distribution of sclerotia was determined on tubers from the plots harvested last; there were significantly more at the rose than at the heel end ($P<0.05$).

The variability of *R. solani* is well known but isolates from sclerotia on potato tubers have been little studied. As sclerotia on seed tubers can be a source of inoculum in the following season, the pathogenicity of such isolates to potato sprouts, as distinct from their ability to cause black scurf on the succeeding crop, is of interest. Eighty-six isolates were obtained from many varieties of potato grown on a wide range of soil types and sites in Scotland. Four isolates were tested for their pathogenicity to potato sprouts; the incidence of infection ranged from low to 100%, but the severity of the damage was not great, whereas an isolate from a potato sprout lesion infected all the sprouts, almost 90% of them being partially or completely severed.

Variability among isolates from sclerotia was further confirmed by examining their pathogenicity to detached potato leaflets. Tests were made with

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

three isolates of differing pathogenicity on detached leaflets selected by a standard sampling procedure from plants of the variety Majestic grown in the field. Invasion of the leaflets ranged from slight to extensive and, with the scoring method used, all three isolates differed significantly ($P<0.05$). The test was repeated on leaflets of varying ages. The isolate which had been most virulent to young leaflets when used in the first test, remained so in all tests, while the two others varied in their activity. Tests with the same three isolates showed that, of the five varieties examined, Record was the most susceptible, followed by Pentland Envoy, King Edward, Majestic and Golden Wonder.

Leaflets of the variety Majestic showed a continuous spectrum of reaction, from mild to very severe, in tests using 86 isolates: thus there was no indication of groups differing in pathogenicity. No correlation could be established between pathogenicity to leaflets, the rate of growth in culture, the type of sclerotia formed, or the source of the isolate. The relationship between pathogenicity to leaves and to sprouts is still under investigation. (D. Spencer).

BACTERIAL SOFT ROT AND BLACKLEG OF POTATO

During November 1966 about 1,200 tubers from stocks of Majestic (5), Pentland Crown (1) and Record (1), grown in Angus and Perthshire, were examined for the presence or absence of soft rotting bacteria. Two of the stocks, both Majestic, had been severely affected with late blackleg, while the other five had been relatively free from the disease. Conditions favourable for rotting were provided by placing the samples in closed containers at room temperature (c. 18°C.) and high humidity for 10 days. Between 80 and 90% of the tubers in each sample rotted, irrespective of variety or origin. About 600 representative isolations were made from the rotted rubers, using McConkey pectate agar as a selective medium. A preliminary check, using the Kovacs oxidase test, suggests that approximately 95% of the pectolytic isolates are *Pectobacterium* spp.

A random sample of about 100 tubers was taken from one of the Majestic stocks, after 4 weeks commercial bulk storage, to determine the location of the soft-rotting organisms. Isolations were attempted at four depths, using 20-25 tubers in each case. The majority of the pectolytic bacteria, assumed to be *Pectobacterium* spp., carried by the tubers, came from the surface and from inside the lenticels, whereas the periderm layer was relatively free of them and none was isolated from the level of the vascular ring. When tubers of another of the Majestic stocks were allowed to dry for 3 weeks at 5°C. in the dark, no organisms could be isolated from the surface, although contamination at the other depths was substantially similar to that in the first stock. This work is being repeated on the same stocks after a further 20 weeks in store.
(M. Pérombelon).

SUGAR CONTENT OF POTATO TUBERS

In 1966, plots of the variety Record were grown from the same stock of seed, under as similar conditions as possible, at 15 centres extending from Bedford-

shire in the south to Aberdeenshire in the north (nine in England, six in Scotland). The following data were collected at each centre on samples lifted fortnightly from tuber initiation to maturity: weight of haulm, yield, and contents of dry matter, reducing sugars, and non-reducing sugars in the tubers.

The total sugar content of both the Scottish and English grown Records 1-2 weeks after tuber initiation was 1.5-1.8% (fresh wt. basis). Thereafter it fell but the rate of fall was much more rapid in England, irrespective of whether in the south or in the north. Five weeks after tuber initiation the average total sugar content of the English crops was about 0.5% and of the Scottish about 1.0%. In both cases a final comparatively low level was reached at about 12 weeks, averaging about 0.15% in England and 0.25% in Scotland. Soon after tuber initiation, sucrose was the predominant sugar, forming some 80-85% of the total. By the end of the growing season the proportion of reducing sugars had risen to 40-50% in Scotland but only to 25-50% in England. This means that the content of reducing sugars in the mature English Records averaged about half that in the Scottish. In this season, however, despite the higher reducing sugar content, the Scottish samples would have been acceptable for crisping when mature. Rather earlier, at the end of August, they would not have been, whereas the English crops had already reached an acceptably low level. Although it accords with the general experience of the processing industry, there is no obvious explanation of this difference between the Scottish and English grown Records and further work on the problem is necessary. There is no correlation, for instance, with any difference in the rate of bulking or in foliage development and longevity. Meteorological data and soil analyses have been obtained but not yet studied.

The residual crop from each centre was lifted and subjected to different conditions of storage and the dry matter and sugar contents of the tubers are being determined at intervals.

Preliminary observations at one centre in Scotland in 1966 on several British and Continental varieties, selected for their crisping potentiality, showed that both total sugar and reducing sugar content of the tubers at maturity ranged from considerably higher to very considerably lower than that of Record. Further trials are being undertaken to establish whether these varietal differences are consistent from year to year.

Acknowledgment is made here of those who helped in that part of the work done in Scotland: Dr J. L. Hardie, D.A.F.S., Agricultural Scientific Services, East Craigs, Edinburgh, the staffs of the Edinburgh and East of Scotland College of Agriculture and the North of Scotland College of Agriculture, and the following growers on whose farms plots were sited: Mr G. B. R. Gray, Preston Mains, East Linton; Mr V. C. V. Cowley, Crowhill Farm, Innerwick, Dunbar; Mr J. P. Crichton, Falsely, Innerwick, Dunbar; Mr W. Andrew, Upper Smiddyseat, Turriff; Messrs W. and A. Strachan, Millfield, Cuminestown, Turriff; and Mr W. A. Benzie, Gairnieston, Turriff. (A. R. Wilson, R. Lowe, W. G. Burton[1]).

---

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

A field survey of plant populations in Eastern Scotland confirmed the variability of emergence between various bulk pea seed lots, and the poor relationship with germination test results found in the 1964-65 trials at Mylnefield. Field populations varied between 24 and 95% of those expected from the sowing rates.

Pre-planting vigour test

Nineteen different seed samples of the varieties Kelvedon Wonder, Lincoln and Dark-skinned Perfection were planted in a field trial on 15 March, and results from laboratory tests were compared with the field emergence figures to define a suitable pre-planting vigour test. A modification of one of the official germination test methods gave a better correlation with field emergence ($r = 0.85$) than the official test ($r = 0.61$)[1]. Surface-sterilised seeds were sown in Molochite[2] or pure silica sand containing 15% w/w water and maintained at 20°C. with 12 hr. illumination daily. The test was concluded after 6 days, instead of at least 10 days for the official test, and only seedlings which had made strong, normal growth were counted. Seedlings which developed slowly or abnormally were rejected because they were considered to be more susceptible to soil-borne pathogens than those which grew vigorously. Seedling development was not correlated with the rate of radicle emergence from the seed coat, nor with seed size. A full account of this work is in preparation.

Cause of low vigour

Two samples of Kelvedon Wonder of low vigour and two of high vigour, as determined in the 1965 trials, were sown in pots in a glasshouse. The plants received a regular balanced nutrient supply and were watered until the daughter seed was fully mature. The parent and progeny seed were sown together in the field in a split-plot design on 15 March. The emergence of the parent lines were similar to those obtained in the previous year, whereas those of all the progeny seed were high, irrespective of the vigour of the parent, indicating that vigour was a phenotypic rather than a genotypic property.

In further glasshouse experiments, seed was harvested from plants of several varieties from the full green pod stage to complete maturity. Low vigour, manifest by symptoms similar to those seen with commercial seed in the laboratory test, occurred in immature seed.

Effect of low vigour on yield

One sample each of high and low vigour of two varieties, Kelvedon Wonder and Lincoln, were sown in field plots at seed rates calculated to provide similar plant populations. Plants were thinned where necessary after emer-

[1] Laboratory analyses were done by the Official Seed Testing Station, Edinburgh.

[2] Calcined aluminium silicate from English Clays Lovering Pochin & Co. Ltd., St. Austell, Cornwall.

gence to achieve populations of 250 plants per 25 sq. ft. The mean plot yields from high and low vigour seed of Kelvedon Wonder were 10.2 lb. and 8.4 lb. (S.E. $\pm$0.65) respectively, and of Lincoln were 8.5 lb. and 7.1 lb. (S.E. $\pm$0.48) respectively showing that vigour can influence final crop yield irrespective of its effect on population. There were no significant differences in tenderometer readings of samples from individual plots within the varieties to bias the yield results. (D. A. Perry).

MISCELLANEOUS

Cavity spot of carrots

A field survey revealed that cavity spot was widespread, although of variable incidence, in carrot crops in the main growing area around Carnoustie.

American work suggested that the disorder was caused by soil calcium deficiency which could be induced by an excessively high level of major inorganic nutrients, particularly potassium. To test this hypothesis in Scottish conditions, excessive quantities of high potash fertiliser were applied in a replicated field trial to a sandy soil at East Scryne, Carnoustie before sowing. The mean percentages of roots with cavity spot increased as the crop matured from 6% in September, to 15 and 24% in October and November respectively. Fertiliser applications did not consistently affect cavity spot, but there was a correlation ($r = 0.55$, $P = 0.01$-0.001) between available soil calcium and incidence of cavity spot when the 24 plots comprising the trial were considered individually.

Thanks are due to Mr A. Gordon Porter for providing land and facilities for this trial. (D. A. Perry, T. G. Rubens[1]).

Verticillium spp. in strawberry

In August 1965, *Verticillium nigrescens* was isolated from the petioles of wilting plants of the variety Templar. Inoculation of this variety, Crusader, and Talisman, before potting, by dipping runner roots in spore suspensions from the Templar isolate or from another isolate from potato[2], failed to establish pathogenicity.

V. dahliae was isolated from the petioles of wilting plants of the variety Crusader. (W. R. Jarvis).

PUBLICATIONS

FOX, R. A. (1966).[3] White root disease of *Hevea brasiliensis*: collar protectant dressings. *J. Rubb. Res. Inst. Malaya*, **19**, 231-241.

(Sources of infection of white root disease, caused by *Fomes lignosus*, are not manually eradicated but are left to be biologically neutralised, a process enhanced by planting a creeping legume cover. It is particularly desirable to protect the collars of trees near known sources of infection. It has been known for some time that physically checking

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

[2] Kindly supplied by Dr Mary Noble, D.A.F.S., Agricultural Scientific Services, East Craigs, Edinburgh.

[3] This paper reports work done at the Rubber Research Institute, Kuala Lumpur, Malaya.

epiphytic growth effectively controls longitudinal progress of the disease inside the root. This paper describes laboratory and field experiments to develop formulations designed to check epiphytic growth at the collar. PCNB at concentrations of 15% and 20% in non-aqueous carriers is effective for over a year).

MONTGOMERIE, Isabel G. (1967). Pathogenicity of British isolates of *Phytophthora fragariae* and their relationship with American and Canadian races. *Trans. Br. mycol. Soc.*, **50**, 57-67.
(The pathogenicity of 27 British isolates of *Phytophthora fragariae* Hickman to strawberry varieties and seedlings is described and nine physiologic races are characterised by the response of Huxley Giant, Perle de Prague, Redgauntlet, Talisman, Siletz and an Auchincruive seedling, 52AC18. The relationship between these races and those described by Hickman is examined and a classification of British races suggested. Tests of the pathogenicity of American and Canadian races are described and the results related to the British classification).

PERRY, D. A. (1967). Seed vigour and field establishment of peas. *Proc. int. Seed Test. Ass.* **32** (in press).
(Precision-sown field trials of 51 seed samples of various pea varieties demonstrated a wide range of emergence ability between the samples which was not always related to laboratory germination and was independent of variety. Poor emergence was sometimes associated with hollow heart or seed coat injury. Seed size did not affect emergence. Emergence over all samples was improved by late planting and by fungicidal seed treatment, although samples with high emergence ability responded less than poor samples).

PERRY, D. A. (1967). Carrot root disorders. *Agriculture, Lond.* **74**, 222-225.
(A semi-popular account of cavity spot, five o'clock shadow and clayburn disorders of carrot roots).

PERRY, D. A. (1967)[1]. Premature death of groundnut plants in Northern Nigeria. *Expl. Agric.* (in press).
(Premature wilting and death of groundnut plants in Northern Nigeria was caused mainly by termites excavating the xylem tissue of the roots. It was also caused to a lesser extent by unidentified lepidopterous larvae, a vascular disease associated with *Pythium myriotylum* and mechanical damage. Complete severance or blockage of the root xylem did not cause immediate death because the pods and pegs were able to absorb sufficient moisture to maintain the plants above permanent wilting point until the onset of the dry season when premature death occurred).

[1] This paper reports work done while on secondment to the Agricultural Research Station, Kano, Northern Nigeria.

Plant Breeding

C. NORTH

The plant breeding work of the former Pomology and Vegetable Crops Departments has been consolidated in this new Section: most of the projects were long-term and have suffered little fundamental change in the re-organisation. Most of the staff members of the Genetics Department have also been absorbed in the Plant Breeding Section, but many of the projects they were engaged upon have been discontinued. However, the breeding of blackberries, begun by G. M. L. Haskell, has been taken over by D. L. Jennings; the objective being to produce thornless, upright-growing types suitable for local conditions. A. B. Wills has also continued his work on the cytogenetics of *Brassica* crops and expanded it to become his major project.

One new project, the breeding of lilies (*Lilium* species), has been started. This genus is gaining popularity as a commercial crop and the breeding work aims to produce vigorous, disease-tolerant or resistant types which can be used for forcing. It is also thought that Scottish climatic conditions may be especially favourable to the production of bulbs free from the complex of virus diseases which are so detrimental to this crop.

Two developments of the work of the Section merit special mention. In blackcurrants, sources of resistance to American gooseberry mildew have been found which make feasible the development of resistant varieties. In Brussels sprouts, the discovery that the glossy leaf character is controlled by complementary genes should greatly increase the usefulness of 'glossy' markers in the production of F_1 hybrid Brassicas.

D. L. Jennings was responsible for the organisation of a visit to America by himself, Mr G. Gilfillan (National Institute of Agricultural Engineering) and Mr G. M. Hodge (National Farmers' Union), to study the mechanical harvesting of raspberries. The tour included establishments in Oregon, Washington State and British Columbia. The group concluded that whilst the machines they saw worked well in the environment for which they were designed, there was doubt whether in Britain fruit would separate well enough from the plug for similar machines to be of use here. A joint report on the tour, addressed to the Agricultural Research Council and the National Farmers' Union, has been prepared by the delegation and published by the National Farmers' Union. I also travelled to America to attend the 17th International Horticultural Congress at Maryland, near Washington D.C. and took advantage of the opportunity to visit a number of research stations in the eastern United States and in Canada.

A number of staff changes have occurred amongst those who found them-

selves in the Plant Breeding Section. H. J.V.Gledhill left the Institute in March for an appointment as Senior Technical Officer in Computer Programming at St. Andrews University, Queen's College in Dundee. He joined the staff in 1961 and, in addition to his work on carrots, he has taken a very keen interest in statistics and computer programming. He has done much to bring modern computer techniques to the notice of the staff and we shall miss his helpful advice on the subject. Roberta Archer left to get married and was replaced by Patricia Wolfe-Murray. Joyce Walker was appointed to the vacancy left by Ilene Duncan who resigned in 1965. We are pleased to record that Pauline Topham was promoted to Experimental Officer.

BEAN

Dwarf French

Release of the variety Glamis has been delayed because it was found to lack uniformity in seed-coat colour. A line of the variety which does not suffer from this defect is being multiplied and it is anticipated that sufficient seed will be available to hand over to the National Institute of Agricultural Botany in 1967 for further multiplication and eventual release. The variety Glencarse continues to be slightly earlier and more productive than Glamis in trials at the Scottish Agricultural College centres, but its pods are less suitable for processing. Small quantities of seed will be maintained but it is not intended at present to multiply this variety for release.

Further breeding work is being continued. Selections have been made from the material arising from Glamis × Glencarse and the white-seeded character is being introduced into these varieties. Resistance to anthracnose (*Colletotrichum lindemuthianum*) is also being introduced and material has reached the fifth back-cross generation.

Dwarf runner

A form with white seed and a dwarf determinate habit has been developed from the cross made in 1962 between Hammond's Dwarf Scarlet and *Phaseolus coccineus* var. *albonanus* Bailey. This material is now in the F_4 generation and will be assessed for processing quality in 1967. (W. G. Priestley, J. Walker).

BLACKCURRANT

American gooseberry mildew

By a combination of glasshouse screening tests and the assessment of seedling populations in the field, 14 sources of resistance within the Eucoreosma section of Ribes have so far been discovered. These are Astrom, Rija, Brödtorp, Gerby, Golubka, Gornoaltajszkaja, Kajaanin Musta, Lepaan Musta, Laxton's Giant, Öjebyn, Rosenthal's Langtraubige, Seabrook's Black, Ukraina and *Ribes dikuscha.*

American gooseberry mildew was prevalent on black currant seedlings in 1966, and marked differences in susceptibility were recorded within families of young seedlings; differences in susceptibility, however, were less well-

defined in older fruiting plantations. The results of an assessment of mildew-infection on April-planted seedlings of Baldwin, Brödtorp and *R. dikuscha* parentage, and of a preliminary glasshouse screening trial of self- and cross-pollinated seedlings of Baldwin and Brödtorp, suggest that both Brödtorp and *R. dikuscha* are heterozygous for susceptibility: in crosses with Baldwin, susceptibility behaves as a simple recessive. In an earlier series of crosses planted in 1965, however, four mildew-resistant F_1 Brödtorp seedlings crossed with either Invincible Giant Prolific or Sztahanovka segregated in a resistant/susceptible ratio of 1:3, and in crosses involving two S1 Brödtorp seedlings known to be homozygous for resistance–S1/27 × Invincible Giant Prolific and S1/33 × Vistavotnaja–approximately half of the seedlings were scored as susceptible. This and other evidence from older seedlings of Laxton's Giant and Seabrook's Black parentage suggest that two independent loci are involved in the inheritance of susceptibility.

Black currant leaf spot

Earlier Reports have mentioned four crosses made in 1958–reciprocal crosses of *Ribes dikuscha* × Baldwin and *R. dikuscha* × Mendip Cross–designed to transfer leaf-spot immunity from *R. dikuscha* into the black currant. Observations extending over six seasons have shown that the inheritance of field-resistance is continuous and that the degree of infection ranges from apparent immunity (no acervuli observed on healthy, green leaves) to complete susceptibility. Of 160 seedlings recorded in 1965 and 1966, 73 were immune, 14 highly resistant, 39 resistant and 34 susceptible. About half of the first back-cross seedlings of immune F_1 hybrids × black currant, planted in 1963 and 1964, were also classified as immune in 1966.

Although all the hybrids are sub-fertile, the leaf spot-immune seedlings within each family are generally inferior in this respect to the susceptible seedlings.

Black currant midge

The resistance of *Ribes ussuriense* (mentioned in the 1964-65 Report) was confirmed in a replicated trial, planted in March 1966, in a sheltered site known to be heavily infested with overwintering pupae. Three Canadian hybrids of *R. ussuriense* × Kerry–Consort, Coronet and Crusader–were infested, however, as were 190 seedlings of four different families of Consort. It was not possible to score the seedlings for grades of susceptibility since they became infected with American gooseberry mildew.

Black currant yellows variegation

A yellow variegation or vein banding of black currant foliage, in its extreme form similar or identical to that found in *Ribes nigrum reticulatum*, has become a feature of some concern in the breeding programme. Yellow variegation of the foliage is common in numerous varieties in the black currant variety collection at Invergowrie, especially those of Russian origin, but it also occurs in the progenies of varieties in which yellow variegation has not been observed,

notably Baldwin and Brödtorp. The condition is inherited or transmitted through the pollen and ovules, and field observations suggest that the frequency of symptom expression in seedlings of crosses between apparently healthy and yellow-variegated plants is related to the intensity of symptoms of the affected parent. However, this is not invariably the case in self-pollinated families, especially where a symptom expression in the parent is slight.

A series of crosses to provide information on the inheritance or transmission of this condition was carried out in 1965. Although several of the segregation ratios obtained from the resultant progenies approximated closely to Mendelian ratios, it is still uncertain whether the yellow variegation is a genetical abnormality or a result of virus-infection. A transient, white streaking of the foliage, superficially reminiscent of 'streaky yellows' in strawberry, has also been recorded in the selfed progeny of a Baldwin × Amos Black seedling. (M. M. Anderson).

BRUSSELS SPROUT

New S.H.R.I. varieties

The two F_1 hybrids, designated No. 9 and 13, continue to give good results in a wide range of trials. No. 9 is now being tested in the N.I.A.B. single-harvest trial for varieties suitable for processing, and arrangements have been made for multiplication of its two parent lines with a view to possible release. Its performance over the past three years in trials at Invergowrie and Scottish Agricultural College centres has indicated that the best results are obtained by sowing outdoors in March, since it is slightly prone to premature flowering if autumn-sown or early spring-sown under glass. No. 13, the first F_1 using one glossy-leaf parent line, continues to give satisfactory yields in trials at Invergowrie and at N.I.A.B. centres, but this material may not be released since it may be superseded by improved S.H.R.I. varieties incorporating the glossy marker.

Genetic markers

Inheritance studies on glossy-leaved plants found in Irish Elegance in 1962 showed this condition to be inherited as a simple recessive. However, test crosses between glossy plants originating from the Cluseed, and those originating from Irish Elegance gave normal-leaf hybrids, indicating that the glossy condition found in plants of these two varieties is controlled by independent complementary genes. The presence of such complementary genes within varieties of Brussels sprout opens up improved techniques for the production of hybrid seed, since siblings from either of the parents are readily distinguishable from the normal-leaf hybrid between the two. An experimental hybrid, using this technique, will be grown in field trials in 1967/68. Genetical studies of glossy material found in other varieties of sprouts are being made.

Work continues on the incorporation of the character white-petal (from a broccoli × cabbage cross) into glossy Brussels sprout material. The two characters, recessive glossy and dominant white-petal, are now combined in a homozygous state in one breeding line, and this material is being used in a

back-crossing programme with the glossy Brussels sprout as the recurrent parent. Plants of the second back-cross generation, grown in the field in 1966/67, resembled Brussels sprouts in height and type, but bore only a few, rather loose sprouts. Sprout type should improve with further back-crossing. Good progress has been made in a project designed to improve the agronomic character of the glossy material; F_3 glossy-leaf families derived from crosses made with normal-leaf inbred lines, now show considerable improvement in sprout quality over the original material. (W. G. Priestley, J. Walker).

CABBAGE

Breeding work on this crop has now reached the stage when several lines with different maturity dates have been developed, and are ready for trial as potential new varieties. The F_1 hybrid cabbage, bred by S.H.R.I., is already included in the N.I.A.B. winter-cabbage trial where it is being tested against the standard winter variety January King. This F_1 matures about November to December and produces very solid green heads which hold well without bursting. The heads are rather large and the spacing/sowing date interaction on head size is being studied by the Crops Research Section.

A very uniform, autumn-maturing line, ready to cut in September/October will be tested by the N.I.A.B. in 1967, and a very late-maturing line, which matures after January King in February and March, will shortly be ready for N.I.A.B. trials. A new variety of cabbage, homozygous for the white-petal character and maturing in November and December has been developed and bulk seed of this will be produced in 1966/67. The dominant white-petal character was originally transferred from broccoli by three generations of back-crossing to a cabbage, followed by two generations of selfing and selection for good agronomic characters. (W. G. Priestley, J. Walker).

BRASSICA CYTOGENETICS

Observations of chromosome behaviour at meiosis have led to the prediction that polysomic inheritance is possible for some linkage groups in *Brassica oleracea*. A collection of suitable marker genes has been assembled during the year; presently comprising 12 genotypes, including some such as glossy foliage determined by more than one gene, they are being used to determine mode of inheritance and linkages, and some 300 progenies are now under observation. Early records on five seedling characters are consistent with simple, diploid inheritance. More marker genes are required for a satisfactory investigation and the experimental induction of mutations by chemical treatments and by irradiation is being investigated. Progenies have been obtained from plants grown from seed exposed to neutron and gamma irradiation. (A. B. Wills, R. Archer).

Induction of polyploidy

The organic solvent dimethylsulphoxide (DMSO) appears promising as a carrier for c-mitotic substances which are only sparingly soluble in water and

which are of interest in cytological investigations and for the induction of polyploidy. To determine toxicity of DMSO, seeds of broad bean and cabbage were steeped in varying concentrations of solution and germinated. Germination rate was related to the concentration of the steeping solution. Only the highest concentration (20%) prevented germination of a proportion of bean seeds but the number of ungerminated cabbage seeds was related to strength of solution at all concentrations down to 1%. Subsequently plant height was also related to concentration although these differences tended to disappear. Growing points of broccoli seedlings were treated with colchicine solutions, either alone, containing NAA, or in combination with NAA and DMSO. The survival rate of those treated with DMSO was only half that of the other treated seedlings and the survivors showed extreme effects. (A. B. Wills, P. Wolfe-Murray).

CARROTS

Selection of early-colouring, bolting-resistant lines of the Short Chantenay type was continued. Selection was also made in material tolerant to motley dwarf virus disease.

An appraisal of the factors influencing variation in root size within a high-density carrot population indicates that time of seedling emergence is one of the most important factors correlated with root size. Whereas seeds tend to germinate at a uniform rate at near optimal temperature (20°C.) this is not so at sub-optimal temperatures and temperature is one factor that may considerably increase the variation in time of seedling emergence. Variation in germination rate can also be ascribed to the genotype and to the environmental conditions obtaining at ripening of the seed crop. Flowering habit of the seed-bearing parent may possibly have considerable influence on the performance of the seed, and selections from carrot varieties and *Daucus* species are being used in an attempt to breed carrot varieties which have a protracted seed-ripening period.

A field survey of plant populations and yields of 17 carrot crops in Perthshire, Angus and Kincardineshire was made in co-operation with Mr T. G. Rubens, Edinburgh and East of Scotland College of Agriculture. The results showed that plant populations achieved in practice are generally too low to produce maximum canning yields. The average yield in the survey of roots within the canning grade harvested in mid-September was 11 tons per acre. (H. J. V. Gledhill, D. Bruce).

LILY

Many lilies (*Lilium* sp.) are especially prone to certain diseases which fall into three groups: virus diseases, fungal diseases of the root and bulb, and *Botrytis elliptica*. No techniques for assessing susceptibility to these diseases have been formulated, so that it is not yet possible to start a breeding programme with material indexed for disease resistance or tolerance. Parent material reputed to have disease resistance was used in a programme of hybridisation and the

progeny will be indexed for disease as soon as suitable tests have been determined.

Crosses were made within groups of species and varieties from S.E. Asia and from Europe. A considerable quantity of seed was obtained from the former group and it is expected that the progeny will begin to flower in 1968/69. Very few hybrids between the European species have previously been reported but a quantity of seed was obtained using *L. pyrenaicum* and *L. szovitzianum* as seed parents. Seeds from some of these crosses had faulty endosperm, but excised embryos from them were successfully germinated on sterile nutrient agar. In the course of this work is was discovered that ripe seed of *L. pyrenaicum*, which normally requires a temperature regime to break the dormancy period, will germinate without delay if part of the testa is removed and the seed placed on sterile nutrient agar. Entire seeds will not germinate on agar unless subjected to the required temperature regime. (C. North, E. B. Paterson).

RASPBERRY

The decision was taken to propagate three of our most promising selections so that one or more of them can be released in 1970, provided their performance in trials is adequate during the next few seasons. Two of these selections are early- and one late-ripening, and they were selected for their good fruit qualities and promise of high yields. There was a moderate incidence of winter injury in 1966, but two of these selections escaped without any visible injury and the hardiness of the third was rated equal to that of Malling Jewel.

Among families of unselected seedlings, it was very noticeable that those with one hardy parent suffered little winter injury, while those where both parents were non-hardy had a high incidence of cane damage. Hardiness appeared to be inherited as a dominant character, and provided that the character can be recognised, the problem of breeding for hardy varieties does not appear as formidable as was first thought. Experiments with a laboratory method of testing for hardiness, described in the last Report, gave results on breeding material parallel to those obtained in the field, and attempts to use this technique to elucidate the effects of cultural treatments on hardiness were also more satisfactory following refinements in technique. (D. L. Jennings, B. M. M. Tulloch, P. B. Topham).

Studies of the breeding system

Several aspects of studies of the breeding system and of factors which affect fertility in *Rubus idaeus* and other *Rubus* species have now reached a stage where they can be written up. Six papers on subjects related to this work were accepted for publication during the year and others are in preparation. Synopses of these are given at the end of this Report. (P. B. Topham, D. L. Jennings).

Fruit abscission

Easy separation of the fruit (easy plugging) will be an essential requirement

when raspberry varieties are harvested mechanically, but the character is affected by environmental conditions and by plant health. Work was therefore started on anatomical aspects of fruit abscission in the raspberry and other *Rubi*. A specialised abscission zone between the torus and the drupelets in the raspberry fruit has been recognised and studies of its development and histochemical characteristics are in progress. (H. M. Wilson, P. B. Topham).

PUBLICATIONS

JENNINGS, D. L. Balanced lethals and polymorphism in *Rubus idaeus*. *Heredity*, (in press).

(Populations of wild raspberries in Britain are usually polymorphic for the presence or absence of cane hairs, determined by genes *H* and *h*, and sometimes for the presence or absence of plant pigment, determined by genes *T* and *t*. A high proportion of raspberry cultivars also are heterozygous for these two genes. It is shown that the aberrant segregation ratios associated with each of these loci can be attributed to their linkage with lethal genes in such a way that the lethals form a balanced system.

Since the lethal system confers a selective advantage on the heterozygote, its presence is probably the reason for the occurrence of polymorphism and allelic diversity and also for the relatively high frequency with which recessive deleterious genes are found in this linkage group. The presence of the lethal system helps raspberry populations to maintain heterozygosity for the particular chromosome segment and may help small populations to avoid inbreeding depression).

JENNINGS, D. L. (1966). Can we pick our raspberries by machine? *The Grower*, 66 No. 21, 816-818.

JENNINGS, D. L., GILFILLAN, G.[1], HODGE, G. M.[2] (1966). Report to the Agricultural Research Council and to the National Farmers' Union of Scotland of a visit to the United States and Canada in July, 1966, to examine developments in mechanical raspberry harvesting. National Farmers' Union of Scotland, Edinburgh, pp. 12.

JENNINGS, D. L. Observations on some instances of partial sterility in red raspberry varieties. *Hort. Res.* (in press).

(A crumbly-fruit condition is sometimes found in raspberry varieties. In the variety Malling Promise a change occurred early in the variety's history and was perpetuated by intensive vegetative propagation. Results from investigation of the condition in Norfolk Giant failed to show whether an observed chromosome change or virus infection was the cause. Some of the results for Malling Promise were similar to those for Norfolk Giant, but in Malling Jewel, and possibly in Latham too, there is evidence that the condition can be caused by mutation of the dominant allele at a heterozygous gene locus to give the homozygous condition for a recessive gene affecting fertility. This gene appeared to be linked in a chromosome segment which forms part of a balanced lethal system, and this probably helps to maintain its frequency. Checking the fertility of material used for propagation is suggested as a means of reducing the incidence of crumbly fruit).

[1] National Institute of Agricultural Engineering, Scottish Station.

[2] National Farmers' Union of Scotland.

JENNINGS, D. L., CRAIG, D. L.[1] and TOPHAM, P. B. (1967). The role of the male parent in the reproduction of *Rubus*. *Heredity*, **22**, 43-55.
(Plants of *Rubus laciniatus*, a pseudogamous apomictic blackberry, and of Merton Thornless, previously regarded as being entirely sexual, were pollinated with different male parents, and auxin was applied to half of the fruits 7-9 days after pollination. In the *R. laciniatus* series, the proportion of non-hybrids differed with different male parents and was positively correlated with the ploidy of the male parent. In two of the crosses auxin treatment significantly increased the proportion of hybrids. Unreduced or diploidised gametes frequently functioned successfully, and in one cross, auxin increased the production of hybrids with high chromosome number. Many non-hybrids occurred in the Merton Thornless series also, and here too their proportion was influenced by the male parent used. The survival of different arrays of genotypes in different crosses was explained by postulating that the selection pressure on the embryo sac is determined by its relative compatibility with the genetic constitution of the pollen parent. The concept of the 'genetic strength' of a genome was of value in explaining the results).

PRIESTLEY, W. G. and WILLS, A. B. (1966). Glossy-leaf in collard (*Brassica oleracea L.* var. *acephala* D. C.) an incomplete dominant. *Euphytica*, **15**, 389-394.
(Glossy-leaf in the collard variety Green Glaze was found to be incompletely dominant to waxy foliage normal in other varieties: the suggested gene symbol is *Go*. The phenotype is similar to that controlled by a recessive gene in Brussels sprout. Further loci may be involved in other glossy-leaved forms reported in *B. oleracea* and such genes would form a useful series of markers in a breeding programme).

PRIESTLEY, W. G. (1967). Complementary 'glossy' genes in Brussels sprout and their application to the production of F_1 varieties *Hort. Res.* **7**.
(A glossy-leaf mutant occurring in the variety Irish Elegance was found to be inherited as a simple recessive, in a similar manner to that found in the variety Cluseed. Hybrids produced from crossing inbred lines from these mutants were all normal, indicating the presence of two independent complementary genes in these two varieties. Such genes will be of value in the production of F_1 varieties, since the inbred siblings from either glossy parent should be readily distinguishable in the seedling stage from the normal hybrid between the two).

TOPHAM, P. B. (1966). Dialled analysis involving maternal and maternal interaction effects. *Heredity*, **21**, 665-674.
(Assuming the existence, in a full diallel of p^2 crosses among p parents, of genic and maternal effects, genic interactions, and interactions between maternal effects and non-recurrent genotypes, expected mean squares can be derived. An index of maternal influence is used to determine to what extent the average difference between parental lines is due to maternal or paternal influence. Formulae are given for estimating parameters and their variances and covariances. The implications are discussed, using data on seed size in raspberry fruits resulting from diallel pollinations).

TOPHAM, P. B. (1967). Fertility in crosses involving diploid and autotetraploid raspberries. 1. The embryo. *Ann. Bot.* (in press).
(Crosses between diploid raspberry cultivars (*Rubus idaeus L.*) and their autotetraploid forms have shown that embryo shape depends on three main factors – the variety, the stage of development reached before growth ceases and the ploidy of the embryo itself. Embryo growth, however, depends on the ability of the endosperm to nourish the embryo and so on the harmonious co-existence of derivatives of the gametes which formed the endosperm. Crosses between plants of unequal ploidy produce endosperms

[1] Head, Small Fruits Section of Kentville Research Station, Canada Department of Agriculture, Nova Scotia, Canada.

which are unbalanced. In general, the order of fertility of the crosses is 2n selfed, 4n selfed, 4n x 2n, 2n x 4n, and this can be partly explained if the effect of chromosome doubling is to increase the genetic strength of the male gametes more than that of the female. Variations in the embryo growth in the 2n x 4n and 4n x 2n crosses are ascribed to smaller differences in genetic strength between varieties and between the male and female gametes within a variety. Embryos derived from crosses within a single variety grew less well than those derived from crosses between varieties, other factors being equal, and this is considered to be an early expression of inbreeding depression in the embryo).

TOPHAM, P. B. (1967). Fertility in crosses involving diploid and autotetraploid raspberries. II. Fruit and seed development, *Ann. Bot.* (in press).
(Variation in fruit and seed development following crosses between diploid and autotetraploid forms of raspberry cultivars is described.
Drupelet set was sensitive to a large number of influences. Varieties differed in their response but, once set, fruit growth was largely independent of seed development. Malling Jewel had a high drupelet set as a seed parent. Chromosome doubling reduced the fertility of both male and female gametes, but the effect was greater in the pollen where the ability to induce set was impaired. This is ascribed to physiological rather than chromosomal causes.
It is suggested that seed size in infertile crosses between plants of different ploidy depended on a balance between early growth, following the stimulus of fertilisation, and later, slower growth due to a weakness in the endosperm.
The rate of fruit maturation was more rapid on tetraploid seed parents, but otherwise showed few consistent features).

Plant Physiology

C. G. GUTTRIDGE

The Section's facilities were greatly improved by the completion of three aluminium alloy glasshouses which are equipped with thermostatically controlled heating and ventilating systems and artificial lighting. It is a pleasure to acknowledge the help of Mr G. F. Sheard, Glasshouse Crops Research Institute and Mr K. W. Winspear, National Institute of Agricultural Engineering, in the planning of these houses. Mr G. A. Carpenter and Mr L. J. Moulseley, also of N.I.A.E., advised on the design of a new set of growth cabinets which have been built by the Maintenance Section. A large twin-roomed cabinet is being built also to our design by John E. Bastow Ltd. Facilities for special work in the main laboratory block still leave something to be desired, but a laboratory is being renovated for work with radio-active isotopes and two small controlled temperature rooms have been equipped for bio-assay work. New developments in work with plant hormones have also necessitated some build-up of laboratory equipment which we did not previously possess.

J. W. Dancer was transferred from the former Vegetable Crops Department in April 1966 but left in September to join the staff of the Department of Biological Sciences, Portsmouth College of Technology. The work he initiated on *Brassica* crops is at present in abeyance. Mrs O. Abdel-Galil, a graduate of Alexandria University, is continuing with her post-graduate research project on growth inhibitors in strawberry.

CHEMICAL REGULATION OF PLANT GROWTH

The hormone regulation of growth in strawberry

Morphogenic studies with strawberry have repeatedly shown the dominant role of long photoperiods in regulating vegetative growth and flowering in strawberry. Experiments with mother and daughter plants joined in pairs by the stolon show that a stimulus arising in long daylength in one plant of the pair can be transported to the other, where it induces runner formation and increased leaf size and inhibits flower formation. The Section's main research effort during the year has been directed towards determining the nature of this hormone stimulus. Because the photoperiodic responses are simulated by applied gibberellins, the work is focussed along two pathways – the extraction of gibberellin-like substances, and further morphogenic studies of the response of strawberry plants in different environments to applications of gibberellins and of growth retardants, which are thought to suppress gibberellin biosynthesis.

Extraction of growth promoting substances from strawberry

In the extraction work, choice of a suitable bio-assay and the development of a method of purification are technical problems that have impeded progress. Lettuce hypocotyls detect a wide spectrum of gibberellins and this test has repeatedly shown the presence of gibberellin-like activity in methanol extracts from runner tips and mature leaf laminae. The characteristic of the natural hormone in strawberry is stimulation of growth of petioles, runners and laminae but not of vegetative stems. The known gibberellins so far tested (A_1, A_3, A_4, A_7, A_9) induce elongation of the vegetative stem, so that bio-assay on strawberry seedlings is necessary to differentiate critically between the natural hormone and the known gibberellins. *Fragaria vesca semperflorens* var. Brilliante, is used but the test is inconveniently prolonged.

No satisfactory solvent system has been found in which activity partitions in a predictable manner, but column chromatography of partially purified extracts on celite and charcoal and elution with increasing concentrations of acetone in water has yielded several fractions that possess activity, in some of which none of the known gibberellins would be expected to occur. (A. Gordon, P. B. Goodwin, J. B. Garrie).

Kaurene, kaurene-19-ol and kaurene-19-oic acid[1] are possible precursors of gibberellins but none had any effect when 5, 2.5 or 0.5μg were applied to young seedlings. (A. Gordon).

Extraction of growth inhibitory substances from strawberry

After prolonged exposure to short photoperiods, strawberry plants become dormant. In this condition enforced growth is characterised by restricted, but not weak vegetative development, and by continued induction of new flower trusses. Although there is no absolute dormancy nor formation of a resting bud as in woody plants, there are obvious parallels. The discovery by Professor P. F. Wareing and his co-workers at Aberystwyth that abscisin II (dormin) induces resting-bud formation and dormancy in several woody species, suggests that this or a similar substance may accumulate in autumn in strawberry and restrict growth.

In current work, partially purified extracts of leaves and crowns of dormant strawberry plants inhibit germination of wheat, cress, lettuce and strawberry (*F. vesca semperflorens*) seeds. This material from strawberry has not yet been characterised and its relationship with abscisin II is unknown. Although it is eluted from a celite-silicic acid column by 5% ethyl acetate in chloroform, a fraction in which abscisin II would not be expected, other results point to a similarity. (O. Abdel-Galil).

Morphogenic studies on strawberry

Some results of an earlier experiment with strawberry suggests that gibberellic acid does not entirely replace the native long-day stimulus. This situation has again been studied and the experimental results show that a further increment

[1] Kindly supplied by Dr J. MacMillan, Bristol University.

of growth of petioles is obtained in long day compared with growth in short day, even when the plant's response is saturated with exogenous gibberellic acid. This additional factor from long days induces a relatively small increment in length of petioles. It is not replaced by indolyl butyric acid, as might be expected from published work on other plants, nor by application of sucrose to the leaves.

The additional factor might be an inhibitor produced in short days rather than a promotive stimulus produced in long days, but petiole growth of receptor plants which were nearly saturated with exogenous gibberellic acid was not depressed in any way by attachment to parent plants in short photoperiods. The indications are therefore that exposure to long daylengths induces the production of an additional factor that supplements growth of plants which are already saturated with gibberellic acid. Some reserve must be placed on these interpretations as experiments with pairs of plants are complex. (C. G. Guttridge).

Effects of growth substances on rooting

In a series of sensitivity tests with lettuce seedlings used for the bio-assay of gibberellins, a number of auxins were observed to stimulate rooting, either by inducing the formation of adventitious roots on hypocotyls or by promoting growth or branching of the main root. Adventitious roots on hypocotyls were induced by γ–(3-indolyl) butyric acid (IBA); ∝ –(2, 4, 5-trichlorophenoxy) propionic acid; γ (2, 4, 5-trichlorophenoxy) butyric acid; β–naphthoxy acetic acid; ∝ –naphthyl acetic acid; and β–(3-indolyl) propionic acid. Only the second of these increased branching of the main root. (A. Gordon).

These chemicals, together with kinetin, were tested on strawberry runner plants, as some publicity has been given elsewhere to a report from U.S.A. that IBA and kinetin promoted rooting in cold-stored strawberry runner plants. Although not exhaustive, the current tests showed no promotion of rooting of cold-stored (chilled) runner plants by either IBA or kinetin, nor of dormant plants by kinetin or any of the auxins listed above. In one experiment the amount of root growth was decreased by previously dipping the plants for 10 min. in aqueous solutions of 40 or 80 p.p.m. IBA. (C. G. Guttridge, H. McC. Anderson).

The control of fruit growth in strawberry

The growth of the strawberry receptacle after flowering appears to be controlled by the carpels. Earlier work suggested that unpollinated carpels inhibit receptacle growth and that pollinated achenes produce a growth stimulator. Current studies aim to analyse this situation by assaying extracts from growing and inhibited fruit on receptacle tissue grown on an artificial medium. By no means least of the difficulties is that of accumulating bulk quantities of unpollinated 'fruits.' A culture medium following Goodwin (J. exp. Bot. *17*, 590) gave a satisfactory 9-fold increase in fresh weight of receptacle tissue in one week in early experiments but later some difficulties arose which have not yet been entirely resolved. In preliminary extractions of unpollinated, inhibited

fruits, the original 80% methanol extract, the ether-insoluble fraction and the cation-adsorbed sub-fraction all gave strong inhibition, but it now seems from more recent work that the inhibition was largely due to the pH and ammonia content of these fractions, and present results suggest that the hormone inhibitor is not extracted by 80% methanol.

The occurrence of misshapen fruits, particularly in the variety Redgauntlet in protected culture, is giving concern in commerce. There may be more than one cause, but an inadequate supply of pollen is implicated. Various light regimes have been tested in spring forcing. They had no influence on pollen formation and the incidence of misshapen fruit. However, there has been a complete failure of fruit-set when plants were transferred into the glasshouse and forced in the autumn after a limited cold treatment. Hence one cause of poor set may be insufficient chilling before forcing. (P. B. Goodwin, J. B. Garrie).

Raspberry propagation

Work done by Professor J. P. Hudson and co-workers at Sutton Bonington has suggested that the ability of adventitious buds on raspberry roots to grow is in some way dependent on season. Buds grow readily from root cuttings made during the winter months but not from roots dug at other times of the year. This is a handicap to the rapid propagation of raspberries, and work was begun to identify the causes of this seasonal behaviour. Results with young plants in pots and in the field suggest that adventitious buds are capable of growth as soon as they are formed, and will grow if the root is severed or the cane is removed, thus releasing them from correlative inhibition. This growth capability persists throughout the winter but appears to be lost in spring, because buds do not grow on root cuttings taken in June, although a few might have grown into inter-row suckers if left undisturbed in the field. The apparent seasonal dependence may reflect a loss of growth capacity in spring and the unavailability of new season buds until late summer.

Early bud-formation on roots could aid rapid propagation but attempts to stimulate it on young plants with sprays of CCC and B9 failed, and exposure to short daylengths actually checked bud-formation and inhibited root-growth. During winter more buds were induced to grow when root cuttings were exposed initially to cool temperatures compared with continuous exposure to warm temperatures. This was probably because correlative inhibition is minimal at low temperatures. Preliminary trials with cuttings showed that proximity to an etiolated portion of the stem was sufficient to permit rooting; inclusion of the etiolated portion itself was unnecessary. (H. McC. Anderson, C. G. Guttridge with J. Chambers, Virology).

Hormone regulation of growth and flowering in Fuchsia

In previous experiments, gibberellic acid inhibited flowering in long-day species and cultivars of *Fuchsia* but not in day-neutral species. Similar inhibition has occurred in scions of the long-day cultivar Howlett's Hardy when grafted on to stocks of the day-neutral *F. triphylla* cultivar Thalia, suggesting that a

graft-transmissible inhibitor of flowering was present in Thalia, although it does not inhibit flowering in Thalia itself. Because of difficulties in establishing satisfactory graft unions, attempts to confirm this have not been very rewarding. Shoots of Howlett's Hardy elongated when they were grafted to Thalia or to *F. microphylla* (a species which is only weakly sensitive to photoperiod) but the shoots of Howlett's Hardy still flowered. Experiments were also done with two-branched plants of *F. magellanica* and of Howlett's Hardy, in which one branch was exposed to short days and the other to long days. Although the internodes of the short-day branches increased in length, suggesting the transmission of gibberellin-like substances, flowering was not promoted, although the branches in long days continued to flower. These results are not clear cut and the relationship between photoperiodic regulation of flowering and flower inhibition by application of gibberellic acid remains obscure. (D. T. Mason).

FIELD INVESTIGATIONS

Brussels sprout

Serial growth analysis of Brussels sprouts indicated that maximum size and leaf number of sprout buttons was attained by early October at the time green leaf area was maximal. The results of component analyses, kindly undertaken by Dr Pearce and Mr C. Moore, East Malling Research Station, show that the loss of leaves from the plant is associated with the proportion of blown sprouts. The practice of stripping leaves to facilitate harvest is thus open to question unless the crop is intended for single harvest. These studies suggest that breeding should be directed towards plants which retain their leaves late into the autumn.

Internal browning–a physiological disorder characterised by areas of necrotic tissue in the sprout button–has been associated with large sprout size. It has occurred in plants grown in a heated greenhouse during the winter in which frost was not recorded and thus it is questionable whether the disorder is necessarily associated with frosting. (J. W. Dancer).

The effect of soil and site on the growth and yield of strawberry

The varieties Redgauntlet and Talisman crop unreliably in some fields at the Institute and certain ill-defined conditions of site and soil apparently lead to deficiencies in truss numbers in some seasons. Usually the highest fruit yields have come from sites of intermediate fertility, but when plants are defoliated after harvest the most fertile sites, judging by plant vigour, yield best. With other varieties, notably Cambridge Favourite and Cambridge Vigour, deficiencies in truss numbers have not been observed. With Talisman and Redgauntlet it is not usually the first crop (15 months from planting) but subsequent crops that suffer. The new variety Templar apparently behaves differently in that the first crop is also subject to deficiencies in numbers of trusses. This occurred in 1966 in Laboratory field which has a southern aspect; the yield was little more than half of that in Garage field which has a north-easterly aspect. However, this result may be exceptional because dissections of

crowns sampled last winter do not show a disparity in truss numbers between the two fields and a full crop is to be expected in 1967 from both. (C. G. Guttridge, H. McC. Anderson).

The control of runners in strawberry

A further trial on the use of the growth retardants Cycocel and B9 for the control of runners in the maiden year was planted in April. Plants were hand-sprayed with growth retardants in late May when the first flowers were opening. In earlier trials a single spray of 8% a.i. Cycocel at flowering time or a 4% spray then, followed by a second 4% spray in July almost completely inhibited runner outgrowth for the whole year. Although growth is temporarily depressed following the spray and the small maiden crop is lost, the suppression of runnering eventually leads to increased branching and a larger mother plant. Such plants crop more heavily than those which are allowed to runner freely and from which the runners are removed in winter. The results have confirmed that varieties differ in sensitivity. Good control was achieved in Crusader and Templar but poor in Cambridge Favourite and Redgauntlet. Previously Talisman has responded well. The addition of 1% spreader improved the response. The required rates are high, amounting in this experiment to applications of 0.8 gm. active ingredient per plant, even when applied economically by spraying individual plants by hand, and because of this, commercial usage may be uneconomic. Rate for rate, Cycocel controls runners more effectively than B9 but is more damaging to foliage. Neither chemical has been cleared for commercial use on strawberries. (H. McC. Anderson, C. G. Guttridge).

The possibility that morphactins might be used for the control of runner formation was tested in preliminary trials in the glasshouse. Two morphactins, IT 3233 (N-butyl-9-hydroxyfluorene-(9)-carboxylate) and IT 3456 (methyl 2-chloro-9-hydroxyfluorene-(9)-carboxylate) used as sprays, checked the development of runners but at the same time almost completely prevented petiole elongation. IT 3456 was slightly more active than IT 3233, and at low concentrations Cambridge Favourite was more sensitive than Talisman. Because morphactins do not appear to be translocated preferentially to the runners it seems unlikely that they will be suitable for the control of runnering in the field. (D. T. Mason).

Cold storage of strawberry plants

The critical conditions for successful storage are known from work here and elsewhere, especially in U.S.A. and Canada, but the physiological or pathological causes of deterioration need further study. Although strawberry runner plants can be dug in winter and cold stored until summer, some deterioration occurs, and this is more severe if the storage period is prolonged. Environmental effects become exaggerated after prolonged storage and so does variation between replicates. This may mean that deterioration, although slow during the early months of storage, becomes progressive and speeds up with the attainment of a critical condition after prolonged storage. Careful inspection on 29 September 1966 showed that plants lifted from the field on 3 March 1966

had deteriorated more, despite their shorter storage period, than similar plants lifted on 21 December 1965. The March plants had grown a little in storage and this suggests that, although no visible signs of growth were present at lifting time, changes in metabolism had occurred before lifting which made the plants more susceptible to deterioration in storage than the December batch. Survival (recorded one, four and seven weeks after planting in pots on 20 September) was increased by stripping away both dead and living foliage before storage, but was decreased by packing plants along with dead strawberry trash from previously stored plants. These effects might be explained if deterioration in storage was due either to pathogenic organisms or to chemical by-products of tissue degeneration and decay. Fungicide dips, before storage, of difolatan (2 lb./100 gal.), dichlofluanid (3 lb./100 gal.), or thiram at two strengths (2 and 4 lb./100 gal.), slightly improved the appearance of the plants upon removal from storage. However, the main benefit of these chemicals, especially thiram, was to decrease the numbers of plants dying between the first and seventh week after planting. Evidently the resistance of stored plants to pathogens is weak. Mycological investigations are reported on p. 31. (C. G. Guttridge, I. G. Montgomerie).

Survey of truss initiation in strawberry in S.W. England

In 1965 maiden strawberry plants in S.W. England produced few flowers and cropped badly, and during the winter 1965-66, in conjunction with Mr J. B. Duggan[1], we undertook a small survey of flower initiation in that area. This confirmed that large runners, planted early, produced the greatest number of potential cropping trusses per plant, and that planting in early to mid-September delayed truss initiation. No explanation of the trouble in 1965 could be found. (D. T. Mason).

PUBLICATIONS

GOODWIN, P. B. (1966)[2]. An improved medium for the rapid growth of isolated potato buds. *J. exp. Bot.*, **17**, 590-595.
(The medium contains a high concentration of inorganic ions and vitamins. It also has an unusual growth substance, 8-hydroxy quinoline).

GOODWIN, P. B. (1966)[2]. The effect of water on dormancy in the Potato. *Eur. Potato J.* **9**, 53-63.
(The combination of moisture, reasonable aeration and temperature of 20°-30°C. leads to an abrupt cessation of dormancy).

GOODWIN, P. B. (1966)[2]. *Fusarium* causing breaking of dormancy in potato tubers. *Trans. Br. Mycol. Soc.*, **49**, 522-523.
(A soft rot causing breaking of dormancy in tubers was identified as *Fusarium moniliforme*).

[1] Regional Fruit Adviser, N.A.A.S., S.W. Region.

[2] This paper reports work done at the University of Nottingham.

GOODWIN, P. B. (1967)[1]. The control of branch growth on potato tubers. I. Anatomy of buds in relation to dormancy and correlative inhibition. *J. exp. Bot.*, **18**, 78-86.
(Dormant buds had distinctive anatomical features, although these did not seem to be primary causes of dormancy. No distinctive features were seen in correlatively inhibited buds).

GOODWIN, P. B. (1967)[1]. The control of branch growth on potato tubers. II. The pattern of sprout growth. *J. exp. Bot.*, **18**, 87-99.
(The observed pattern is interpreted in terms of a bud inhibitor, continuously formed and continuously destroyed).

GOODWIN, P. B. (1967)[1]. The control of branch growth on potato tubers. III. The basis of correlative inhibition. *J. exp. Bot.*, **18**, 297-307.
(Feeding experiments suggested that inhibition is not due to a shortage of nutrients. A bud inhibitor was extracted, partly purified and shown to disappear from the tuber within 24 hrs. of removing the growing sprouts).

GOODWIN, P. B., MILTHORPE, F. L., BROWN, A. and LENNARD, J. H. (1966)[2]. Effect of centre of production and maturity of seed tubers on yields of early potatoes. *Expt. Hort.*, **14**, 31-38.
(The climate during the growing season was the most important determinant of yield. The effect of centre of production and maturity could be largely duplicated by appropriate storage treatment).

MASON, D. T. (1967). Inflorescence initiation in the strawberry. II. Some effects of date and severity of post-harvest defoliation. *Hort. Res.*, 7 (in press).
(In field trials in Scotland, defoliated plants of the strawberry cultivars Cambridge Favourite and Royal Sovereign usually initiated fewer inflorescences than untreated plants. By contrast, defoliation of Talisman and Redgauntlet in mid-August increased inflorescence initiation, although it did so less when performed in either late July or early September. These results suggest that the leaves can have a dual role and may control inflorescence initiation through both promotive and inhibitory systems).

[1] These papers report work done at the University of Nottingham.

[2] This paper reports work done at the University of Nottingham.

Virology

B. D. HARRISON

During the year there has been a major re-organisation of the Virology Section and its laboratory facilities. When the Zoology Section became autonomous in April 1966, R. M. Lister took over as Acting-Head of the Virology Section until he left in September to take up his appointment as Associate Professor of Plant Pathology at Purdue University, Indiana, U.S.A. I took up my post as Head of Section in October, when J. I. Cooper and R. A. C. Jones, post-graduate research students of the Ministry of Agriculture, and Potato Marketing Board, respectively, joined us. Susan Allen took time off during August and September while becoming a mother. Of our visiting workers from overseas, T. Munthe of the Statens Plantevern, Vollebekk, Norway, extended his stay by two months until the end of February 1967, and H. S. Abu Salih of the Gezira Research Station, Sudan, continued to divide his time between us and his base at Queen's College, Dundee. Among the Scientific Assistant staff, D. E. Branney joined the Section in January, and Margaret J. Cameron left in the previous September.

Early in the year the laboratory accommodation was completely re-organised to make the most efficient use of the space available, and towards the year's end the low temperature laboratory was completed. A new animal house is in the course of erection. Except for the electron microscope laboratory, which unfortunately remains in a separate building across the courtyard from the main laboratories, our facilities are now compactly arranged.

It is still too early to see any great influence of these various developments on the scope of our investigations and our productivity, but a few general comments on the work of the Section would seem appropriate. Our aim is to investigate virus diseases of crop plants from a plant pathological standpoint, that is, to identify the causes of the diseases and to find ways of avoiding disease in crops. We also aim to study in more depth some of the basic properties of the viruses involved, for none of the great problems of plant virology is yet solved. For instance, it is not known what determines the ability of a virus to infect one plant species or cultivar and not another, nor how it is that a virus will kill one kind of plant, cause only leaf mottling or stunting in a second and have no obvious effect in a third. Only a few of the organisms that seem well fitted to carry viruses from plant to plant actually do so, and this too is not understood. Also, knowledge of how viruses infect, and multiply in, plants is still fragmentary. Obviously we cannot investigate all these basic problems effectively, nor do we aim to do so, but where the viruses we study as plant pathogens offer the opportunity of some new approach, we would hope to exploit this.

During the year, as described below, we have continued to collaborate with the Zoologists on problems relating to virus transmission by animal vectors, our biochemical work is gaining momentum, studies of viruses of parsnips and of flower bulbs have developed, and work has been started on two diseases of potato that we are especially well placed to study.

VIRUS MULTIPLICATION

Tobacco rattle virus

Previous work has shown this virus produces particles of two or more lengths, which are characteristic of the isolate. When infections are initiated by purified long particles (typically about 190 mμ long), symptoms develop and virus nucleic acid replicates, but the tubular nucleoprotein particles are not formed. The short particles, by contrast, do not on their own cause symptoms and apparently do not multiply. Long and short tubular nucleoprotein particles are produced only following infection by inocula containing both types of particle.

From one line of new work, isolates that produce virus ribonucleic acid but not nucleoprotein particles (NM isolates) were used. Attempts were made to free the virus RNA from plant RNA by centrifugation through sucrose density gradients. No difference was found between the RNA profiles obtained using extracts of healthy *Nicotiana clevelandii* or *Chenopodium quinoa* leaves, and those obtained from infected material. Infectivity was associated with ribosomal RNA peaks, and was distributed as a broad zone throughout the regions corresponding to 28-18 S (approximately) material. In some experiments, there seemed to be two peaks of infectivity (about 28 S and 20 S). This general picture was not altered by variations in (a) the pH value of the extraction buffer, in the range 5.0-9.5, or (b) salt concentration, or (c) concentration of Mg^{++}. Dialysis made no difference. Throughout the summer months the RNA preparations were associated with considerable quantities of small molecular weight peptide which was not removed by two treatments with phenol or by dialysis.

Experiments with inhibitors of ribonuclease showed that when added to the buffer used to make extracts of leaves neither bentonite, nor 8-hydroxyquinoline with or without naphthalene-1:5-disulphonate, gave preparations of greater infectivity than buffer alone. Extracts made with buffer+inhibitors+water-saturated phenol were highly infective, but slightly less so than those made with buffer+phenol alone. (S. Allen).

When plants infected with NM isolates were inoculated with short particles of closely related strains, infective material was produced which was resistant to freezing and thawing, as are the tubular nucleoprotein particles but not the infective material produced by NM isolates alone. For instance, when the NM isolate was one that caused necrosis in *Nicotiana glutinosa*, and the short particles were of an isolate that did not cause necrosis, necrosis-inducing virus that was resistant to freezing and thawing was produced. Such interactions occurred only when the NM isolates and the short particles were derived from serologically closely related virus strains. Similarly, the inter-

action needed to produce stable virus particles, which occurs when plants are inoculated with mixtures of long and short particles, was detected only when the two kinds of particles were of serologically closely related strains. (R. M. Lister).

In the experiments described in the previous paragraph, the infective material resistant to freezing and thawing seemed likely to consist of nucleoprotein particles in which the RNA strand was of one strain and the protein was of the other. Because the lengths of the particles probably is determined by the length of their RNA strand, and strand length seems characteristic of the virus isolate, the modal lengths of the particles produced were measured to see whether evidence for the presence of such 'hybrid' particles could be obtained. Although the results are not yet fully interpreted, differences between the lengths of the long particles of pairs of viruses seem too small to be detected and the short particles produced were insufficiently uniform in length for modal differences to be reliable. (R. M. Lister, I. M. Roberts).

Work was started to supplement the little information available on the early events following inoculation with tobacco rattle virus, and their timescale. The timing of the increase in resistance of infections in French bean (*Phaseolus vulgaris*) leaves to inactivation by ultraviolet irradiation, and that of the first detectable increase of infectivity of extracts of tobacco leaves depended on temperature in the same way. The capacity of *P. vulgaris* leaves to support virus infection was much less sensitive to ultraviolet inactivation than were potential virus infections in newly inoculated leaves. (J. I. Cooper, B. D. Harrison).

Pea early-browning virus

Pea early-browning virus has many properties in common with tobacco rattle virus, and its particles of different specific lengths apparently interact in a similar manner. However, experiments showed that whereas the stock culture of the English form of the virus caused only the typical large ring-like lesions in leaves of *Phaseolus vulgaris* some, though not all, of the NM isolates derived from it produced small necrotic lesions resembling those of tobacco rattle virus. This difference in symptoms produced by the different isolates of pea early-browning virus may reflect the occurrence or failure of some interaction between the RNA's of long and short particles. (R. M. Lister).

Parsnip yellow fleck virus

In spinach, the most suitable host known, this virus reaches only moderate concentrations in plants kept in the glasshouse (the maximum dilution endpoint of sap is about 1:5000). The virus is particularly interesting because it has a low optimum temperature (12-15°C.) for accumulation in leaves, with little or no virus accumulating at 24°C. Even at 12-15°C. its concentration is at a maximum for merely a day or two, and only then can the virus be detected in gel-diffusion serological tests. As possible aids to obtaining more information on the behaviour of this virus, two serological assays which detect very small amounts of virus, the bentonite flocculation and the passive haemag-

glutination tests, were compared. The experiments were done with bentonite particles or tanned red blood cells sensitised with antibody instead of with antigen, as is more commonly done with red cells. Both tests were used successfully, not only with purified virus preparations, but also with crude sap extracts. Parsnip yellow fleck, raspberry ringspot, turnip yellow mosaic, potato *X*, narcissus mosaic and tobacco rattle viruses all proved suitable test objects, provided that the tanned red cells or bentonite particles were sensitised with optimal amounts of antibody. With the filamentous and the rod-shaped viruses, the bentonite flocculation and passive haemagglutination tests respectively were about 2-5 and 100-125 times more sensitive than precipitin tests in mixed liquids. With the isometric viruses they were respectively about 10-20 and 500-1000 times more sensitive. The passive haemagglutination test therefore offers great promise for assaying viruses that are in small concentration in crude extracts, and is being used routinely with parsnip yellow fleck virus. (A. F. Murant, with H. S. Abu Salih and M. J. Daft, Queen's College, Dundee).

ELECTRON MICROSCOPY

The routine examinations of virus preparations so indispensable in many of the projects of the Section have continued, but more time than previously was given to collaborative work with the Zoology Section on ultra-thin sections of the nematodes that are virus vectors. Several methods of fixing and staining the material were compared, and the main results are described in the report of the Zoology Section. (J. Cathro, I. M. Roberts).

High resolution electron microscopy of the particles of narcissus mosaic virus was done to complement X-ray diffraction studies made by the Department of Physics, Queen's College, Dundee. Purified preparations of the virus were strongly birefringent, and electron micrographs showed particles aggregated side to side. Particles treated with uranyl formate+formic acid displayed cross-banding at intervals of about 36 Å, confirming the identity of the 34-36 Å structure indicated by the X-ray diffraction patterns. The cross-bands presumably represent successive turns of a helix. (J. Cathro, W. P. Mowat).

NEMATODE-BORNE VIRUSES

Resistance-breaking strains of raspberry ringspot virus

The majority of isolates of raspberry ringspot virus found in Scotland do not invade Lloyd George raspberry when inoculations are made by grafting. In the field, however, very occasional infected Lloyd George plants can be found, and the viruses from these can apparently infect any of the raspberry varieties that are not susceptible to virus isolates of the more commonly-occurring type. No serological differences were consistently found between isolates of the resistance-breaking and commonly-occurring types, but there was some variation between the isolates in each group. Two serologically distinguishable resistance-breaking isolates were each transmitted by the nematode *Longidorus elongatus*, as are isolates of the commonly-occurring type. (A. F. Murant, T. Munthe, R. A. Goold, with C. E. Taylor, Zoology).

Strawberry latent ringspot virus

Several new records were obtained of this virus in various hosts, and it seems widely distributed in western Europe.

A second outbreak in Scotland of the virus in Malling Jewel raspberry, associated with an infestation of the vector *Xiphinema diversicaudatum*, was diagnosed from samples sent by the West of Scotland Agricultural College. (A. F. Murant, R. A. Goold, with C. E. Taylor, Zoology).

Other isolates of the virus came from further afield. Infected standard roses were received from Northern Ireland, and viruses isolated from diseased peach trees in Italy by Dr A. Corte, Pavia, were also identified as strawberry latent ringspot virus. (B. D. Harrison).

Malling Jewel and Malling Promise raspberries, and *Rubus occidentalis*, became infected when grown in soil infested with virus-carrying *X. diversicaudatum*. Malling Jewel was severely dwarfed and showed chlorotic leaf blotches, also present but less obviously in Malling Promise. *R. occidentalis* was symptomless. In Cambridge Vigour strawberry, the virus, despite its name, caused severe dwarfing and leaf symptoms resembling those caused by arabis mosaic virus. In serological tests, an isolate of the virus obtained from *Euonymus europaeus* in Eastern Germany differed somewhat from the type culture. (R. M. Lister).

Tobacco rattle virus in potato

The virus was detected in spraing-affected potato tubers from several parts of Britain, mostly in the variety Pentland Dell, which shows severe symptoms. It seems widespread on light soils, where its vectors (*Trichodorus* spp.) are common. In Scotland, the virus seems common on the sandy land bordering the Moray Firth, where it was found in all eight fields tested by growing cucumber bait seedlings in soil brought into the glasshouse. This region is one where spraing has long been known to be prevalent. (J. I. Cooper, B. D. Harrison).

FUNGUS-BORNE VIRUSES

Augusta disease of tulip

A common matter for dispute is whether the tobacco necrosis viruses, which cause this disease, are acquired during propagation or during forcing. Last year we reported that symptoms could develop when apparently virus-free bulbs were grown on in soil infested with virus-carrying *Olpidium*. Now we find that, alternatively, the viruses can be acquired during propagation, without symptoms appearing. When normal-looking bulbs from an infested field were either forced, or grown in field conditions, in each instance in sterilised potting compost, the disease was more prevalent in the forced plants. In the variety Queen Augusta 10-19% of the forced plants were diseased, but only 1% or fewer of the field-planted ones. Fewer plants of Crimson Rambler and Turner were affected than of Queen Augusta.

When infection is contracted in the plunge bed, the incidence of disease seems much affected by the soil conditions. Disease incidence and severity

were greatest among plants in boxes kept in the warmest part of the plunge bed. Whether this reflects an effect on vector activity or on ability of the virus to invade the aerial parts of the plant, or both, is not clear.

The incidence of disease seems therefore to depend on many factors: the source and variety of the bulbs planted, the temperature of the soil in the plunge bed, and of course its virus content and *Olpidium* content. At present no reliable control measure can be recommended.

A strain of tomato bushy stunt virus was obtained from tulip plants from an Edinburgh garden. They showed symptoms resembling Augusta disease, but the association of virus and symptoms may be fortuitous. (W. P. Mowat).

Transmission of tobacco necrosis virus by Olpidium

Whether or not transmission of tobacco necrosis virus can be aided by *Olpidium* zoospores depends on the *Olpidium* isolate used. One possibility is that transmission is contingent upon some specific interaction between the virus and the plasmalemma, which electron microscopy indicates to be the outer layer of the zoospore. Indeed, the net charge at the zoospore surface, as indicated by the electrophoretic mobility of the zoospores, was found to be correlated with ability to transmit and, like ability to transmit, did not depend on the host plant in which the *Olpidium* was grown. Zoospores of two virus-transmitting *Olpidium* isolates carried a larger net negative charge than those of three non-transmitting isolates. Within each group of isolates the charges were identical. Hence, it seems that inability to transmit does not reflect inability of the negatively charged virus particles to approach the zoospores. The ionic conditions in the medium also affect transmission. Increasing the concentration of $CaCl_2$ or $MgCl_2$ to 10^{-2}M decreased transmission of a strain of the A serotype of tobacco necrosis virus but not that of a strain of the D serotype. (W. P. Mowat).

Potato mop-top virus

Work was started on potato mop-top virus, probably the commonest virus in the best British stocks of seed potatoes, and which preliminary experiments have indicated to be transmitted by the powdery scab fungus (*Spongospora subterranea*). Although the virus is not readily transmitted by inoculation of sap, fifteen species in the Solanaceae and Chenopodiaceae were infected in this way, seven systemically. Systemic invasion was however usually incomplete, and most systemically infected plants continued to produce some apparently virus-free leaves. A few elongated virus-like particles were found in infective sap. The virus was inactivated in 10 min. at 80°C., but at room temperature some infectivity remained for several days. Of the four solanaceous species that became infected when grown in soil collected from a field where the previous potato crop was affected, White Burley tobacco was at least as good a bait plant as the other three species. (R. A. C. Jones, B. D. Harrison).

RUBUS VIRUSES

In addition to work on nematode-borne viruses in raspberry, described on

pp. 60, and on the application of insecticides to prevent the spread of aphid-borne latent viruses, described in the Zoology Section report, some other *Rubus* viruses have received attention, and the propagation of virus-free raspberries has continued.

Raspberry propagation

Although propagation of raspberries from root-cuttings now presents few problems, protecting the stocks from incoming virus is proving less straightforward. The cane nurseries of Malling Jewel and Lloyd George established at a site in Perthshire in late spring 1965, although regularly sprayed with systemic insecticides, became colonised by *Amphorophora rubi* and in 1966 showed about 1% of mosaic. However, some 48,000 first size canes of Stock Cane grade were sold to growers. In 1966 about 3000 plants raised from root-cuttings were planted out at a more isolated site in Perthshire, where it is hoped there will be little incoming virus. (J. Chambers).

Such introductions raise the possible role of other species of *Rubus*, especially blackberry, as reservoirs of viruses or vectors. Wild blackberry shows various virus-like symptoms, and the aphids *Amphorophora rubi* and *Macrosiphum euphorbiae* transmitted viruses from wild blackberry to black raspberry seedlings. The effects of these viruses on commercial raspberry varieties are being tested. (J. Chambers with C. E. Taylor, Zoology).

Raspberry bushy dwarf

Although previous work showed that in glasshouse conditions the virus associated with this disease can be transmitted by raspberry pollen to plants bearing the flowers that are pollinated, whether this is the sole or main method of spread in the field is not clear. Field spread can however be rapid. New plots established near old infected raspberry plantings contained less than 1% of infected plants when two years old, and 14% a year later. However, neither fruit yields nor the average weight per fruit were significantly different for infected and healthy plants of Lloyd George. (J. Chambers).

Viruses in black raspberry

Further work was done to characterise the virus isolate designated New Logan-64, originally obtained from a U.S. Department of Agriculture heat-treated stock of black raspberry (*Rubus occidentalis*). As an aid to virus purification, adjusting the sap to pH 5 was superior for clarifying preparations to treatment with chloroform. Erratic virus yields seemed traceable to instability of the virus during the initial extraction of sap in a mechanical blendor, but not to oxidation. The virus was also unstable when mixed with phosphotungstate for electron microscopy, unless first treated with formaldehyde, glyceraldehyde or glutaraldehyde, which preserved the particles slightly, moderately well, and very well, respectively. When injected into rabbits, virus preparations treated with formaldehyde or glutaraldehyde, like untreated preparations, failed to elicit the production of detectable amounts of virus antibodies. In rate-zonal centrifugation in sucrose density gradients, the best

preparations of untreated virus sedimented as an obvious specific, light-scattering, infective band strongly absorbing light of 260 mμ, but this procedure showed that they were far from pure. (R. M. Lister, J. Cathro).

PARSNIP VIRUSES

Several apparently undescribed viruses were obtained from parsnip plants, but their importance cannot be assessed until more is known about them and the symptoms they cause, both alone and in combination with each other.

Parsnip yellow fleck virus

This virus has isometric particles about 30 mμ in diameter, a maximum dilution end-point in sap of 10^{-3} – 10^{-4}, thermal inactivation point of 55-60°C., and survived in sap at room temperature for 4-7 days. There is some serological variation between isolates from parsnip, and an isolate from wild *Anthriscus sylvestris* differs considerably from the stock culture from parsnip.

The *Anthriscus* isolate was transmitted by aphids in the semi-persistent manner not, as previously reported, in the persistent manner. In some experiments, vector aphids (*Cavariella aegopodii*, but not apparently *C. theobaldi* or *Myzus persicae*) acquired infectivity only after feeding for more than two days on the virus source plant, but in others after 4-6 hr. Aphids retained infectivity for 24 but rarely 48 hr. They could acquire the virus from aphid-inoculated coriander or chervil plants but not from manually inoculated coriander, chervil or carrot, or from aphid-inoculated carrot or parsnip plants. The fact that naturally infected *Anthriscus sylvestris* source plants also contained a virus, provisionally named *Anthriscus* yellows virus, which is transmitted by *C. aegopodii* in the persistent manner, but not by inoculation of sap, and can infect coriander and chervil but not carrot or parsnip, may be significant in this connection. (A. F. Murant, R. A. Goold).

Parsnip mosaic virus

Another virus, tentatively named parsnip mosaic virus, occurs commonly in parsnip but reaches only small concentrations in plants and was difficult to propagate in the glasshouse in summer. It has filamentous particles 750 mμ long, a maximum dilution end-point in sap of 10^{-3}, thermal inactivation point of 50-55°C. and survived up to 7 days in sap at room temperature. The virus was transmitted in the non-persistent manner by the aphids *Cavariella aegopodii*, *C. theobaldi* and *Myzus persicae*. It infected parsnip, chervil, coriander and carrot plants systemically and caused lesions in manually inoculated leaves of *Chenopodium* spp, *Spinacea oleracea*, *Gomphrena globosa* and *Torenia fournieri*. No reaction was obtained between the virus and antisera to other viruses with the same or similar particle lengths (those tested were henbane mosaic, pea mosaic, bean yellow mosaic, cocksfoot streak, clover yellow vein and potato *X* viruses). (A. F. Murant, T. Munthe).

LISTER, R. M. (1967). A symptomatological difference between some unstable and stable variants of pea early browning virus. *Virology*, **31**, 739-742.
(The local lesions caused on *Phaseolus vulgaris* by some unstable variants of PEBV are strikingly different from those typical of the stable variant from which the unstable variants were derived. The difference seems related to differences in the ribonucleic acids concerned. It is suggested that, like stability (= protein production), these differences may be mediated by interaction between the ribonucleic acids of 'long' and 'short' particles).

LISTER, R. M. and MURANT, A. F. (1967). Seed-transmission of nematode-borne viruses. *Ann. appl. Biol.*, **59**, 49-62.
(Transmission through seed of crop and weed plants seems to be a characteristic property of nematode-borne viruses. It was demonstrated for tomato black ring virus in 20 species (13 botanical families), for arabis mosaic virus in 13 species (11 families), for raspberry ringspot virus in 6 species (5 families), and also, in more limited investigations, for tomato ringspot, cherry leaf roll and tobacco rattle viruses. A remarkable feature was that infected progenies, except those containing tobacco rattle virus, usually appeared healthy. The occurrence and extent of seed-transmission depended both on the virus and on the host plant involved. In the examples studied, the viruses were transmitted through several generations of their host plants and were detected in infected seed, which was still viable, after 6 years.
In controlled crossing experiments with strawberry and raspberry, virus was transmitted to seed from both male and female parents but, at least in raspberry, the presence of competing healthy pollen much reduced the ability of pollen from infected plants to set seed. There was no evidence of maternal infection from the use of infected pollen).

MURANT, A. F. and LISTER, R. M. (1967). Seed-transmission in the ecology of nematode-borne viruses. *Ann. appl. Biol.*, **59**, 63-76.
(In studies to assess the importance of seed transmission in the persistence and spread of nematode-borne viruses, the extent to which infected seed occurs in nature was measured. Tomato black ring virus and, probably, raspberry ringspot virus occur commonly in weed seeds in soils from outbreak areas, but arabis mosaic virus was found only rarely; tomato ringspot, grapevine fanleaf and tobacco rattle viruses were not detected at all in weed seed in the single soil studied in each case. All these viruses are known to be seed-borne in some of their hosts and the differences between viruses in the amount of infected weed seed found in soils are attributed largely to differences in the host preferences of their vectors. Similar causes also probably account for the fact that not all weed species in which TBRV and RRV are known to be seed-transmitted were found to be carrying virus in their seeds in soils from outbreak areas.
Tomato black ring and raspberry ringspot viruses were retained for only 8 weeks within their vector, *Longidorus elongatus*, and persistence of the virus through periods of fallow or fasting of the vector depends on the presence of virus in infected weed seeds. This is probably less true of arabis mosaic and other viruses transmitted by *Xiphinema spp.*, which are retained within their vectors for 8 months or more).

TAYLOR, C. E. and MURANT, A. F. (1966). Nematicidal activity of aqueous extracts from raspberry canes and roots. *Nematologica*, **12**, 488-494.
(For Summary see Zoology Section report).

TAYLOR, C. E., THOMAS, P. R. and CONVERSE, R. H.[1] (1966). An outbreak of arabis mosaic virus and *Xiphinema diversicaudatum* (Micoletzky) in Scotland. *Plant Pathology*, **15**, 170-174.
(For Summary see Zoology Section report).

[1]On leave from Crops Research Division, Agricultural Research Service, United States Department of Agriculture, Beltsville, Maryland.

Zoology

C. E. TAYLOR

The Zoology Section emerged in April 1966, not as something new and untried, but as a consolidation of the nematology and entomology research that had flourished for several years in the former Virology Department. The links with Virology are not only evident from the research on nematode and aphid vectors of virus diseases but also by the number of joint projects with Virology staff. Whilst co-operative work between the two Sections on transmission of nematode-borne viruses continues, entomological interests and the work on fine structure of nematodes will expand. A new soil-washing laboratory for nematode work, converted from a glasshouse, and a laboratory converted for ultra-sectioning work, are two prospects which have been long awaited and are now in the process of realisation.

Two new assistants, Jane Bowes and S. C. Gordon, joined the Section in August. Winifred Pattullo left in April to take up a post in France, after acting as assistant to several senior members of the Virology Department during her six years at the Institute.

The Section was included in the itinerary of several of the visitors to the Institute, but in addition Dr S. K. Prasad of the Indian Agricultural Research Institute, New Delhi, and Dr R. S. Pitcher, East Malling Research Station, were welcomed for their more specific interests in nematode virus vectors. Mr J. J. M. Flegg, Plant Pathology Laboratory, Harpenden, spent a week at the Institute studying techniques for the ultra-sectioning of nematodes.

This year sees the completion of an annotated bibliography of nematological literature from Africa South of the Sahara, which was started by P. R. Thomas when he was employed at the Commonwealth Bureau of Helminthology, and continued with myself when he joined the Institute staff. The completed work, involving over 600 annotations, is to be published as a Technical Communication of the Bureau.

NEMATOLOGY

The biology of Longidorus elongatus

Most of the soil samples collected from arable land in many areas in Scotland contained *L. elongatus*, but ringspot viruses were detected in very few. Field and laboratory experiments have shown that *L. elongatus* has a very wide host range and that populations are likely to be maintained under most cropping systems, including grass and clover leys. Many weeds are also hosts for the nematode and the viruses it transmits. On *Senecio vulgaris* and *Matricaria matricoides*, the nematode fails to reproduce, although both weed species

readily become infected with raspberry ringspot and tomato black ring viruses. On many of the weed and crop hosts on which reproduction occurred, small galls caused by the feeding of the nematode were observed at the root tips, but there was little evidence that this damage decreased the vigour of the plants.

Studies continue on the population dynamics of *L. elongatus* in field-grown strawberry by soil sampling at regular intervals at several sites. The trend towards low populations in the spring and high populations at the end of the year has been confirmed. Analysis of populations is being made at two strawberry sites, and fortnightly counts of females in plots of strawberry, raspberry and perennial ryegrass are being made to determine the period of oviposition. (P. R. Thomas).

L. elongatus is usually found in the upper layer of the soil in association with the young roots of its host plants. In strawberry crops the largest populations were found in the top 8 in. of soil and very few nematodes were found below 12 in. Horizontal sampling showed that the bulk of the populations were within a 9 in. radius of the plants, and relatively few *L. elongatus* were found between the rows, except where weeds were present. (C. E. Taylor).

In laboratory experiments a local variant of raspberry ringspot virus isolated from Lloyd George raspberry (see Virology Section) was transmitted by *L. elongatus* as readily as the type strain of the virus; an English variant, obtained from *L. macrosoma*-infested soil in Oxfordshire, was also transmitted by *L. elongatus*. In direct transmission tests, made by cutting up lots of 20 nematodes in a drop of water and using this suspension to inoculate *Chenopodium quinoa* indicator plants, the English variant was transmitted from larvae only, whereas the type strain and the Lloyd George variant were transmitted from adults and larvae. In an experiment with tomato black ring virus, *L. elongatus* transmitted several Scottish isolates of the virus but not the English (lettuce ringspot) strain; the German (potato bouquet) strain was transmitted in one instance only. In direct transmission tests only the Scottish isolates were transmitted. (C. E. Taylor with A. F. Murant, Virology).

Control

Quintozene, applied at 300 lbs./acre of 20% product, was as successful as D-D, applied at 400 lb./acre, in controlling *L. elongatus* infestations in the field, but whereas D-D killed 98% of the population within three weeks quintozene required several months to achieve this level of control. Both treatments prevented the spread of nematode-transmitted viruses to Redgauntlet strawberry. In the second fruiting season the yield from untreated plots, which were almost completely virus-infected, had dropped to the equivalent of $\frac{1}{3}$ ton/acre, whereas the quintozene plots which remained free from infection yielded 3.3 tons/acre, and the D-D plots, with about 3% infection, 2.5 tons.

Yields of Talisman strawberry, planted in *L. elongatus*-free soil treated with quintozene at 600 or 1200 lb. of 20% product per acre were about 11% lower than those from untreated soil, but yields of strawberries from soil treated with quintozene at 300 lb./acre were unaffected. It is therefore inadvisable to apply quintozene in excessive amounts, and in fact this may be uneconomic because

the chemical persists in the soil for many years and its effect against *L. elongatus* is long lasting. This was demonstrated by planting Redgauntlet strawberry in plots that had grown Talisman for five years after a pre-planting treatment of the soil with quintozene at 1200 lb./acre. The replanted crop remained free from virus infection and the numbers of *L. elongatus* were low, whereas plots that had previously been treated with D-D contained over 5% infection in their first year and *L. elongatus* populations were relatively high. (C. E. Taylor with A. F. Murant, Virology).

Biology of Xiphinema diversicaudatum

Two further infestations of *X. diversicaudatum* have been discovered, one in Fife and the other in the Clyde Valley. In Fife the infestation was associated with an outbreak of arabis mosaic and strawberry latent ringspot viruses in Malling Jewel raspberry; in the Clyde Valley the infestation was again associated with a disease outbreak in Malling Jewel but here only strawberry latent ringspot virus was identified (see p. 61). Sampling on a grid pattern in the first outbreak showed that the extent of the diseased patch was closely related to the higher densities of *X. diversicaudatum* and only small populations of the nematode occurred outside the disease patch. The weeds *Stellaria media*, *Lamium amplexicaule*, *Mentha arvensis*, *Senecio vulgaris*, *Veronica officinalis*, *Poa annua* and *Capsella Bursa-pastoris* from within the diseased patch were infected with arabis mosaic virus but only *L. amplexicaule* and *S. media* were infected with strawberry latent ringspot virus. No evidence of passage of the virus through weed seeds was found in tests made by germinating seeds in soil from the outbreak area heated to 30°C. for five weeks or by germinating seed collected from infected plants. In laboratory experiments it was shown that *X. diversicaudatum*, maintained in soil without host plants, retains arabis mosaic and strawberry latent ringspot viruses for at least 112 days. (C. E. Taylor, P. R. Thomas).

Electron microscopy

An electron microscope study has been made of the fine structure of *Longidorus elongatus* by means of a series of transverse and longitudinal sections. Many interesting morphological features have been revealed, such as the structure of the spear and oesophageal region, the cuticle, male and female reproductive apparatus and various features of moulting.

The needle-like spear is circular with a ventral slit, which measures about 34 mμ wide at the tip and 80 mμ wide at the base; the lumen of the spear is between 240 mμ and 560 mμ in diameter. The spear extension is cylindrical but less heavily cuticularised than the spear; running parallel to the digestive tract are three sinuses, the ventral one of which extends almost to the anterior end of the spear extension. Cell tissue within these sinuses is contiguous with that in the oesophagus suggesting that the spear extension is, in fact, a modification of the anterior oesophagus. Eight powerful protractor muscles extend from the head of the nematode to the spear extension and three retractor muscles run posteriad from this region to their anchorage on the oesophageal bulb.

The cuticle is made up of the external cortical layers overlying a homogeneous layer, three fibre layers and the basement membrane. The cuticle of the anterior neck region is characterised by an additional, seemingly elastic layer, interposed between the fibre layers and the basement membrane; this layer probably enables the nematode to make radial searching movements with its head end, in contrast to the normal dorso-ventral movements of the remainder of the body.

Raspberry ringspot and tomato black ring viruses were identified serologically and virus-like particles observed with the electron microscope in preparations of the macerated intestines of *L. elongatus*. It seems unlikely that these particles would pass forward into the oesophageal lumen, or be recirculated in some other way, to be transmitted by the nematode during feeding. On the other hand, no virus particles have been identified in the buccal capsule or within the guiding sheath of the spear, although, considering the feeding mechanism of the nematode, these seem to be the most likely storage places for transmissible virus.

Large numbers of hexagonal-shaped particles measuring about 27 mμ in diameter were seen in preparations of macerated Dorylaimid nematodes, but not in *L. elongatus* or *Xiphinema diversicaudatum*. Each particle was formed from six similar capsomeres at the corners of a regular hexagon surrounding one at the centre. Several discs were also seen which appear to be composed of two particles opposed to one another. This structure is similar to the oxygen-carrying pigment chlorocruorin. (C. E. Taylor, P. R. Thomas with J. Cathro, I. M. Roberts, Virology).

ENTOMOLOGY

Raspberry aphids and viruses

Raspberry cane nurseries become infested with aphids migrating from fruiting plantations, wild raspberries and blackberries, the migration period extending from about the end of June to mid-August; winged aphids are also produced in the colonies developing on the plants and these extend the infestation to other plants within the crop. To prevent the invasion and subsequent spread of aphid-borne viruses, almost continuous insecticidal protection of the crop seems necessary. In 1965 newly-planted plots of Malling Jewel were maintained practically free from aphid infestation by spraying them with methyl demeton at 21-day intervals from early June until mid-August; applications of granular 5% disulfoton in early June and mid-July were almost as successful. Neither treatment prevented winged migrants from settling on the plants although most were killed before they could deposit young. There was no evidence of infection with aphid-borne mosaic viruses in these treated plots but tests made in 1966 showed that the insecticidal treatments had failed to prevent infection with latent viruses; about 20% of the treated plants were infected, compared with about 60% infection in untreated plots. In 1966, granular disulfoton was applied to plots of Malling Jewel raspberry in factorial combinations of 20 or 30 lb. of product per acre applied at 5 or 10 week intervals either as a spot treatment to each plot or as a band along the rows. Band-treatment at 5 week

intervals starting in mid-June and continuing until mid-August was the most successful treatment for the control of aphids, with 30 lb./acre application slightly better than 20 lb. None of the treatments acted quickly enough to prevent the migrant aphids from feeding on the plants and probably transmitting latent viruses.

Raspberry crops mostly become infested with *Amphorophora rubi* but colonies of *Macrosiphum euphorbiae* are frequently found, particularly from July onwards. Both these aphid species are found on wild blackberry but it is not known to what extent these infestations may contribute to the migration to raspberry crops, or whether viruses are transmitted by aphids flying from blackberry to raspberry. Wild blackberries, and some cultivars, exhibit virus symptoms ranging from mild chlorotic spots and rings on the leaves to irregular chlorotic and yellow markings of the main veins. Viruses have been experimentally transmitted from such plants to black raspberry seedlings by *A. rubi*, and much less frequently by *M. euphorbiae*, and by grafting infected scions on to raspberry cultivars. (C. E. Taylor with J. Chambers, Virology).

Raspberry beetle

Further observations confirmed that *Rubus phoenicolasius* resists infestation by the raspberry beetle (*Byturus urbanus*) but this resistance is not transmitted to F_1 hybrids with raspberry nor to backcrosses of these with raspberry, although the infestations recorded on them were not as great as on the raspberry cultivars Malling Jewel and Lloyd George. About 40% of the fruits of each of the various hybrids were infested with larvae compared with more than 90% infestation of the raspberry cultivars. In laboratory experiments it was shown that a substance is present in the flower buds and leaves of *R. phoenicolasius* which is repellent to adult raspberry beetles. When Malling Jewel leaves or buds were rubbed with those from *R. phoenicolasius* the beetles refused to feed on them, although untreated leaves and buds were readily eaten. The nature of this substance is being investigated in co-operation with Dr J. T. Martin of Long Ashton Research Station. (C. E. Taylor with D. L. Jennings, Plant Breeding).

Raspberry mite

Although the raspberry mite (*Eriophyes gracilis*) appears to be widespread in raspberry plantations little is known about its biology or the extent of the damage it causes. Studies on the life cycle and population dynamics were started in autumn 1965 with a series of observations on overwintering populations in Malling Jewel and Lloyd George raspberry cultivars. The buds are infested only by female mites which remain quiescent throughout the winter except for a tendency to migrate towards the central part of the bud in early spring. Up to 100 females may initially infest a single bud but relatively few survive to infest the developing leaves in the spring. As the lateral shoots open out from the buds, the females migrate to the leaflets and lay the first batches of eggs on the upper surface about mid-March. Within two weeks, the first generation is complete and adult males and females appear in the first of

several generations that are completed during the spring and summer. Flowers become infested before they open from the buds, and later the mites feed between the drupelets of the ripening fruits. About the beginning of September the females move from the leaves of the young canes into the buds where they remain during the winter.

Mite populations may number several thousands per cane and at this level they cause yellow mottling of the leaves and stunting of the plants. Infested fruits ripen unevenly and many of the drupelets are dull in appearance or dried up. (H. P. Holmes, C. E. Taylor).

PUBLICATIONS

TAYLOR, C. E. (1966). The control of cabbage root fly with diazinon in direct-seeded cabbage crops. *Hort. Res.*, **6**, 126-127.
(Granular 5% diazinon applied post-emergence as band or spot treatments prevented infestation by the cabbage root fly (*Erioischia brassica*) and increased yields by up to 26% compared with untreated plots).

TAYLOR, C. E. (1967). The multiplication of *Longidorus elongatus* (de Man) on different host plants with reference to virus transmission. *Ann. appl. Biol.*, **59**, 275-281.
(Experiments in the glasshouse and in the field showed that *L. elongatus* reproduced on strawberry, chickweed, mint and rye grass. Raspberry ringspot and tomato black ring viruses were readily transmitted to chickweed; tomato black ring virus only was transmitted to rye grass, and mint did not become infected with either virus. Raspberry ringspot virus was transmitted to Malling Jewel raspberry, but the nematode did not multiply on this host).

TAYLOR, C. E. and MURANT, A. F. (1966). Nematicidal activity of aqueous extracts from raspberry canes and roots. *Nematologica*, **12**, 488-494.
(Populations of *Longidorus elongatus* and other plant parasitic nematodes were much reduced after raspberry canes were incorporated into the soil. In laboratory experiments it was shown that aqueous extracts of raspberry roots and canes were toxic to *L. elongatus*. The chemical involved was not identified but it is observed that raspberry contains large amounts of tannin and a number of polyphenols derived from other plant tannins were shown to be nematicidal).

TAYLOR, C. E., THOMAS, P. R. and CONVERSE, R. H.[1] (1966). An outbreak of arabis mosaic and *Xiphinema diversicaudatum* (Micoletzky) in Scotland. *Pl. Path.*, **15** 170-174.
(The first natural outbreak of arabis mosaic virus in Scotland is reported from the Edinburgh area, in association with rose and raspberry. The virus was obtained from raspberry cultivars Malling Promise, Lloyd George and Norfolk Giant, all previously found to be immune. The virus isolate from Malling Promise was found to be serologically similar to the type strain. The largest populations of the nematode vector, *X. diversicaudatum*, were found in association with roses and Myrobalan plums).

[1]On leave from Crops Research Division, Agricultural Research Service, United States Department of Agriculture, Beltsville, Maryland.

West of Scotland Unit

R. D. REID

The year has been one of transition and by the time this Report appears, I shall have retired on reaching the age limit of 65. In May 1966, Dr H. J. Gooding joined the Unit as my colleague and successor and, during the year he has been familiarising himself with the materials, the techniques and the problems of strawberry breeding. He has taken an increasing share of organising the work of the Unit and has initiated pilot trials of new projects, and new methods of approach to old and new problems. For my part, I have endeavoured to taper off my own activities, so bringing to a close my share in a project started 36 years ago. It is with very mixed feelings that I relinquish my responsibilities and I have been very touched by the many tributes that have been paid both to me personally and to the work of the Unit. As my contribution to this Report is something of a valedictory one, I have permitted myself some licence in expressing views about the present and future of strawberry breeding which may help to clarify some of the issues which are being currently debated.

During the year, I continued to serve on the strawberry sub-committee of the National Fruit Trials and as president of the Scottish branch of the Horticultural Education Association. In February 1967 the Association honoured me by electing me an Honorary Life Member. I lectured to growers in Hampshire and visited Efford E.H.S. and Dr Gooding and I attended a conference of strawberry breeders at the John Innes Institute in July, organised by the A.R.C. Dr Gooding served on an advisory committee of the City and Guilds of London Institute on Agricultural Subjects in Tropical Countries.

STRAWBERRY BREEDING

Assessment of seedlings

Perhaps because of rainfall in autumn 1965 and late winter 1966, red core disease was intense in 1966 and older plots of seedlings showed more severe deterioration in vigour than in preceding years. Plots planted in April 1965 and cropping for the first time in 1966 were, however, exceedingly good, both in crop weight and fruit quality and showed high tolerance to disease. *Botrytis* was not a problem this year, possibly because July was the sunniest (204.8 hr.) for over 10 years.

Selections from recent crossings continue to look promising and one in particular has qualities that may make it acceptable for processing. About 7000 seedlings, fruiting for the first time in 1966, contained interesting material and the 180 selections made comprise some very promising ones. However, past experience emphasises the need for caution, because observation of per-

formance for three or four consecutive seasons is necessary before optimism can be justified. Some 10,000 seedlings planted out in April 1966 will fruit for the first time in 1967. The last programme of crossing for which I have been responsible has yielded about 10,000 seedlings which should fruit in 1968.

Recent introductions

The new variety Templar was released in 1964 and this was followed by Crusader in spring 1966. Templar has met with a somewhat mixed reception. Some growers have reported excellent crops of fine quality fruit which was well received on the markets; others have been disappointed with yield and quality, reporting the fruit to be soft and prone to mildew. It would seem, therefore, that Templar is not as adaptable to different environmental conditions as some of its predecessors. Whilst ability to perform consistently in a wide range of environments is probably genetically controlled and is a characteristic of relatively few cultivars, there is also a case for growers considering modifications to their cultural practices in order to exploit a variety to its best advantage.

The features of Templar that have made an adverse impression are quite possibly the result of selection for ability to survive on land with a long history of strawberry growing and a high level of soil-borne disease, and selection under west of Scotland conditions. It may well be that autumn planting–as against spring planting in Scotland, exposure to more favourable cultural conditions and to a drier climate all combine to accentuate the tendency of Templar to excessive vigour and to mildew-susceptibility, this last being a characteristic of one of its parents–Cambridge Vigour. Trials at Mylnefield during the last four years have confirmed the potential of Templar to produce excellent crops of high quality fruit but have also indicated that the variety is selective in its environmental requirements. No reports on Crusader are yet available from commercial growers but, at trial stations in the south of England, vegetative growth has also been excessive. It will take some time to assess the real value of each of these varieties.

The relations of strawberry breeding to industry

From time to time our methods have been subject to criticism from growers. On the one hand it has been suggested that we have delayed release of new selections unnecessarily long; on the other, comment has suggested that our introductions have been released without adequate testing at other stations. These two criticisms are mutually contradictory. This may be an appropriate time in which to consider the whole question of duration and extent of pre-release trials in relation to the time and manner of release of new introductions.

Throughout the greater part of this Unit's existence the industry has been faced with a dearth of suitable varieties. In sympathy with this need, our policy has been to release introductions at the earliest stage consonant with reasonable satisfaction with the apparent potential of the selection and the availability of runners. In practice this has meant that introductions have been made

at from 7 to 11 years after making a cross. Coincident with the naming of a new variety, some 50,000 runners have been released, spreading the plants over as many growers as possible and strictly restricting the number of plants allocated to each. This initial allocation of a few hundred plants should in fact serve as material for a pilot trial enabling each grower to appraise a variety's suitability for his particular conditions. This to some extent puts the onus of testing for local adaptability and/or finding the best methods of cultivation for a particular area upon the grower himself. The limited expenditure involved in the small allocation of available plants means that no heavy financial risk is incurred if the introduction is not quite to the grower's satisfaction. This procedure follows what – until two decades ago – has been the accepted practice of commercial breeders. In recent years fewer varieties have been available, and new introductions have tended to be accepted without pilot trials on a larger scale, a tendency no doubt encouraged by the success of some of our previous introductions which proved widely adaptable. Auchincruive Climax, in particular, was the closest approach of any introduction of the century to the ideal of a universal variety. Any introduction which is widely planted and which falls short of this ideal may lead to disappointment and so some growers are demanding more extended pre-release trials.

In my personal view, no matter how extensive the official trials nothing can replace individual observation by the grower under his own conditions, but other factors such as a new policy of introduction related to Plant Variety Rights may call for more extended pre-release trials at E.H.S. or other substations. On the technical side, the emergence of more specialised needs of the industry suggests that the extent and duration of pre-release trials should be related to the specific market for which the new variety is designed.

As I see it, the industry in this country caters for three needs. These are production of fruit for processing – jam, freezing, canning, fruit juices, etc. – for high class early markets and for the fresh fruit market generally.

The processing trade probably accounts for something like half the total acreage but considerably less than half of the total cash value of the crop. At the moment Cambridge Favourite is practically the only variety used. The main producing areas are in East Anglia, Angus and Perthshire with smaller areas elsewhere. High productivity and a standardised product are the main essentials. Even when the technical qualities of colour, texture, size, flavour and easy plugging meet the required standard, unless high productivity can be assured a variety will not be grown no matter how excellent it may be in other respects. A uniform pack throughout the season would demand that only one variety be grown or alternatively several with virtually similar characters. Some statements have recently appeared in the press that varieties to extend this season, both earlier and later, are wanted but the consensus of opinion would appear to point in the opposite direction. I am informed that the present trend is for factories to be geared to the processing of a specific crop for a limited period of three or four weeks after which production lines are switched to another type of fruit, so that varieties ripening outwith the period of mass production are unacceptable. This would suggest, for the processing trade,

varieties with a short harvesting season. Breeders of the future may have to face up to the problem of producing varieties suitable for mechanical harvesting. One of the essentials of mechanical harvesting is that the bulk of the crop is secured at one harvesting so bringing concentrated ripening to its extreme expression. It is obvious that, with these specialised requirements and the realisation that a very large acreage will be devoted to one variety, a much more extended series of pre-release trials in areas suited to processing, will be an essential part of policy for this particular trade.

The area devoted to the production of early fruit – mainly by some form of protected cultivation – is small, probably less than 1,000 acres, concentrated mainly in Hampshire. Here a range of early-ripening varieties producing only large-size fruits and ripening over a concentrated period around two weeks is needed. At one time the general purpose variety met the need; the first few pickings consisted of large fruits for the choice markets and the later-ripening, usually smaller, fruits were used for processing. With the present demand for choice fruits in small packs and the great difficulty in obtaining labour for picking there is now no room for small fruit in this market, nor for a prolonged fruiting season. A large tonnage per acre is not looked for: earliness, size, appearance and ease of picking are essential. Unlike the processing trade, a large range of varieties is no disadvantage – indeed it would be an asset, and growers are quick to try anything new. In cloche cultivation, maiden-cropping is usual, and there would appear to be an increasing move towards maiden-cropping even under field conditions. As a supplement to this early and protected cropping, the tendency of some varieties to produce a second, autumn crop is being looked to as a source of profit. This characteristic is quite distinct from the behaviour of the remontant types, mostly of French origin, and was first observed in Climax. Several varieties produce bi-annual crops but Redgauntlet behaves most consistently in this way and this has been an additional point in its favour. To meet the needs of this particular industry therefore, it seems to me that a large number of trial introductions could be made and that relatively small numbers of plants of each variety would be required each season (although much closer planting in the rows would to some extent compensate for low acreages). All this suggests that a much shorter pre-release period of testing is required than for processing varieties. For this trade, therefore, I would favour release at an early stage of test and encourage growers to regard their first planting of new introductions as experimental.

The general purpose variety, typified by Climax, was once universally demanded and is nowadays still wanted by the growers who are mainly interested in the fresh fruit market and who grow on a large field scale. Probably Kent, with approximately 2,000 acres is the most concentrated producing area but in every part of the British Isles where strawberries are grown this type of variety is in demand. It probably accounts for the largest share of the total cash returns from strawberries in this country. Unlike the processing trade, there is a demand for a range of varieties giving a prolonged picking season extending for at least six weeks or longer. A concentrated ripening period is not an asset: too much fruit ripening in a short period involves difficulties of

harvesting, spoilage in inclement weather, and glutted markets. High productivity, large sized fruits, ease of picking, good carrying qualities and an attractive appearance when it reaches the consumer are essential. At the moment Redgauntlet seems to be most popular but there is an urgent demand for more varieties to extend the season, both earlier and later. This is the type of variety which breeders traditionally aim at and it must continue to be the backbone of the industry. Consciously or unconsciously, most breeders and those in charge of variety trials have this type in mind, so there is little likelihood of its being neglected when making selections from trials. There still remains the question of local adaptability and a limited series of pre-release trials seems to be called for, with, once again, the grower willing to regard his preliminary plantings as pilot trials under his own conditions.

Whilst little of the foregoing constitutes a report of work done, it has seemed natural to me at the close of my plant breeding career to look back over the way I have come and to give my personal interpretation of the way which seems to lie ahead for my successors. In the period between the two wars, strawberry growing was at its lowest ebb. Plantations were riddled with diseases; crops were frequently less than one ton per acre and only too often whole plantations died without yielding any crop. The challenge facing the plant breeder and the pathologist was to produce plants which would grow and produce crops. Disease problems have not been solved nor will they ever be, but by the combined efforts of plant pathologists, plant breeders, certification schemes and propagators–both growers and organisations–strawberries can again be grown. Crops of from four, six, eight, or even ten tons per acre are by no means unknown. But unexpected economic developments have cut across the picture making soft fruit growing no longer possible in many areas and resulted in a redistribution of the industry. Whereas the problem was once getting the plants to grow, nowadays it may be getting labour to handle the crop. Whereas a crop of two tons per acre might once have been profitable now the grower aims at a minimum of four tons. The markets become more exacting in their specifications and varieties once acceptable are no longer wanted. The challenge before the plant breeder is greater than ever and no doubt he will rise to the occasion.

PUBLICATIONS

GOODING, H. J. (1966). The National Apple Collection: a classification problem. *Exp. Hort.*, **15**, 38-46.

GOODING, H. J. (1966). Systematic Research at the National Fruit Trials. *Exp. Husb. and Hort. Stns. Progress Report* 1966, *pp.* 21-24.

Meteorological Records 1966

J. SUNDERLAND

Meteorological records from Mylnefield and Auchincruive for the year 1966 are summarised in the tables that follow, the figures for Aucincruive being taken from the Monthly Weather Report, issued by the Meteorological Office.

The weather at Mylnefield during 1966, with the exception of March, May and July was notably wet, dull and cold. In particular, the rainfall during April and June (4.09 and 4.19 in. respectively) was the heaviest since our records began in 1954. Although the high rainfall during August (4.27 in.) established no record, the month lived up to its reputation of being our wettest of the year.

The rainfall at Auchincruive for the months of June and December (5.53 and 5.59 in. respectively) was the highest for a decade.

AUCHINCRUIVE 1966

Month	Temperature (°C.)[1] Mean of daily maxima		Mean of daily minima		Rainfall (inches)	Sunshine (hours)	Ground Frost (days)
January	5.3	**41.5**	0.6	**33.1**	1.52	36	21
February	6.4	**43.5**	1.6	**34.9**	2.74	47	14
March	9.2	**48.6**	3.9	**39.0**	2.77	116	8
April	9.2	**48.6**	2.8	**37.0**	1.01	137	8
May	14.0	**57.2**	5.7	**42.3**	2.58	220	0
June	16.8	**62.2**	10.3	**50.5**	5.53	114	0
July	17.1	**62.8**	10.2	**50.4**	1.41	205	0
August	16.7	**62.1**	9.1	**48.4**	4.44	163	3
September	15.7	**60.3**	10.0	**50.0**	3.95	95	0
October	11.9	**53.4**	5.1	**41.2**	3.07	91	13
November	7.7	**45.9**	1.6	**34.9**	4.35	65	19
December	7.2	**45.0**	2.4	**36.3**	5.59	36	14
Year	11.4	**52.5**	5.3	**41.5**	38.96	1325	100

[1]Fahrenheit equivalents shown in bold figures

MYLNEFIELD 1966

Month	Temperature (°C.) Fahrenheit equivalents shown in bold figures														Rainfall		Sunshine		Run of Wind
	Mean of daily maxima		Deviation from average[1] (°C.)	Mean of daily minima		Deviation from average[1] (°C.)	Accumulated Temperature Above 5.6°C.	Accumulated Temperature Below 5.6°C.	Highest Max. Temp.	Highest Max. Date	Lowest Min. Temp.	Lowest Min. Date	Soil Temperature at 1 ft Depth Mean	Soil Temperature at 1 ft Depth Deviation from average[3]	Ground Frost (days)	Inches	Deviation from average[2]	Hours	Deviation from average[1]	Miles
January	4.5	**40.1**	—1.3	—0.1	**31.8**	—0.2	16	204	10	29	—8	18	1.1	—0.9	22	2.05	+0.12	32	—18	4961
February	5.0	**41.0**	—1.4	0.0	**32.1**	—0.9	26	178	11	28	—9	15	2.3	+0.2	18	3.50	+1.65	38	—38	4541[4]
March	10.1	**50.3**	+1.5	2.5	**36.6**	+0.7	104	60	13	15	—2	25	5.1	+0.8	19	0.76	—1.09	137	+32	8147
April	7.7	**45.9**	—3.3	2.4	**36.3**	—0.8	78	101	19	30	—3	2	4.9	—2.4	13	4.09	+2.48	115	—25	6497[4]
May	14.6	**58.3**	+0.6	5.2	**41.4**	—0.1	258	18	22	1	2	28	9.2	—1.0	7	2.03	+0.03	223	+57	5483
June	17.0	**62.7**	—0.7	10.1	**50.3**	+1.9	431	1	21	15	4	28	14.0	+0.4	0	4.19	+2.50	107	—75	4540
July	18.7	**65.7**	—0.7	8.9	**48.0**	—1.8	459	1	26	21	4	27	15.1	—0.2	0	2.16	—0.40	198	+44	4755
August	16.3	**61.3**	—2.4	9.2	**48.5**	—1.0	403	4	22	17	3	25	13.6	—1.2	2	4.27	+1.00	121	—20	4394
September	16.5	**61.8**	+0.1	9.7	**49.5**	+1.6	409	0	20	3	5	16	13.1	+0.2	0	2.08	+0.08	119	—3	4117
October	11.9	**53.5**	—0.7	4.7	**40.5**	—0.6	188	30	14	7	—2	5	9.4	—0.3	13	2.93	+0.33	85	—10	3624
November	7.1	**44.8**	—1.4	1.1	**34.1**	—1.4	36	128	10	7	—5	11	4.5	—1.4	25	1.80	—0.52	61	—2	6198
December	6.0	**42.8**	—0.7	0.3	**32.5**	—0.9	17	155	12	17	—5	14	2.5	—1.2	27	3.45	+0.93	52	+11	5735[4]
Year	11.3	**52.3**	—0.8	4.5	**40.1**	—0.3	2425	876	—	—	—	—	7.9	—0.6	146	33.31	+7.11	1288	—47	63052

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

[3] Recorded at Mylnefield 1954-1961.

[4] Records missed through instrument failure.

Printed by Culross (cp) the printers, Coupar Angus