ROTHAMSTED RESEARCH

Report for 1948

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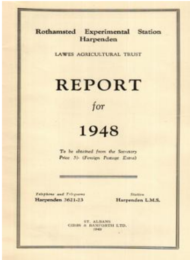
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Plant Pathology Department

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PLANT PATHOLOGY DEPARTMENT

By F. C. Bawden

Dr. S. D. Garrett left in February to work on Panama Disease of banana in Jamaica and Dr. P. H. Gregory, who has worked in the Department since 1940 as a Research Officer of the Agricultural Research Council, was appointed in his place. To continue the work on potato virus diseases, Mr. T. W. Tinsley joined the staff in June. Mr. Salt replaced Miss B. M. Hawkey for work on *Cercosporella herpotrichoides* and Mr. Gates was appointed in August to work on sugar beet diseases at Hackthorn.

Dr. M. A. Watson returned in June from a year's leave of absence spent partly at the Waite Agricultural Research Institute at Adelaide and partly visiting Research Stations in Australia and the United States. At the invitation of the Centre National de la Recherche Scientifique, Mr. F. C. Bawden attended a Conference in Paris on Les unités biologiques douées de continuité génétique, and Dr. L. Broadbent attended the International Congress of Entomology in Stockholm.

Messrs. K. S. Bhargava, L. Broadbent and R. P. Chaudhuri were awarded Ph.D. degrees of London University.

Viruses and Virus Diseases

Laboratory and glass-house work

The main lines of work described in previous reports on the physio-chemical and serological properties of viruses were all continued. The electron microscope was completely overhauled and, with the acquisition of a shadow-casting apparatus, the quality of pictures obtained has been greatly improved. The method by which mounts are prepared greatly affects the manner in which particles of tobacco mosaic virus orientate and the type of picture obtained. The rod-shaped particles of potato virus X appear less rigid than those of tobacco mosaic virus and all methods of purification tried caused them to become entangled. Studies on preparations of virus X partially hydrolysed by trypsin gave no indication that hydrolysis disrupts the particles to produce rods of decreasing lengths. Preliminary work in conjunction with the Soil Microbiology Department on the bacteriophages that attack *Rhizobium* sp. suggests that some, but not all, forms occur with tail-like appendages similar to those described with certain other bacterial viruses.

With the Biochemistry Department work was continued in an attempt to gain further information on the relation between the crystallizable nucleoprotein obtainable from plants infected with the Rothamsted culture of tobacco necrosis virus and the infective particles. The crystallizable material has smaller particles than any other virus (about 17 mμ diameter), but the infective particles may be larger as they sediment more readily. The manner in which extracts of infected plants are made influences the ratio of infective to non-infective material, but consistent results have not yet been achieved.

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Outbreaks of a systemic necrotic disease in tulips were diagnosed as resulting from infections with various tobacco necrosis viruses (67). This is the first host encountered in which these viruses seem to become fully systemic, but a lethal disease in French bean, known in Holland as stipplestreak, was also identified as caused by a tobacco necrosis virus related to the Rothamsted culture.

Tobacco veinal necrosis virus was found by serological tests to be related to potato virus Y, but unlike other viruses that share antigens, these two were not mutually antagonistic when present together in the same plant.

Studies were made on the ratios with which tobacco mosaic and tomato bushy stunt viruses combine with albumin when heated with it under various conditions; complexes that contained three or more times as much albumin as bushy stunt virus still combined with virus antiserum but were not precipitated by it (70).

Results from work on the yellowing disease in Family 41 sugar beet did not support the claim of workers in Eire that it is caused by a strain of sugar beet yellows virus that is seed-transmitted in this family. The cause was only with difficulty transmitted by aphides and produced less generalized symptoms than those caused by sugar beet yellows virus; it did not protect plants against the latter or react with antiserum to yellows virus. It seems possible that this is a distinct disease that may have arisen in this genotype.

Sugar beet yellows was transmitted for the first time by inoculation with sap from diseased plants (68). Shading plants after infection by aphides both delayed the appearance and reduced the severity of symptoms. Also, when fully infected plants were shaded, they produced new leaves much less yellowed than those produced by control plants.

The frequency distribution of local lesions caused by certain viruses was analysed and found to be skew, so that statistical tests of significance should not be directly applied to them (69).

Evidence was obtained that water-culture solutions in which roots of infected plants were growing could become infective. The addition of sap containing virus X, tobacco mosaic or tomato bushy stunt viruses, to soil in which tomato plants were growing produced infections of roots with all three viruses. In most plants the viruses were confined to the roots, the leaves and stems remaining virus-free; passage of virus into aerial parts occurred more frequently when plants were cut back so that new side shoots developed.

Experiments on the effect of fertilizers on the susceptibility of tobacco plants to tobacco mosaic virus were continued. Using sand cultures, N, P and K, affected virus multiplication in the same way as with plants growing in soil, but increasing nitrogen increased susceptibility to infection (as measured by local-lesion counts) more in sand than in soil.

Field work

Field experiments and observations on commercial crops were continued to gain information on the epidemiology of potato and sugar beet virus diseases, and were also extended to lettuce mosaic.

Close topping of mangolds reduced the spring infestation of *Myzus persicae* on clamped mangolds, but not of *Hyperomyzus* *staphyleae*, which successfully colonizes roots. Blowing derris powder on to roots at time of clamping did not reduce infestation. The survival of *H.staphyleae* is less important, for it is apparently unable to transmit sugar beet yellows or mosaic. A new over-wintering host for *M.persicae*, an ornamental almond hybrid, *Prunus Amygdalus-persicae*, was identified. Eggs laid on this hatched and produced large infestations in spring. No evidence was obtained than aphides use any olfactory sense to find their winter host; nor were flying aphides attracted by other *M.persicae* or by honey-dew. Having found the host, apparently by chance, winged aphides tend to associate in groups.

Work is continuing on the effects of micro-climate on aphid multiplication and movement; results of experiments to test the frequency with which winged *M.persicae* fly under various conditions (58) show that changes within crops are adequate to influence mobility and consequent likelihood of spreading viruses.

Results are not yet complete on experiments made with potatoes to study the effects on aphid population and virus spread of varying such factors as water and nutrient supply, date of planting and time when exposed. Records were also made of the manner in which fumigated plots became re-infested with *M.persicae* and of the relative abundance of the aphid on different susceptible hosts through the summer.

The effect of roguing to prevent spread of leaf roll and rugose mosaic was again tested; results of tests in 1947 agreed with those from earlier work (60), in showing that roguing needs to be done by the first week in July with Majestic and earlier with Arran Pilot to produce any significant result.

Work at Hackthorn largely dealt with developing control methods against sugar beet yellows. Steckling beds in areas which produced healthy plants in previous years were heavily infected in 1947–48. An experiment was made to test beds in counties relatively free from sugar beet and mangolds and known to be favourable for seed-potato production. A number of methods of clamping stecklings was tested and the only failure was with a cover of loose straw, when the plants became dry and were attacked by mice. Better stands of seed plants were obtained with clamped stecklings raised in Berwickshire than with those out-wintered there. There was no evidence that plants deteriorated when stored three weeks between transport and planting, although the stands were poorer in the later plantings because of drier and more unfavourable soil conditions. Different planting times were tested and yield data have been obtained, but the most important result was the demonstration that *Myzus persicae* over-wintered on plants out-wintered and grown on without transplanting. Large populations developed on these plants in May, but not on those transplanted.

The number of infected plants was reduced and yield increased by sowing stecklings in April in a cover crop of barley compared with July sowing in a nursery bed. Delaying sowing until late August also reduced incidence of yellows and increased yield of seed.

In a field experiment to compare isolates of yellows virus that consistently produce either mild or severe symptoms under glass, all isolates produced similar severe symptoms. Further experiments

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are being made to elucidate the differences in symptoms in the two conditions.

Field counts and aphid trapping, such as were done intensively in recent years, were continued on a much reduced scale in 1948. Local surveys have been undertaken in the Hackthorn area at intervals throughout the year, but the results have not yet been analysed. Beet fields have been examined near seed crops and a survey of mangold clamps by the Sugar Corporation staff was organized and associated with field counts of disease infection in sugar beet. The incidence of yellows in root crops in June was closely related to proximity of mangold clamps and seed crops.

In a field experiment at Woburn, both the number of sugar beet plants becoming infected with yellows and the size of aphis infestation were found to be approximately a constant per unit area. Doubling the plant population approximately halved the percentage of the crop that became infected. Observations on irrigated sugar beet at Milford, Surrey, showed no effects of irrigation on either aphid population or incidence of virus disease.

Experiments and observations on lettuce at Taplow, Bucks., showed that *Myzus persicae*, *Nasonovia ribicola* and *Macrosiphum euphorbiae* were the most common pests, and of these *M.persicae* is the important vector of lettuce mosaic. Over-wintering crops were most severely affected by mosaic, many being rendered worthless. Young lettuce crops became infected by aphids migrating from older crops, which may also serve as sources of virus. Alternative sources, however, are also often provided by diseased plants within the crops arising from infected seed. Such seed-borne virus may account for 3 per cent. or more of the crop being initially infected. In crops well isolated from other lettuce, infected seed is probably the chief cause of outbreaks, but spread from neighbouring diseased crops can lead to a high incidence in crops initially virus-free.

Mycology

Work was started to study the factors affecting the dispersal and deposition of spores, and a suitable wind tunnel for this was designed and is now being constructed. To supplement data from laboratory work, field work was started to study the deposition of spores on leaves and other surfaces and their dispersal by wind up to distances of 1 metre from the point of liberation. There has been little previous work on this subject, and the main object is to study factors determining the number of spores deposited per unit area from a volume of air containing a known spore load. This information is needed for a better understanding of the first stages of infection of plants by spores, for predicting disease gradients and for interpreting data on the numbers of spores caught on sticky traps. As yet only vertical traps have been tested; the number of spores caught per unit area increases as the size of trap is reduced, and, except with very small traps, only a small proportion of spores in the air subtended by the trap is deposited.

Experiments on eyespot of wheat (*Cercosporella herpotrichoides*) were continued, and a severe attack of take-all (*Ophiobolus graminis*) introduced an additional factor to those planned for the last year of the experiment in Little Knott. Spraying with H_2SO_4 was again highly beneficial; it reduced the area infested with weeds from 76 to 14 per cent. and the area lodged from 59 to 20 per cent., but was without effect on take-all. For the first time, spraying increased straw (by 17·6 cwt. per acre) and it also increased grain by 7·3 cwt. per acre. Addition of 2 and 4 cwt. of ammonium sulphate per acre reduced the area affected by take-all from 54 to 26 and 13 per cent. respectively. Nitrogen increased the proportion of crop that became lodged and increased yield only on acid-sprayed plots which did not become lodged.

Increasing rate of seeding from 1·5 to 2·8 and 3·5 bushels per acre, increased the area affected by take-all, which prevented any increased lodging such as occurred in previous years. Rate of seeding had little effect on yield, but the lowest rate gave the highest yield. The worst plots were those which were unsprayed, received no nitrogen and largest seed rate; these were weedy and had much take-all and gave a grain yield of only 11·7 cwt. per acre. Lower seed rate, combined with spraying and addition of nitrogen, reduced weeds and take-all and increased yield to 29·1 cwt. per acre.

Experiments out-of-doors with plants in pots showed that severity of eyespot was much reduced by adding ammonium sulphate to both ordinary field soil and soil rich in organic matter. Phosphate, on the other hand, in the presence of lime increased the severity of eyespot and decreased yield. In plants grown in sand cultures, the loss of yield caused by eyespot was decreased by addition of N, P and K, N being most effective in reducing loss and P least effective.

The survival of *Plasmodiophora brassicæ*, the cause of club root in cruciferous plants, was studied under various crops and in fallow. Boxes of infested soil were sown with cabbage, kale, *Lepidium sativum*, *Matthiola incana*, *M.bicornis*, *Papaver rhoeas*, *Tropæolum majus*, bean and onion, and after three months, survival was tested by the method of counting infected root hairs described by Samuel and Garrett. Susceptible crops were removed before decay of the clubs had begun. Infection-counts after cruciferous crops were lower than after non-crucifers (except *Papaver*). After *Papaver*, infection-count figures were comparable to those obtained after crucifers, but this requires to be repeated on a larger scale. Survival in fallow soil appeared to be affected by the addition of fertilizers as judged by the infection count on cabbage seedlings. After soil samples had been taken for the infected root hair test, the various crops were removed and cabbage sown in every box. 90–100 per cent. of these plants developed club root after all types of crop, in spite of differences in root hair infection.

Contrary to frequent reports in the literature, *Lepidium sativum* was found to be susceptible, more than 90 per cent. of the plants becoming affected. Tap roots showed only slight swellings and there were only a few small galls on lateral roots, although the roots contained plasmodia and resting spores. Marrow stem kale plants were all severely clubbed and one systemically infected plant was found, much dwarfed and distorted. Neither species of *Matthiola* formed clubs, nor could any plasmodia or resting spores be seen in sections of the root, although the root hairs were infected and contained zoosporangia. This suggests a difference in pathogenicity between the stage found in root hairs and that usually associated with clubbed roots.

Zoosporangia, indistinguishable from those of *P. brassicæ*, have been found in the roots of many non-cruciferous plants and zoospores have been seen discharged from the root hairs of *P. rhoeas*. Infection experiments have provided convincing evidence that *P. brassicæ* can infect and form zoosporangia in the root hairs of: *Papaver rhoeas*, *Tropæolum majus*, *Reseda odorata*, *Lolium perenne*, *Agrostis alba stolonifera*, *Dactylis glomerata*. No other recognizable stages of *Plasmodiophora* have been seen in the roots of these plants, and their importance in the epidemiology of club root remains uncertain. The root hairs of wheat, oats, rye, barley and maize, when grown under identical conditions, were not infected.

Differences in root-hair infections in different soils, in which the proportion of plants clubbed and the severity of the disease were all the same, prompted experiments on the relation between the number of spores in the soil, the number of root hair infections (measured after seven days), percentage of plants clubbed and severity of attack. Results are still incomplete, but it seems that the minimum number of infections associated with club formation is small, probably under ten. Cabbage stems were infected with *P. brassicæ* through needle wounds as described by Larson (1934), and this led to the formation of cortical galls and cambial invasion, the pathogen migrating up the stem and causing proliferation of axillary buds. Tissue removed from such stems was grafted to healthy stems which, several weeks later when stock and scion were united, began to swell into a large gall, indicating cambial invasion. This was followed by invasion and expansion of axillary buds above and below the graft.

Work was begun on seedling diseases of sugar beet which are becoming increasingly prevalent, presumably because of the lower plant populations now obtained with the common practice of early sowing. Better stands were obtained by treating seed with an organo-mercury dressing by the "short-wet" method than by treatment with another organo-mercury powder. The beneficial effect was most pronounced with seed heavily infected with *Phoma betæ*.

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