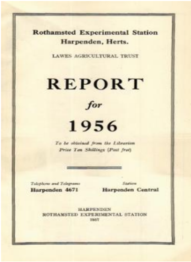
Report for 1956

Full Table of Content


Rothamsted Experimental Station
Harpenden, Herts.

REPORT
for
1956

Plant Pathology Department

F. C. Bawden

F. C. Bawden (1957) *Plant Pathology Department ;* Report For 1956, pp 98 - 120 **- DOI: https://doi.org/10.23637/ERADOC-1-117**

PLANT PATHOLOGY DEPARTMENT

F. C. BAWDEN

With the increased space gained by the mycologists moving to the West Building, more visitors can be accommodated, and there are now six working in the department; J. T. Slykhuis from Canada, J. G. Bald and M. Chessin from the U.S.A., R. S. Badami from India, and A. J. Gibbs and D. A. Perry from the U.K.

H. L. Fisher left to become chemist at F. W. Berk & Co. L. J. Cock was appointed to work on foot rots of cereals. D. H. Firth left the Dunholme Field Station, where he was replaced by E. C. W. Dunham. S. N. Adams was appointed to a new post of soil chemist there. Making a chemical laboratory and building new cloak rooms progressed so slowly that work in the laboratory was almost prohibited for most of the year.

Marion Watson attended the International Entomological Congress in Montreal, R. Hull and J. W. Blencowe the Institut International de Recherches Betteravières Virus Yellows Colloquium in the Netherlands, L. F. Gates the I.I.R.B. 19th Congress in Belgium and D. H. Firth the I.I.R.B. summer meeting in France. At the invitation of their Departments of Agriculture, Mary D. Glynne visited Eire and Northern Ireland to survey cereal crops for eyespot disease, which in Eire is more damaging and less easy to control than in England. F. C. Bawden also visited Eire, to lecture at University College, Dublin.

I. Macfarlane was awarded the Ph.D. degree of London University.

VIRUSES AND VIRUS DISEASES

Work on a virus-inactivating system present in small quantities in healthy tobacco plants and in larger amounts in plants infected with the Rothamsted tobacco necrosis virus or with tobacco ringspot virus, is described in the report of the Biochemistry Department. There also is described other joint work with N. W. Pirie showing that the protein fragments produced by disrupting tobacco mosaic virus (TMV) with alkali are inhibitors of infectivity, and suggesting that the nucleic acid of TMV, when newly separated by treating the virus with phenol, is infective, though much less so than intact virus.

Last year we reported on an unusual strain of TMV, unusual because it infects leguminous plants systemically, but even more so because its physical and serological properties differ greatly, depending on whether the virus is obtained from systemically infected tobacco or French bean plants. Amino-acid analyses (made at the Biochemistry Department, Cambridge University) of purified virus preparations from the two plants showed considerable differences, of which the most striking was the presence of histidine in preparations from beans but not from tobacco as ordinarily grown.

https://doi.org/10.23637/ERADOC-1-117

When tobacco plants inoculated with the virus from beans are grown at temperatures above 30° C., however, the usual tobacco form is not produced; the virus then has the pathological and serological qualities of the usual bean form and it also contains histidine. (Bawden.)

The electrophoretic patterns of sap from normal and virus-infected leaves

Infecting tobacco plants with TMV characteristically alters the electrophoretic pattern of clarified leaf sap by adding two new components to the four present in normal sap. One of these contains the virus and shows as a tall, slim peak; the other, much smaller, appears only when the first is already large, and it consists of material serologically related to the virus but with little or no nucleic acid or infectivity. Some workers have found that the proteins of normal leaves decrease in amount as the virus increases, and others that they remain unchanged. To study the effect of infection and to see whether any change in the normal proteins is directly correlated with the virus content or with the severity of symptoms shown, we have examined the electrophoretic patterns of sap from plants infected with four viruses and grown under a range of conditions. Two of these viruses, potato Y and tobacco etch, accumulate to only a small fraction of the amount of TMV, and the first causes a less severe and the second a much more severe disease than tobacco mosaic. The third virus was a strain of potato X, which accumulates to about one-quarter the amount of TMV and causes a disease of approximately the same severity. Of the three other viruses only potato X introduced new components into the pattern; as with TMV, there was a tall, slim peak, although a striking difference is that this peak with virus X does not move in the electric field in pH 7 phosphate buffer; two small peaks given by components whose nature we have not determined are by analogy with TMV likely to be not infective and to lack nucleic acid. The patterns with sap from plants infected with virus Y or tobacco etch resembled those from uninfected plants, and the concentration of normal proteins was not decreased even by the etch virus which greatly crippled the plants. The concentration of the normal proteins varied with the age of plants and of leaves, and with their manuring. It was greater in young plants than old ones, and in young leaves than in old ones of the same plant, and was least in old leaves of plants deficient in nitrogen. Their concentration fell as leaves aged, but often fell no more in leaves where TMV was multiplying than in others. Sometimes there was considerably less in sap from infected than from uninfected leaves, but there was no correlation between the amount of TMV present and the amount of any normal protein. Most TMV and most normal protein occurred in leaves of plants receiving abundant nitrogen; in nitrogen-deficient plants the relatively small amount of virus produced was not at the expense of any electrophoretically detectable normal protein.

Extracts from upper leaves of tobacco plants could be examined directly in the electrophoresis apparatus after dialysis against pH 7 phosphate buffer. With extracts from lower leaves, however, this method could not be used, as the patterns obtained were highly unstable, apparently because such leaves contain something that causes the normal proteins to aggregate. (Bawden and Kleczkowski.)

The antigenic components of preparations of tobacco mosaic virus

Ordinary precipitation tests with purified preparations of TMV and its antiserum do not suggest the presence of more than one antigenic component, but when made by the gel-diffusion method three components can be distinguished. One is the typical nucleoprotein, particles with weights equivalent to molecular weights of from 2–50,000,000, not all of which is infective. The other two seem to be identical with the so-called X-proteins that remain in the supernatant fluid when sap from infected plants is ultracentrifuged. These proteins are serologically related to the virus but lack some of its antigenic groups; they contain little or no nucleic acid, and usually have molecular weights of about 90,000 but they can aggregate into long, rod-shaped particles morphologically resembling the virus.

The X-proteins in purified preparations seem normally to be attached to virus particles, but some become detached when put into colloidal materials, such as agar gels or solutions of serum albumen. More is detached by incubating preparations with pH 8·8 borate buffer and still more by incubating at pH 10, but the virus particles then disintegrate and at least five other serologically distinguishable components are produced. (Kleczkowski.)

Electron microscopy

The objective-lens system of the electron microscope has now become so worn that it cannot be centred with an aperture in the objective lens. This has made impossible the continuation of thin-section work, and the decline in image contrast and resolution has also limited the scope and performance of the instrument in all other work.

Particle counting, which makes only modest demands on the microscope, has therefore been its main use, and an improved method for doing this was developed. Using this method, the multiplication of TMV in inoculated leaves has been studied, and particularly the changes immediately following inoculation. Preliminary tests showed that TMV rods extracted from recently inoculated leaves are damaged by dialysis against tap water. Dialysis against $M/5$-ammonium acetate has proved satisfactory, and counts give results closely paralleled by serological assays when the samples are prepared by grinding leaves, squeezing the sap through muslin, heating to 60° C. for 10 minutes, centrifuging at 8,000 g. for 10 minutes and then dialysing against $M/5$-ammonium acetate at room temperature.

The number of virus particles recovered from inoculated leaves sampled immediately after inoculation and washing depends on the concentration of the inoculum, and "Celite" increases the number to about the extent of increasing the concentration of inoculum by 100 times. When young leaves are inoculated, washed briefly in running water and then sampled at intervals, the particle counts from successive samples decline rapidly to about 10 per cent of the initial value, and then rise more slowly. When older leaves are inoculated, the recovery of particles immediately after inoculation seems to be better than with young leaves, and the decline in concentration is less, and sometimes inapparent; the particle counts then remain more or less steady before they increase at the rate found with young leaves. When old leaves are detached from the plant immediately after inoculation and washing, and floated in water, the counts in successive samples go down, as with young leaves left on the plant; rods can be found in the water in numbers corresponding roughly to the difference between counts on extracts from washed, and washed and floated leaves. When purified TMV is rubbed over filter-paper and dried, rods can be recovered in much the same numbers from samples extracted with water up to at least 24 hours. Rubbing newly inoculated young leaves with $N/10$-NaOH or with 1 per cent "Teepol R" (Shell Chemicals Ltd.) did not significantly affect the number of rods found in samples taken soon after the second rubbing, but "Teepol R" decreased the concentration in samples taken 24 and 48 hours after the original inoculation.

These observations suggest that virus particles in the inoculum have three possible fates, distinguishable by the intensity of washing necessary to detach them:

1. They may immediately reach a state or site where they are unaffected by any washing.
2. They may reach a site where they are protected from a brief wash in running water, but not from the effects of a prolonged soaking.
3. They may remain on the surface of the leaf and be detachable by a brief rinse in running water.

Only particles of type 1 are likely to infect and multiply, and as these are most easily studied in leaves floated in water immediately after inoculation, most experiments were made with such detached leaves, which also seem to give less-variable results than leaves on the plants. The proportion of the rods found in the sample taken immediately following inoculation, which are of type 1, have been estimated by two methods, and it seems to be about 0·2 per cent at 25° C. and 5 per cent at 35° C.

The length and width of rod-shaped plant viruses show that narrow rods tend to be long and wide rods short, which is to be expected if the particles become increasingly brittle as they become wider. The scatter diagram of particles shows no obvious grouping of related viruses, and does not support the idea that there is a particular unique length for each virus, but rather that the length is determined mainly by mechanical considerations. (Nixon.)

The multiplication of viruses at 36°

The study of virus multiplication at 36° has more than academic interest because of the practical application of heat-therapy in producing virus-free lines of clonal varieties that are at present universally infected. It now seems that viruses do not fall neatly into two types, one of which multiplies at high temperatures and the other not, but that strains of one virus may differ in their ability to multiply at 36°. We have previously reported that cucumber mosaic virus does not multiply at 36° and that healthy progeny can be obtained by keeping systemically infected plants at this temperature, but we have now confirmed that at least one strain of this virus will infect, and multiply in, plants kept at this temperature.

Similarly, the extent to which different strains of TMV accumulate in tobacco plants at 36° differs, and it also varies with the identity of the host plant. Our type strain accumulates much less at 36° than at 20°, particularly in the short days and low light intensity during the winter. An isolate obtained from infected plants kept at 36°, however, reaches higher concentrations in plants at 36° than at 20°. In *Nicotiana glutinosa* the type strain produces necrotic local lesions at 20° and chlorotic ones at 36° and the change to chlorosis is accompanied by virus accumulating in greater amounts, probably because many more cells now become invaded. Tomato aucuba mosaic virus, a strain that produces necrotic local lesions in tobacco leaves at 20° and chlorotic lesions at 36° shows a different effect. Despite the large chlorotic lesions at 36°, the virus increases so little that it does not reach an amount sufficient to be detected serologically; when such plants are put at 20° the virus increases rapidly, and within a day sap gives a precipitation end-point of 1/16 with virus antiserum. (Kassanis.)

Tissue cultures

The line of King Edward potatoes reported last year as being freed from paracrinkle virus by culturing the stem meristem on agar was extensively propagated in the glasshouse and tested, and except for its failure to produce paracrinkle when grafted to Arran Victory plants, no significant difference was noted between it and the customary infected ones. There are now enough tubers for plants to be raised in the open next year so that its performance can be critically assessed. This year, again by excising the apical meristems from sprouts of tubers, which were cultured on agar before they were established, first as scions on tomato plants, and later as cuttings with their own roots, we have produced a line of Arran Victory plants free from potato virus S, which is present in all previously existing lines.

To assess the value of tissue cultures in work on the factors affecting virus multiplication, the amount of TMV present in tumorous tissue cultured in different conditions was compared with that in leaves of systemically infected plants. The protein content of extracts from tumours is less than that of leaf sap and so is the virus content, averaging about $\frac{1}{25}$ and apparently independent of whether or not the tissues are actively growing. Some additions to the medium increased the growth of the tissues but not their virus content, and others influenced virus content but not the growth of the tissues.

Although the tissues have no cuticle, they do not become infected by TMV unless they are wounded. Virus spread through inoculated tissue at a rate of about 1 mm. per week, of the same order as the rate reported for spread through leaf parenchyma. No plasmodesmata could be detected in the tissues by methods that showed them clearly in leaf cells, and so the rôle previously attributed to plasmodesmata as the route for virus spreading from cell to cell seems a doubtful one. (Kassanis.)

Virus diseases of leguminous plants

Five distinct viruses were identified in leguminous plants of various kinds. One was broad-bean mottle virus, found in field beans at Cambridge, and which has only once been reported previously, in 1948, when it ruined a bean crop in the Midlands. Another, and this year the most prevalent in crops of field beans, was pea mosaic virus. A third, was a new record for this country, pea-leaf roll virus, which was found frequently in pea and field bean crops. It was first reported from Germany, Holland and Belgium in 1954 and 1955, where a disease previously thought to be caused by fungi was shown to be a virus disease. It appears to be widely distributed in the U.K., and when its effects were brought to the notice of growers they said they had long known plants in this condition. Samples taken from naturally infected plants at Rothamsted suggest that it halves the yield of field beans. It was transmitted, though only infrequently, between peas and field beans by *Macrosiphum pisi*.

The fourth was bean yellow mosaic virus, which also seems to be widely distributed and overlooked previously. It occurs in many strains of different virulence. An antiserum was prepared against a strain found infecting Gladiolus plants, and it proved most useful in distinguishing between this and the other viruses that are common in clovers, field beans and French beans. Although not prevalent in cultivated clovers, bean yellow mosaic virus is present in most of the clovers growing on waste land in and around Harpenden. It is common, too, in field beans, though infected plants usually are not greatly affected; some strains obtained from white clover, however, cripple field beans grown in the glasshouse.

The fifth was lucerne mosaic virus, which is very prevalent in lucerne more than two years old. The strain obtained from lucerne at Rothamsted, like one found in Northern Ireland infecting potatoes, does little harm to potato plants, and is transmitted through only a small proportion of tubers set by infected plants. Serological tests with antisera from America and Holland show that this is related to the American strains of lucerne mosaic that cause the serious disease, potato calico, characterized by severe leaf symptoms and necrosis of the tubers. (Tinsley.)

Viruses of cereals and grasses

In addition to barley yellow dwarf, whose occurrence in Britain we reported last year, three other viruses were distinguished in grasses and cereals during 1956. They were barley false stripe, a previously undescribed one that causes a disease we shall call streak mosaic of ryegrass, and one that causes a disease in wheat closely resembling striate mosaic.

Symptoms suggesting barley false stripe, sometimes called barley stripe mosaic, were seen in the variety Gloire du-Velay, growing in

https://doi.org/10.23637/ERADOC-1-117

Cambridge and raised from seed imported from France. Serological and other tests showed that these plants contained a virus related to barley false stripe, a seed-borne virus that is of considerable economic importance in Canada and the U.S.A.

Ryegrasses, both *Lolium perenne* L. and *L. multiflorum* Lam., were seen in many parts of England, Wales, Scotland and Holland with chlorotic streaks on their leaves and sometimes with leaves brown and necrotic. Mechanical inoculation of sap from such plants readily transmitted a virus to healthy ryegrass in the glasshouse. In thick stands of perennial ryegrass there is no obvious sign that the infected plants are much harmed, but with plants widely spaced the decrease in growth is striking. The virus was seen causing considerable damage to some crops of Italian ryegrass. Aphids, leafhoppers, thrips and Eriophyid mites were collected from naturally infected ryegrasses and transferred to healthy S22 IRG seedlings in the glasshouse. About one-sixth of the plants infested with mites developed symptoms of the streak mosaic, but all those infested with insects remained healthy. Further experiments with aphids, given widely differing feeding times on infected plants and test seedlings, failed to give any transmission. Suggestive evidence that the vector is smaller than aphids or leafhoppers was obtained by placing pots containing S22 seedlings, some covered with muslin and others uncovered, in a ley containing naturally infected plants. After 2 weeks in the ley, similar numbers of plants became infected in both the covered and uncovered pots. When 84 healthy seedlings were infested with 10 mites each, 5 developed streak mosaic. Dr. Keifer has identified three species of mites in our collection, and it is hoped to be able to identify the vector species certainly and, if it transmits readily, to do more exact experiments on the factors that affect its ability to transmit.

A disease of wheat closely resembling that caused by the leafhopper-transmitted striate mosaic virus, first recognized in 1950 infecting wheat in the U.S.A., was found to be caused by a virus transmitted by the Delphacid, *Delphacodes pellucida* (F.), which is common on grasses in the U.K. Insects do not transmit until 8–16 days after they first feed on infected plants, and they have remained able to do so for more than two months after ceasing to feed on infected plants. The initial symptoms appear 2–3 weeks after infection, and show as thread-like chlorotic spots and streaks; plants infected before they tiller are usually killed. In addition to wheat, barley, oats and perennial and Italian ryegrass were found to be susceptible.

We have made no survey to find the relative prevalence of the different virus diseases of cereals and grasses, but casual observations suggest that barley yellow dwarf is the most common. However, it is uncertain how prevalent this is, because the aphid *Rhopalosiphon padi*, which readily transmits from infected to healthy plants in the glasshouse, often failed to transmit anything from oat and barley plants showing what seemed typical symptoms in the field. The virus was transmitted from Bersee wheat infected artificially in the field as late as mid-August, and it was transmitted from Timothy grass found naturally infected at Aberystwyth and from perennial ryegrass at Harpenden. Preliminary tests suggest that different grasses and different strains of grasses may differ in their susceptibility to infection, for it was transmitted in the glasshouse to some but not to all tested.

A field experiment to compare the losses caused by barley yellow dwarf in different varieties of wheat, oats and barley was complicated by excessive lodging in the wet August. Nevertheless, there were considerable differences in yield between infected and uninfected plants. Except with wheat, which suffered greater losses when infected between 14 and 19 May than when infected between 24 and 30 April, losses increased with earliness of infection. Losses were also correlated with the severity of leaf symptoms. In barley the losses were similar to those recorded in 1955, 25 per cent when infected early and 8 per cent when infected late. The losses in varieties of oats varied greatly, in some being less than in wheat or barley and in others more. (Slykhuis, Watson and Mulligan.)

The prevalence and importance of these virus diseases of grasses, as with those of clovers, have yet to be determined, but their existence immediately poses a question. Do any of the benefits derived from ploughing old pastures and reseeding come from the fact that virus-infected plants are thereby replaced by uninfected ones?

Viruses of cruciferous plants

Severely diseased turnip plants, which were first thought to be infected with a virulent strain of turnip crinkle virus, were found to contain the crinkle and what seems to be a previously undescribed virus. The new virus has spherical particles about the same size as those of crinkle virus, but the two are not related serologically, and they can be separated by differential precipitation with ammonium sulphate. This new virus has recently been found alone infecting turnips in Kincardineshire, near to the farm where the crinkle virus was first encountered. The host range and transmission by beetles of these viruses are being compared with those of turnip yellow mosaic virus, several strains of which, differentiated by the severity of symptoms they cause in Chinese cabbage, have been isolated from cruciferous plants growing in different localities. (Blencowe and Broadbent.)

We again co-operated with the National Institute of Agricultural Botany in trials to assess the relative susceptibility of cauliflower varieties to cauliflower mosaic, and operated fifteen insect traps in conjunction with a survey on this disease by the National Agricultural Advisory Service. *Myzus persicae* were exceptionally abundant in Kent during July, but not elsewhere, and few *Brevicoryne brassicae* were caught except in Devon and Kent during July and at Evesham in August. Of winged aphids bred on infected cauliflower plants, 18 per cent of *M. persicae* and 15 per cent *B. brassicae* transmitted cauliflower mosaic virus and 11 per cent of *M. persicae* and 3 per cent of *B. brassicae* transmitted cabbage black ringspot virus. (Broadbent and Heathcote.)

Further experiments confirmed that *M. persicae* is most effective as a vector of cabbage ringspot virus when it is first starved and then fed for only 2 minutes on infected plants, whereas cauliflower mosaic virus is transmitted only little more frequently by aphids given this treatment than by aphids allowed to feed for 24 hours on infected plants. That the two viruses may be differently distributed in infected leaves was suggested by experiments with leaves irradiated with ultra-violet light, which again showed that this treatment almost prevents the transmission of the ringspot virus but has little effect on the transmission of cauliflower mosaic virus. Transmission from some leaves infected with the mosaic virus occurred much more readily than from others. Attempts to make an antiserum against this virus failed. (Mulligan.)

Potato viruses

Although as reported last year DDT was less effective in the hot summer of 1955 than previously in controlling aphids, the spray nevertheless checked the spread of potato virus diseases at Rothamsted. Two high-volume sprays decreased the incidence of leaf roll in the seed saved and planted in 1956 from 11·7 to 2·8, and eight sprays decreased it to 0·7 per cent: the incidence of virus Y was decreased from 11·5 to 7 and 5 per cent by the two and eight sprayings. At Lymington, too, spraying fortnightly with DDT decreased the incidence of leaf roll in plots containing initially 1 per cent infected plants from 19 to 2 per cent and of virus Y from 7 to 3 per cent. The stock of sprayed Ulster Prince now in its third year at Lymington had 0·1 per cent plants with virus Y and 1 per cent with leaf roll. The experiment at Harlow with King Edward was abandoned after four years because virus Y spread into the stock from other potato crops. Combined spraying and roguing maintained the health of the stock and cost less than buying new seed. The incidence of virus-infected plants was:

	LR				Per Cent Y			
	1953	1954	1955	1956	1953	1954	1955	1956
Unsprayed ...	0	4·1	26·6	—	0	0·05	0·3	—
DDT	0	3·7	4·4	4·5	0	0·05	0·7	13·2
Endrin	0	3·8	6·2	7·8	0	0·06	0·5	13·8
DDT + rogued	0	(3·7)	(1·6)	1·5	0	(0·05)	(0·5)	4·5
Endrin + rogued	0	(3·8)	(1·4)	2·9	0	(0·06)	(0·7)	9·1

The date-of-planting trial with the variety King Edward at Sutton Bonington was concluded. The percentages of infected tubers saved from 1955 were:

	Date of planting					
Time of lifting	14 Apr.	9 May	3 June	28 June	23 July	17 Aug.
LR:						
After 12 weeks ...	0	5·0	22·7	40·5	58·2	—
Lifted after haulm died	40·8	39·2	37·5	38·5	35·6	58·8
Y:						
After 12 weeks ...	0	2·3	3·7	14·4	10·0	—
Lifted after haulm died	12·4	15·0	11·2	14·4	15·2	7·9

As in the previous two years, (1) the healthiest stocks were those planted early and lifted after 12 weeks; (2) yield in 1956 from LR infected and healthy plants was greater from tubers lifted after haulm death than from those lifted early in 1955; (3) leaf-roll infection reduced yield by 76 per cent.

In an experiment at Rothamsted, done in co-operation with the Insecticides Department, DDT emulsion (2 lb. DDT per acre) was sprayed at low and high volumes, 4 and 6 times on 0·06-acre plots of S.S. Majestic, in which were planted 6 leaf roll and 6 virus Y infected tubers. Potato aphids were scarce during spring, but increased rapidly during July, leaving the crop during late July and early August. Aphid control was good, as the count on 150 leaves on 23 July shows :

	Total aphids	*M. persicae*
Unsprayed	2864	2700
HV × 4	12	11
HV × 6	12	7
LV × 4	8	2
LV × 6	24	23

Thirty-one other trials were made in various parts of England in co-operation with the National Agricultural Advisory Service. DDT was used in all, and in 3 this was compared with " Metasystox ". High- and low-volume application, with and without underleaf lances, was tested.

Eighteen insect traps were operated in unsprayed crops near to sprayed ones. *M. persicae* was scarce in May and June, but numerous in the Eastern Counties during late July and early August.

Two hundred and fifty tubers from a diseased stock of King Edward were subjected to the resorcin blue test for leaf roll and then planted. Leaf roll was correctly indicated in 66 per cent of the infected plants, but 42 per cent of those which reacted positively failed to show the disease; 6 per cent of the tubers which did not react produced infected plants. (Broadbent and Heathcote.)

Narcissus viruses

The trials at Rothamsted on the spread of viruses in Narcissus have been discontinued until the identity of the viruses present is better determined. Three types of symptom have been recorded, " severe stripe ", " mild stripe " and a faint mottle. Severe stripe spread little in 1953 or 1955, but more in 1954, when aphids were many times more numerous in spring than in the other years. Nevertheless, spread was slow : even in plots with 10 per cent of the plants initially infected, only another 16 per cent became infected during three years. When plots of healthy plants were bounded on 2 sides by 3 rows of infected bulbs, 6 ft. distant from the plots, only 7·6 per cent of the plants were infected.

Removing infected plants did not decrease spread, possibly because the plots were small and surrounded by others left unrogued. Spraying with DDT or " Mazidox " seemed to increase the incidence of stripe. (Broadbent and Heathcote.)

Sugar-beet virus diseases

A survey of the incidence of yellows in representative crops planted from commercial sugar-beet and mangold steckling-beds was organized with the help of the National Agricultural Advisory Service and sugar factory field staff; 87 per cent of sugar-beet and 46 per cent of mangold seed crops had less than 5 per cent plants with yellows, and only 5 per cent of beet and 9 per cent of mangold crops had more than 20 per cent infected plants.

In the autumn of 1956, 135 sugar-beet steckling-beds had on average 0·12 per cent of plants with yellows, and only 2 beds were rejected because they had over 1 per cent. 344 mangold steckling-beds had an average of 0·46 per cent of infected plants, and 37 beds had more than 1 per cent.

Experiments and experience have shown that yellows can be controlled by raising stecklings under cover crops. An experimental sugar-beet seed crop raised under a barley cover crop contained no plants with yellows, so no effect from autumn insecticidal spray treatments could be assessed. Some of these stecklings were grown-on without transplanting; although they grew bigger, they did not lodge like the transplanted ones; were ready to harvest 2 weeks earlier, and were free from "second growth", which was common in lodged seed crops in 1956. Seed yields have not yet been determined. IPC and TCA sprays (done in conjunction with C. Parker, Norfolk Agricultural Station) in the autumn or in spring controlled weeds, especially volunteer barley from the cover crop and, without injuring the beet, greatly decreased the labour needed to clean the crop. This method of growing seed combines effective virus control with economies in labour and gives scope for mechanizing the cultivation of the crop. (Hull and Firth.)

The insecticidal effect of "Hanane" and "Metasystox" applied to the soil along the rows at drilling time was compared with "Metasystox" spraying started immediately after the seedlings emerged and 10 days later. Incidence of yellows will be assessed in the plants next June. Seedlings from "Hanane"-treated rows drilled on 10 August were still toxic to aphids in petri-dish tests on 19 September. On 12 October the "Hanane" plots had 1 aphid on 40 plants, compared with 17 on the unsprayed controls. "Metasystox" was less persistent. "Thimet" was as effective as "Hanane" but depressed germination. (Gates.)

Spraying experiments on root crops at eighteen centres tested an early spray with "Metasystox" (end May–mid-June), a late spray (2–3 weeks later) and both. Only at Ipswich did more than 5 per cent of plants show yellows on unsprayed plots by the end of September; here the late spray decreased the incidence of yellows more than the early, though neither was as effective as in previous years. Aphids presumably arrived later and over a longer period than usual, and the double spray was more effective than either single spray, whereas previously two sprays have been little better than one early. Spraying increased yield by 5–8 per cent.

At Sprowston both early and late sprays with "Metasystox" decreased the incidence of yellows. The late spray had less effect on plots already sprayed early. DDT had no effect on yellows incidence.

The simultaneous control of *Pegomyia betae* and spread of yellows by aphids was tested at Dunholme. *P. betae* was controlled best by "Dipterex" (a proprietary organo-phosphorus insecticide with low mammalian toxicity), almost as well by "Metasystox" and least, though still effectively, by DDT emulsion applied at the end of May. Spread of yellows from artificially infected plants was decreased most by " Metasystox ", not at all by " Dipterex " and the DDT plots had more infected plants than the unsprayed ones. A second " Metasystox " spray applied on 2 July decreased the number of plants infected by mid-September to less than a quarter. The early spraying halved the number of plants with yellows at this time, and the early and late spray together decreased them to a tenth. " Metasystox " sprayed at high volume was more effective than at low volume. (Blencowe, Firth, Gates and Hull.)

The testing of 150 inbred progenies selected for tolerance to yellows was continued. Some progenies, self-pollinated for a second time, had vigorous, green leaves free from necrosis when infected in the field. Yields are not yet known from this or another experiment to compare the yields of progenies with different foliage characters, when infected early and late with mild and virulent isolates of yellows virus. Plants inoculated in the field simultaneously with mild and virulent isolates were less stunted and yellow than when infected with either isolate alone. Field plants inoculated by aphids fed on glasshouse plants, which had earlier been inoculated with both isolates, developed very mild symptoms. (Hull.)

A plant of white campion (*Melandrium album*) showing ringspot and mosaic symptoms not previously recorded was found at Dunholme. The cause was readily transmitted to seedlings of white campion by sap inoculations using " Celite ", but not by *M. persicae*. Sap inoculations caused systemic infections in sugar beet, spinach and cowpea, a slight necrosis on rubbed leaves of thornapple, antirrhinum and pea, and no symptoms in tobacco, marrow, cucumber, carnation, lettuce, clover (*Melilotus* sp.) or runner bean. (Cornford.)

The work started in 1955 to assess the importance of wild beet as a source of pests and diseases for the sugar-beet crop was continued. It is apparent that wild beet is increasing in quantity in its old habitats and is appearing in new places on the British coasts and estuaries. On the East Coast it is one of the first plants to colonize the freshly disturbed soil of newly made sea-walls.

Seed collected from 80 individual *Beta maritima* plants in 20 localities was planted at Rothamsted. The plants grew well, and the form of the plants varied greatly. Seed from the East Coast generally gave larger and more upright plants than seed from the Atlantic Coast. Most seed lots produced plants of uniform type, but some from the East Coast gave mixed progeny, suggesting that the parent plant had been cross-pollinated with plants of different type. Occasional dark-red plants suggest that some of the cross pollination was with garden beet. A few samples were completely non-bolting, and a few plants bolted early enough to produce ripe seed during the first season's growth. Seed collected in and near the Ouse Outfall most resembled commercial beet, and this population may have arisen from commercial beet that has " gone wild " and not be true *Beta maritima*.

The plants from which seed was collected were labelled and revisited in the spring, to see whether they were perennial. All but a few labels had disappeared, and it was possible to see only that most of the groups of plants had survived or increased and not to decide on the survival of individual plants.

https://doi.org/10.23637/ERADOC-1-117

Wild beet continues to grow as a hedgerow weed in places where it established itself when the seed was washed inland by the tidal floods of 1953. In a few localities new seedlings were seen. Some of these hedgerow plants have sugar-beet diseases, but less frequently than those growing on the foreshores and sea-banks.

The ability of wild and commercial beet seed to germinate and grow in competition with the other plants of scrub grassland was tested at Rothamsted. Seed scattered in rough grass did not germinate; when the vegetation was removed to soil level and the seed raked in, a few seedlings appeared, but did not survive competition with the subsequent vigorous growth of grasses, briar and annual weeds. On plots where vegetation was first killed by sodium chloride applied at the rate of 8½ tons/acre, both wild and commercial beet seed germinated and grew, whether the seed was raked into bare soil or scattered among the dead vegetation. Observations will be continued to see how long these plants survive.

The distribution of diseases in 140 beet and mangold crops (about 2,000 acres) in the Shotley peninsula of Suffolk was studied in detail to see whether there was evidence of spread from the plentiful wild beet on the foreshore. All fields with more than 1 per cent of plants with beet mosaic or downy mildew (*Peronospora schachtii*) were within 1,000 yards of the foreshore. In some fields adjoining the foreshore nearly all the plants near the beach were infected with beet mosaic virus, and there was a steep gradient of infection, so that a hundred yards inland less than a tenth of the plants were infected. Beet yellows virus was generally more severe in this and the adjoining peninsulas than in much of the remainder of East Anglia, and was especially prevalent near the tip of the peninsula, where some fields were nearly 100 per cent infected by mid-August. A rough estimate suggests that losses from yellows infection on the 1,400 acres of sugar beet in this area were at least 2,800 tons of beet. One field, otherwise expected to yield 18 tons/acre, gave only 11 tons/acre.

In districts like this the effect of wild beet seems evident, and the following recommendations are made :

1. Farmers in such areas are more likely to profit from routine spraying of their sugar beet with a systemic insecticide than are growers in most other parts of the country.
2. Farmers might benefit if they decreased the growth of wild beet on their foreshores by spraying with 2, 4D or MCPA in the spring.
3. Wild beet should not be allowed to establish itself on the coast of north-east Norfolk or on the banks of the rivers Ouse and Nene, because of the very large areas of sugar beet near by.
4. An attempt should be made to destroy the wild beet growing in the areas flooded in 1953, especially when commercial beet is to be grown in adjacent fields. (Blencowe.)

Changes in transmissibility by insects

The isolate of potato virus C found to become aphid-transmitted after ten years in *Nicotiana* sp. in the glasshouses has retained this ability while continually propagated in *N. glutinosa*; most lines transmitted to Majestic potato plants lost this ability, and subsequent propagation for a year in *N. glutinosa* did not restore it. Similarly, strains of potato virus C obtained from Edgecote Purple potatoes have not become aphid-transmissible after a year or more in *N. glutinosa*. From *N. glutinosa* plants infected simultaneously with potato viruses C and Y, aphids have sometimes transmitted viruses that behave differently from either of these. Inoculated Majestic potatoes give black local lesions as with potato virus C, but they also become systemically infected, although these symptoms take longer to appear than those caused by virus Y. Isolations from such necrotic lesions in Majestic to *N. glutinosa* have sometimes given cultures difficult or impossible to transmit by *M. persicae*. (Watson.)

Another example of a virus apparently changing its ability to be transmitted by *M. persicae* was encountered in a strain of cucumber mosaic virus obtained about ten years ago from a naturally infected spinach plant. At that time and up till 1954 the virus was readily transmitted, under optimal conditions more than half the plants colonized with only one aphid became infected. Now other strains of cucumber mosaic virus maintained in the same manner and in the same glasshouses are still readily transmitted by *M. persicae*, but this one is not. It is transmissible by *Myzus ascolonicus*, though less readily than other strains. (Badami.)

Mycology

Potato blight

In further studies on the early phases of potato blight attacks, 300 tubers of each of 3 potato varieties were artificially infected in December 1955, and planted in April among a plot of healthy plants. Six of the Ulster Cromlech tubers, and 1 each of Majestic and King Edward, produced stem lesions, which originated below ground. The first 2 stem lesions were found on 12 June and others appeared at intervals up to 3 July. Sporangial infections near these plants were first found on 19 June and, of nearly 2,000 plants in the plot, 92 per cent were infected by 24 July. Blight was first found on commercial crops in the district on 1 August.

1956 was the last of a series of years in which we have tested, on the variety Majestic, the effects of applying two protective copper sprays and sulphuric acid for killing haulm. Spraying increased yield this year, when blight was severe, by 2 tons/acre; few tubers became infected in plots sprayed with copper. The sulphuric acid spray again did not affect the numbers of tubers infected, but by killing haulm and weeds it considerably facilitated lifting.

The proportion of infections caused by sporangia spreading between leaves touching or in water running off leaves was studied by exposing plants in pots to two different conditions. In one the plants were unprotected and were exposed to sporangia from all routes; in the second the potted plants were in a cage, which prevented contact with the leaves of crop plants, or spore-laden water dripping on the plant, but only very slightly obstructed the arrival of dry sporangia or those carried in splash droplets. Exposed for

24 hours, the protected plants developed 40 per cent as many infections as the unprotected plants. (Hirst and Stedman.)

Experiments on the nature of field resistance to potato blight were begun using the varieties Up-to-Date, King Edward, Majestic and Arran Viking. The growth of the 4 varieties was studied in plots arranged in a 4 × 4 Latin square. Majestic took a week longer than the others to emerge and to flower. Up-to-Date formed the densest canopy, and in mid-July the afternoon temperatures at ridge level averaged 2° F. lower in this variety than in plots of Majestic. Most varieties were severely damaged by gales in late July, and only King Edward remained erect.

A single Majestic plant with 7 infected leaflets was placed centrally in each of the 4 plots of 1 column of the Latin square for 1 week in mid-July. Spread occurred only once during this period, and lesions appeared on 42 King Edward plants, 32 Up-to-Date, 31 Majestic and 21 Arran Viking. As in glasshouse tests, the sporing zone on Arran Viking leaves was narrower than on leaves of the other varieties. The total number of spores produced per leaf decreased in the order Up-to-Date, King Edward, Majestic and Arran Viking, but on sporing areas the density of spores was similar with all varieties.

In the artificially inoculated plots, King Edward was 50 per cent defoliated 9 days before Arran Viking, and 5 days before in the uninoculated plots. This difference may be less than if each variety had been planted on its own as a crop; the small plots were all surrounded by guard areas of Majestic, which may have provided similar numbers of spores for all plots and so diminished differences between the 4 varieties. (Lapwood.)

Potato skin-spot

In another attempt to find whether skin-spots on tubers could be caused by isolates of *Oospora pustulans* from potato roots, 50 tubers of each of 6 varieties were dipped in spore suspensions 4 days after lifting, and then stored. In the spring 16 per cent of undipped tubers and 25 and 29 per cent of those inoculated with the isolates from roots and tubers had skin-spots. Many sprouts on tubers of all the varieties were infected, and it seems that infection of eyes or sprouts by *O. pustulans* is much more prevalent and important than the better-known skin-spot symptom. Eyes on growing tubers can become infected, and dormant eyes, cut from washed tubers soon after lifting, have produced conidiophores when incubated for 5 days at 18° C. in a humid atmosphere. Such conidiophores occurred on 30 per cent of the eyes of Majestic tubers grown at Rothamsted in 1956, and 90 per cent of the tubers carried the fungus either in eyes or on the stolon scar, although no skin-spots were visible. Similar infections occurred on Majestic grown in Yorkshire.

Tomato seedlings grown in pots of soil taken from several different fields at Rothamsted became infected with *O. pustulans*; one field had not grown potatoes for at least ten years.

At each of the six National Institute of Agricultural Botany centres, six maincrop varieties were examined in late August. As in 1955, the fungus was found everywhere causing brown lesions on the cortex of roots and stolons, and it varied in amount with variety and locality. The disease rating in mid-August was correlated with the extent to which the seed tubers were infected at the time of planting. Mean disease ratings over the six centres of 56, 39 and 9 per cent were given to the roots of King Edward, Ulster Torch and Arran Viking, which had respectively 28 per cent seed tubers infected (13 per cent with skin-spot), 20 per cent with infected eyes (none with skin-spot) and no infection of eyes or skin-spot.

Of fungicides tested in a field experiment none showed promise of controlling the browning symptoms or increasing yield. The incidence and severity of symptoms on roots and stolons were decreased by applying a 10 per cent thiram dust to the seed tubers and in the furrow at 100 lb./acre, but not when either application was made separately.

In culture on both solid and liquid potato dextrose media the fungus grew better at 16° C., and there was little or no growth at 0° or 24° C. The dry weight of mycelium which grew in 14 days on 20 ml. of potato dextrose broth inoculated with a spore suspension was 18·5, 98·2, 101·6, 91·1 and 6·6 mg. at 4°, 12°, 16°, 20° and 24° C. respectively. The better growth of the fungus in low temperature may explain the fact that artificial inoculation of plants under glass in spring has produced severe browning and few, less severe lesions later in the year. (Salt.)

Apple scab

We have collaborated with the National Agricultural Advisory Service in observations on the correlation between outbreaks of apple scab and occurrence of the kind of weather thought to favour infection. We have also made observations on weather and spore concentration at Wisbech, Sudbury, Evesham and at East Malling. From each orchard, replicated dead leaf samples were taken in spring to estimate the relative number of ascospores they produced per unit area. Samples from Evesham and from one orchard at Wisbech gave few ascospores, but most others gave many. These differences were not necessarily associated with varieties or districts, for leaf samples from a series of Bramley's Seedling orchards in the Wisbech area differed by factors of 1,000 in their content of ascospores. These leaf samples alone give no certain guide to the spores caught by traps in orchards, for these catches depend also on the amount of leaf remaining per unit area of ground.

In the Wisbech area many growers successfully controlled scab by spraying when advised to from thermograph and dew-balance records. In conjunction with the Meteorological Office we have designed and tested a simplified dew balance to record how long surfaces remain wet, using as a test surface expanded plastic instead of an apple shoot. The new balance agreed with the older one to within about ± 1 hour, except during the earliest stages of dew formation. The differences between the two instruments are rarely greater than differences between leaves in different parts of the orchard.

Spraying the ground with 500 gal. of 0·1 per cent Sodium DNOC/acre in March again greatly decreased, by 92 per cent, the number of ascospores liberated from dead leaves.

https://doi.org/10.23637/ERADOC-1-117

A spore trap, operated among severely affected trees at Harpenden in July and August, caught more air-borne conidia on dry, sunny days than during wet weather. (Hirst and Stedman.)

Spore trapping

Preliminary experiments, with the main aim of devising suitable methods and apparatus for trapping spores from aeroplanes, were made in conjunction with the Meteorological Office and showed interesting changes in the number of spores trapped at various heights up to 10,000 feet.

Mushroom composts from beds suffering from the troublesome "Mat disease" were studied in the wind tunnel. At low wind speeds few of the ridged spores of the unidentified hyphomycete that forms the "mat" were dispersed, but as wind speeds were increased they came off in increasing numbers, and disturbing the dry compost dispersed them in quantity. Experiments are now to be made to see whether beds normally become infected by air-borne spores and, if so, at what stage of their development. (Hirst.)

The wind tunnel was also used to study the liberation of ascospores of *Ophiobolus graminis* from infected wheat stubble. Their liberation after wetting the stubble was confirmed, but attempts to measure the rate at which asci mature were inconclusive, probably because the stubble was collected too late. (Stedman.)

Pea wilt and foot rot

Field experiments on pea wilt, caused by *Fusarium oxysporum*, and foot rot of peas, caused by *Fusarium solani*, were continued at Rothamsted and on a wilt-sick field in Essex. Of nine English pea varieties tested in Essex, only Kelvedon Triumph and Harrison's Glory were wilt-resistant. Adding DBNP (2 : 4-dinitro-6-*sec*-butylphenol) herbicide to inoculated soil in pots in the glasshouse before planting peas decreased wilt by 70 per cent, but applications after peas had grown for 4 days in inoculated soil were ineffective. *Fusaria* growing on agar media were strongly inhibited by the herbicide. When DBNP was applied as a drench to wilt-sick soil in Essex before sowing, the onset of wilt was delayed. Later in the season, however, treated plots developed wilt as severe as that on untreated plots.

Only 8·6 per cent of all *F. oxysporum* isolates obtained by direct soil plating from wilt-sick soil were pathogenic towards the pea variety Onward, and none was pathogenic towards varieties Alaska and Delwiche Commando, which are differential hosts for races 2 and 3 respectively. Over 80 per cent of the isolates from the roots of diseased Onward peas grown in infested soil infected Onward. Centrifuging water suspensions of soil and plating out the supernatant fluid increased the *Fusaria* isolated, and this technique may lead to a rapid test for showing whether or not particular fields are suitable for growing peas.

Field experiments at Rothamsted again showed that foot rot spread quicker than wilt and that each developed quicker alone than when soil was inoculated simultaneously with *F. oxysporum* and *F. solani*. Although seedling blight reappeared, very little wilt developed when soil was inoculated with *F. oxysporum* at planting time. To test whether Rothamsted soil deters growth of *F. oxysporum*, the effects of aqueous extracts on spore germination were compared with extracts from 4 Essex soils, 2 wilt-sick and 2 wilt-free. After 12 days, only 5 per cent of the spores germinated in Rothamsted soil extract, 17 per cent in wilt-free soil extract and 61 per cent in wilt-sick soil extract. Comparable figures for *F. solani* were 4, 14 and 8 per cent respectively.

The rhizosphere populations and root exudates from pea varieties with different susceptibilities to 3 physiologic races of *F. oxysporum* f. *pisi* were further studied. The variety Onward, susceptible to race 1, had more fungi, bacteria and actinomycetes near its root surfaces than did either Alaska or Delwiche Commando, which resist race 1. Qualitative differences between rhizosphere populations of the 3 varieties were most apparent in *Fusaria* and bacteria, but *Mucorales*, *Trichoderma*, *Penicillium* spp. and *Gliocladium* were more abundant in the rhizospheres of plants resistant to race 1 than in the susceptible variety Onward. Rhizosphere populations changed both quantitatively and qualitatively as plants aged, and they were usually maximal after 14 days. The germination of spores of the 3 races of the fungus were differently affected by water extracts of the 3 rhizosphere soils. Spores of a race able to wilt a given variety germinated well in rhizosphere soil extract from that variety, and germination was less in extracts from the rhizosphere of a resistant variety.

When soils in which each of the 3 pea varieties had grown were inoculated with spores of race 1 and planted 48 hours later with seedlings of the susceptible variety Onward, plants became severely wilted in pots in which Onward had previously grown. Wilting was much less, and developed more slowly, in pots previously cropped with the resistant varieties Alaska and Delwiche Commando. As Onward peas wilted in fresh soil inoculated with race 1, it seems that roots of resistant varieties either secrete substances that prevent race 1 spores from germinating or stimulate a soil microflora with this effect. (Buxton.)

New records of diseases

Melon wilt, caused by *Fusarium oxysporum* f. *melonis*, was identified in a commercial garden at Chorley Wood, Herts, during August, where it killed about 70 per cent of plants of *Cucumis melo* var. *cantaloupa* variety Tiger.

Lucerne wilt, not recognizable as the well-known Verticillium wilt, was first seen on 2 July at Rayne, Essex, where diseased plants occurred along the edge of a patch of wilted peas. Of 17 cultures of *Fusarium oxysporum* isolated from pieces of discoloured stem vascular tract, 4 wilted Onward peas, an exception to the high degree of specificity usually found in *F. oxysporum*. At Rothamsted a similar disease was seen in August among lucerne in the ley–arable experiments on Highfield and on Fosters. Again *F. oxysporum* was isolated from the discoloured vascular tracts, but *Verticillium* sp. also grew from diseased stems kept in a damp atmosphere. Wilt symptoms are appearing in pots of lucerne inoculated with the Fusarium. (Buxton.)

Cereal diseases

Dry weather in May checked eyespot, *Cercosporella herpotrichoides*, on late-sown wheat in which the fungus had not already penetrated deeply, but the cold, wet summer favoured its later development and gave an unusually high proportion of straws with slight lesions at harvest. On Broadbalk, sown in November, the proportion of infected straws was as usual lower in the first than in the second, third or fourth crop after fallow. Mean values for 8 plots after fallow were 9 per cent straws with severe lesions, and 22 per cent with slight, compared with the average for the preceding 18 years of 21 per cent severe and 19 per cent slight. Plots after wheat averaged 27 per cent severe and 24 per cent slight, compared with the 18-year average of 45 per cent severe and 22 per cent slight. About 26 per cent of the total area was lodged, and much was untidily straggled; both effects were associated with eyespot.

In the four-course rotation experiment, wheat sown in mid-October had 54 per cent straws with severe and 23 per cent with slight lesions, almost doubling the previous average. Substituting beans for ryegrass before wheat did not decrease the incidence of eyespot, which in spring killed many plants. Spring-sown barley which preceded beans in this experiment had the unusually high proportion of 19 per cent straws infected, mostly too slight to do direct harm but enough to maintain the fungus in dangerous amounts for later wheat crops. In the six-course rotation experiment eyespot was about average on wheat, but there were more lesions than usual on barley and rye. (Glynne.)

Take-all caused by *Ophiobolus graminis* was very severe on the sixth successive wheat crop in an experiment on this disease, and was more severe on spring- than on autumn-sown Atle. One year free from susceptible crops on our farm usually decreases this fungus to negligible amounts, but in this wet year whiteheads occurred where wheat alternated with potatoes.

Take-all was negligible on Broadbalk after fallow, and although it occurred on other parts of the field, it was less than in some other fields at Rothamsted. On plots 13 and 14 for the second year in succession take-all was more severe on the heavily limed than on the lightly limed parts.

Gibellina cerealis occurred again on the alternate wheat and fallow experiment on Hoos field, its only known habitat in Britain. (Glynne and Cock.)

In the third and last year of an experiment at Rothamsted, in which 2 varieties of winter wheat followed 2 years under various crops, the first, second and third successive crops of Holdfast wheat yielded 34·8, 23·7 and 18·8 cwt./acre and Cappelle 49·6, 35·8 and 22·5 cwt./acre, with an average of 23, 18 and 16 ears per linear foot of row. The large differences in yield and ear number after different crops were closely associated with difference in incidence of eyespot, take-all and weeds. Despite an exceptionally difficult harvest, contrasting with the excellent conditions in 1955, yields on land that carried no cereals in the two previous years averaged only 6 cwt./acre less than in 1955; the best plot of Cappelle gave 56½ cwt./acre, 10 cwt./acre less than in 1955.

This experiment is one in a series which has shown that responses of wheat to various agricultural treatments depend partly on the incidence of eyespot and take-all, and that the responses need to be measured on land free from and infested with these diseases. Early sowing has given the best yields on uninfested land, but eyespot, which is most damaging on early-sown crops, can counteract this effect. A preliminary experiment, on rich, uninfested land, heavily dressed with nitrogen, was made to measure the effects of varying the date and rate when Cappelle wheat was sown. Mean yield of 9 plots sown 27 September was 61½ cwt./acre, and from successive sowings at 3-weekly intervals 58, 50 and 41 cwt./acre. Much smaller differences depended on seed rate and nitrogen; 3 bushels of seed yielded more than 1½ or 4½ bushels/acre, the largest effect amounting to 3½ cwt./acre of grain; 6 cwt./acre of sulphate of ammonia applied in spring gave slightly higher mean yields than did 3 or 9 cwt./acre; the largest increase from nitrogen amounted to only 1½ cwt./acre. (Glynne and Slope.)

In the ley–arable rotation experiment at Rothamsted eyespot has always been more prevalent in wheat following arable crops than after ley, and in 1954 and 1955 its incidence was so high that it decreased yields. Barley, which is susceptible to eyespot, and which preceded wheat in the arable sequence, was therefore replaced by oats, a much more resistant crop. The wheat crop in 1956, following oats, had only 0·2 per cent of the straws with eyespot lesions on both Fosters and Highfield, and for the first time since the experiment began the incidence of eyespot was the same in the ley and arable treatments.

The incidence and severity of take-all increased in each successive crop when winter wheat was grown at Woburn for 3 years; weeds, especially *Agrostis gigantea*, also increased. The severity of take-all was not decreased by nitrogen or thin sowing, as it was in previous experiments at Rothamsted, possibly because the intense weed competition limited root growth. Eyespot was much less prevalent in 1956 than in 1955, and was enough to cause damage only in plots of Holdfast which received 6 cwt./acre "Nitro-Chalk" in March. Grain yields averaged only 10·3 cwt./acre compared with 14·6 in 1955 and 27·4 in 1954 when the crop was much cleaner. For the third successive year 6 cwt./acre "Nitro-Chalk" applied in April yielded most grain, it averaged 18·7 cwt./acre compared with 5·3, 14·8 and 12·9 cwt./acre respectively for no nitrogen, an application in March, and one divided equally between March and May. The fertilizer applied in May, which strikingly increased weed growth as well as take-all, had little effect on yield, which averaged 5·9 cwt./acre. The two seed rates yielded the same weight of grain in nitrogen-deficient plots, but thin sowing yielded 29 per cent less than thick sowing, where 6 cwt./acre of "Nitro-Chalk" were applied. (Salt.)

Club-root of cruciferous plants

The main work, done in conjunction with F. T. Last of the Insecticides and Fungicides Department, was to study the action of the systemic fungicide, griseofulvin, on club-root, particularly to establish whether it could suppress or retard the disease when applied only as a spray to the leaves. Last year we found that griseofulvin decreased club-root almost as well when sprayed on to plants as when added to the soil, but then no strict precautions were taken to prevent the spray from reaching the soil. This year great care was taken to ensure that the spray could not reach the soil, and it seems that, when this is done, griseofulvin applied to the leaves has little or no effect on the development of clubs. The earlier results are now attributed to spray falling on the soil or running down the stems, so that it could have inhibited *Plasmodiophora brassicae* in the soil or have been taken up by the roots and inhibited the pathogen within the host.

As effects of griseofulvin were being assessed by weighing tops and roots, it seemed opportune to make some observations on the effects of *P. brassicae* on the growth of its host plant. No such study appears to have been made before. Two growth analyses were made by taking samples frequently, from the time of planting and inoculating, until the clubs eventually began to decay. Measurements were made principally of the dry weights of various organs and of leaf area. The many data obtained are still being analysed, but the main effects of *P. brassicae* on cabbage seem to be as follows:

The most important (if also the expected) consequence of infection is to alter the distribution of dry weight in the plant. No changes in dry weight, or indeed, in any other quantity, were detected until there were visibly clubbed roots, and differences between healthy and diseased plants began when the gall was initiated, and they increased as the gall grew.

Compared with healthy plants, the root system of diseased plants constituted a greater proportion of the total dry weight, and this proportion increased with time. After clubs appeared, i.e., about three to four weeks after inoculation, there was very little further increase in the weight of fibrous root, and increase in root weight was nearly all from growth of the clubroot gall. With this diversion of an increasing proportion of the dry weight to the root, the weight and rate of growth of tops correspondingly decreased.

Changes in the assimilating system were considered in terms of leaf area and net assimilation rate. Increase in total leaf area closely paralleled that of total dry weight; it was slower than in healthy plants and attained a lower limit. The rate of production of expanded leaves was lowered immediately clubs began to grow. There were fewer leaves on diseased plants, but a decrease in the mean area of leaves contributed equally to the decrease in total leaf area. Leaves of diseased plants failed to attain either the area or thickness of leaves in corresponding positions on healthy plants.

There was a suggestion that net assimilation rate was slightly lowered by infection. One factor which might have affected this was the frequent wilting of leaves of diseased plants, caused by the fibrous root system failing to develop when clubs were formed. There were no effects on the succulence of the shoot as measured by water content per unit dry weight.

Inoculating later, or with fewer spores, delayed growth of clubs and the consequent interference with growth of fibrous roots and tops. A larger plant then grew before clubs developed, but this larger plant later produced a much larger club than could form on a plant inoculated early. Clubs produced on cabbage by different isolates of *P. brassicae* varied in form and in their rate of growth.

It has been previously reported that the proportion of spores which germinates depends on their source. Germination is also affected by the treatment of the sample during storage, and by secretions of the roots of host plants. When spores were stored (at 4° C.) in dilute suspension their capacity to germinate and to infect was sometimes decreased, suggesting that a factor necessary for germination can be leached from the spores. Germination was hastened, and the proportion of spores that germinated was increased by the presence of host plants or by incubation in diffusates from roots of host plants. (Macfarlane.)

Sugar-beet diseases

A spray containing 1 per cent streptomycin and 1 per cent glycerol effectively controlled downy mildew (*Peronospora schachtii*) on sugar-beet seedlings in the glasshouse. In a preliminary study of the incidence of oospores in infected leaves from Lincolnshire and Norfolk in September and October, oospores were found in 35 out of 193 leaves.

The hypocotyls of sugar-beet seedlings were found to be more susceptible to damage by ultra-violet rays than the seedling leaves, or the leaves of fully grown field plants. The hypocotyl injury resembled the early stages of strangles, the cause of which is not known. (Cornford.)

Insecticidal seed dusts containing gamma-benzene hexachloride gave an increase in seedling emergence from seed sown in July and in the field at Dunholme. After singling, however, toxic effects from the gamma-BHC caused loss of plants, distortion and stunting of the foliage and death of the tap root. The injury was greatest on natural seed of a polyploid variety and was worse on natural seed of a diploid variety than on rubbed seed, and was greater with increased dosage of seed dressing and with high seeding rates. The percentages of surviving plants with damaged tap roots for half, normal and double the recommended dosage were 0·5, 10 and 43 for natural diploid seed; 2, 3 and 31 for rubbed seed and 8, 38 and 67 for natural polyploid seed. (Hull.)

In a series of experiments arranged in co-operation with Sugar Corporation fieldmen, seed soaked in ethyl mercury phosphate solution gave an average of 10–20 per cent more seedlings from 4 different seed batches. In three years this treatment has given an extra 10 per cent seedlings under good emergence conditions and 20–30 per cent more under adverse conditions, and has increased plant stand by 1·8–5·8 per cent. In small-scale trials benefits similar to those from ethyl mercury phosphate were given by "Aretan" or "Abavit S" (0·5 per cent formulated material) steeps. Where soil fungicides were applied along rows sown with seed treated with ethyl mercury phosphate, emergence was increased by 3·5 per cent. (Gates.)

Several fungi were isolated from roots of plants suffering from "Docking disorder". Of 8 species inoculated to sugar-beet seedlings in pots of John Innes compost adjusted to three pH levels, 5·3, 6·5 and 8·0, only *Fusarium oxysporum* and a *Pythium* sp. caused damage. Symptoms were more pronounced in acid soil than in alkaline. Affected plants were shorter than controls and had inwardly-rolled somewhat chlorotic leaves. Roots were not fanged, but 19 per cent were twisted and forked in plants inoculated with *F. oxysporum*, 21 per cent in those with *Pythium* and 5 per cent in uninoculated controls. Profuse lateral root production was also characteristic of plants inoculated with these two fungi. It seems that, although *F. oxysporum* and *Pythium* can damage sugar beet, there are probably additional causes for root fanginess. (Buxton.)

Disease survey of experimental crops

Lucerne wilt. During hot, dry weather in early September extensive wilting occurred on second- and third-year plots on the Highfield Ley–Arable Experiment and on the third-year plots of the Fosters Ley–Arable Experiment. On 4 October the percentage area wilted on first-, second- and third-year plots was 0, 17, 45 on Highfield and 0, 0, 22 on Fosters. The vascular tissues of root and stem of wilted plants were stained brown, and from this tissue a *Fusarium* sp. and a *Verticillium* sp. were isolated.

Crown wart of lucerne (Urophlyctis alfalfae). This disease was prevalent on the third-year lucerne plots of the Woburn Ley–Arable Experiment, but only when the previous rotational sequence contained lucerne. The disease did not occur on any of the first- or second-year lucerne plots. Infected plants were vigorous and seemed to be suffering little loss of yield.

Chocolate spot of beans (Botrytis cinerea). This disease was more prevalent than usual on both winter- and spring-sown beans, but the aggressive stage (coalescence of spots) did not occur until mid-July, and losses of yield were not very great. In an experiment comparing winter- and spring-sown beans at different levels of potash and phosphate fertilizer, there were considerable differences in the incidence of chocolate spot on different plots. On 9 August an estimate was made, but the only treatment difference was that winter-sown beans were more heavily infected than spring-sown; there was no consistent effect of potash or phosphate fertilizer. However, the disease was well advanced when the estimate was made, and there may have been differences earlier.

Rust of beans (Uromyces fabae). This disease was unusually widespread at Rothamsted during August and September, but too late to affect yield greatly.

Clover rot (Sclerotinia trifoliorum). The clover in the Six-course Experiment at Rothamsted was very badly infected by *Sclerotinia* in the winter and spring, and many plants were killed. The surviving plants were too few to cover the ground in the summer, and the crop was further weakened by an infestation of larvae of the pea and bean weevil in June. All the lucerne crops on the farms had a few plants killed by *Sclerotinia*. (Slope.)

https://doi.org/10.23637/ERADOC-1-117