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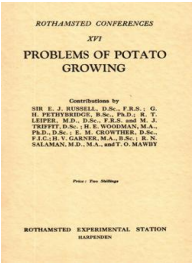
Problems of Potato Growing

Full Table of Content



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THE EELWORM PROBLEM

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That the potato-root eelworm, *Heterodera schachtii*, is widely distributed in Britain is now unhappily a well recognised fact, but it is of significance that although the parasite was diagnosed in England as long ago as 1917, the serious nature of the infection has only recently been realised by the majority of growers.

Now, there is every reason to suppose that previous to 1917 the parasite was well established in several district, for, only two years after Taylor's diagnosis of the pest in Yorkshire, it was recognised both in Cumberland and Cambridgeshire. In the latter instance the attack was so severe that in a field where 7 cwt. of seed was planted, the yield was 5½ cwt. only. This clearly indicates that this infection at least was of several years standing. Subsequent records show that in the early post-war years practically all the potato-growing districts in Britain contained foci of infection. Since no steps were taken to limit the spread of the disease, and in many districts potatoes were grown almost annually on infected land, it is not surprising that the eelworm problem has assumed its present very serious aspect.

In this connection it may be worthy of mention that a similar state of affairs had previously been brought about in Germany by the same eelworm, only in that case sugar-beet was the plant attacked. The sugar-beet industry, begun in Germany about 1800, was for many years so successful, and beet growing proved so profitable, that sugar-beet was repeatedly grown on the same land. The system of rotation and fallowing formerly practised was abandoned. As a result of this, eelworm became very prevalent, and in 1876 no less than 24 factories were closed down and thousands of acres of previously fertile land had to be returned to pasture. Scientific investigation of the eelworm problem was begun in Germany as early as 1870, and is still being carried out, but so far no practicable measure of ridding infested land of eelworm, other than by prolonged rotation with non-susceptible crops, has been devised. That the pest can be controlled by this means is amply demonstrated by the present day success of beet-growing in Germany.

Of recent years attention has been paid in Europe generally, as well as in Britain, rather more to the depredations of the eelworm on potatoes than on beet, for although the nematode responsible for the damage is the same, the problems it presents differ in certain important respects. This is due to the remarkably high specialisation

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which occurs when this particular eelworm lives for many generations parasitic upon a single species of host. It has been found that not only does such a specialised population of eelworm tend to lose the power of attacking plants other than the usual host or closely related species, but other physiological differences occur which influence the response of the eelworm to certain stimuli. One very important difference is that, whereas the larvae of the strains specialised for beet require only the stimulus afforded by suitable conditions of temperature and moisture to cause them to emerge freely from the cysts, the larvae of the potato strain require a further chemical stimulus before hatching will take place with any great freedom. This is provided by the root excretions of the potato plant. When non-susceptible crops are grown, the beet strain tends to die out from infected land much more rapidly than the potato strain, for greater numbers of larvae are freed each year. The advantage of this to the grower is, however, counteracted by the higher probability in the case of the beet strain that some weed may become infected and serve as a reservoir of infection, for in general the beet strain is less highly specialised than the potato strain.

Although it is usual to refer to these specialised populations of eelworm under such general titles as " beet strain," " potato strain " and " pea strain," for example, yet another important factor, which is perhaps insufficiently realised even by scientific workers whose experience is confined to a limited district, is that a strain specialised for a single host in one district may differ in minute respects from an apparently similar strain specialised for the same host in another area. Yet these slight differences may assume very great importance, more particularly in relation to the question of devising methods of control.

That such differences in the potato strain do exist in Britain has been repeatedly pointed out in publications of the Institute of Agricultural Parasitology. Research workers of this Institute, while carrying out laboratory studies and small scale experiments at the field station at St. Albans, pursue their main observational work, and conduct field experiments, in those districts where the parasite constitutes the most serious menace to agriculture. In this way knowledge has been gained of the different strains of eelworm which occur in north and south Lincolnshire, Yorkshire, Lancashire, Bedfordshire and Wiltshire, as well as Hertfordshire, and thereby contradictory results appearing in the literature have been understood and assigned to differences in soil type and agricultural practice.

To appreciate fully the significance of these minute differences in physiological reaction, a detailed knowledge of the work which has been carried out, both in this country and abroad over a period of years, is, of course, necessary. A summary of some of the more striking points can only be attempted here.

The most obvious point which arises in connection with the control of the eelworm and the treatment of the disease known as " potato-

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sickness" with which it is associated, is its association with certain types of soil, and bound up with this are questions of land values and agricultural practice. It is obvious that where very fertile, highly-valued land becomes infected, it is economically possible to apply manurial or chemical treatment involving considerable outlay, while any other method of control which might include, for example, fallowing for a considerable period, would be quite impracticable. In other cases exactly opposite conditions prevail. Very frequently highly fertile land is found to be infected as a result of potato cultivation carried on year after year despite eelworm and "potato-sickness" making their appearance, until a stage is reached where it becomes impossible for the land to bear a successful potato crop.

In these cases it is common to find the grower of the opinion that potatoes are the only possible crop from which he can make a profit. Where this is actually the case, as sometimes happens with small holdings, there seems no alternative to the land becoming derelict; but where alternative crops can be grown there is some evidence that one reasonable crop of potatoes can be produced every four or six years, which is preferable to annual losses from the constant failure of the potatoes.

There is little doubt that the establishment of the sugar-beet industry in Lincolnshire and South Yorkshire has saved thousands of acres of fertile but "potato-sick" land from going out of cultivation. But there is now great danger that beet may be grown so frequently on this infected land that a host transference may be effected by the eelworm. As an illustration of the depreciation in land values which follows as a result of eelworm infection the case of a farm in Yorkshire may be quoted. In 1930 this farm was let at a rental of £2 an acre: in 1933 it failed to let at a rental of 10s. an acre although it is situated in a beet growing area. Land depreciation is therefore one of the serious consequences which must be kept in mind in estimating the damage following upon the spread of this eelworm.

There is another point which must not be omitted in considering the relative importance of eelworm in different districts and different types of land. The physical condition of soil greatly influences the eelworm's rate of reproduction and consequently affects the rate of spread from isolated foci of infection. Recent work has also shown that the rapidity of eelworm elimination which follows a suspension of potato planting is likewise influenced by soil composition, so that the good results obtained by this means in a light, sandy, well aerated soil must not be too confidently anticipated in districts where the soil has a closer texture.

With regard to the more inherent physiological variations which are found to occur in strains of eelworm in different parts of the country, comparatively little is as yet known. Such information as is available, however, serves to emphasise the importance of this aspect of the eelworm problem. Variations in size of the larvae

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would scarcely seem to have a bearing on the economic side of the problem. Yet it has been shown in Germany that a proportion of larvae contained in the cysts of the highly specialised oat strain are capable of penetrating the roots of beet, and that these larvae can be distinguished from the ordinary forms, which attack oats only, by their shorter length. It is a probable and generally accepted supposition that the specialised strains or races of *Heterodera schachtii* have arisen from a common unspecialised stock, and have acquired their specialisation as a direct adaptation to environment. That is to say, that following each successive generation produced upon any host plant, the worm tends to attack that particular host plant more readily, and other possible hosts less readily. Hence the greater frequency with which any crop is grown, the higher becomes the specialisation of the parasite for that particular host. In the potato strain this specialisation has become so intense that in some districts no other plant species can serve as host. Hence when potatoes are withheld from infected land the parasite gradually and very slowly dies out. It remains, however, always a matter for conjecture how far the specialisation has been carried in any one district. Some other plant, either cultivated or a weed, is quite liable to serve as a host under exceptional circumstances and slight infections of this sort are generally overlooked although they are sufficient to carry on the infection during a rotation period.

In certain districts of Ireland docks are attacked ; in Lancashire, couch grass ; in South Lincolnshire, *Chenopodium album ;* and in Wiltshire, carrots have on one occasion been found to serve as a host. In other districts cysts which do not conform to the type produced on the potato plant have been isolated from the soil of potato fields although it has not been possible to discover on what plant they have been developed.

Whether in these cases the infection can be re-transferred to the potato, or passed on to some other cultivated host, is not known as the conditions governing host selection have not yet been fully investigated. It has been found, however, that in some districts, under special conditions, the potato strain of the eelworm will attack beet, hence it is of the utmost importance that sugar-beet should not be grown too frequently, and under no circumstances for two consecutive seasons upon land infected with the potato strain of *Heterodera schachtii*. A strain of the eelworm which very readily attacks beet, mangolds, cabbages and a large variety of weeds is known to exist already in western England. It is of interest that this strain does not attack potatoes. As yet it is not known whether, following reproduction upon an unusual host the parasite shows a loss of previously acquired specialisation, but if this proved to be the case occasional infections on weeds would assume an even greater importance.

In the main the researches carried out in Britain have been directed towards the discovery of some means of controlling the

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parasite. Towards this end three main lines of investigation have been followed. Firstly, methods have been sought for eliminating the eelworm from infected land. Secondly, variations in farming practice have been tried with the object of ensuring an occasional good crop of potatoes from land known to be infected. And thirdly, reasons for the alarming rate of spread of the parasite have been investigated.

The application of chemical substances to infected soil has given no evidence of control by elimination of the eelworm. In such instances better crops have been obtained following the use of chemicals, but this improvement has been due probably to a temporary effect, not on the parasite but on a second factor, which is probably nutritional. Some such treatment may yet be discovered which can be used on small areas of very valuable land, but for general purposes most substances which might be employed are prohibitively costly.

Good results have been obtained in eliminating eelworm by the use of grass excretions, but this method is still in the experimental stage. On infected "warp" land the eelworm is known to survive for more than ten years when potatoes are withheld and cereal and other immune crops are grown. In a field of this type the eelworms have been reduced by 48 per cent. in eighteen months by the use of a grass ley. By this method the eelworms are stimulated to hatch from the cysts, after which, in the absence of the potato plant, they die out. What effect this method will have upon the second factor concerned in the production of disease, remains unknown. It may well be that in some districts the eelworm may attack the grass, although this has not yet occurred in the experimental area. In any event it seems probable that at least four years will be necessary for anything like a complete elimination of the parasite, though the time will be strongly influenced by the type of soil.

With regard to the second method of approaching the control of the eelworm, it has been shown that after a four-year rest from potatoes certain types of land, such as that occurring in South Lincolnshire, will produce a satisfactory crop despite a high degree of eelworm infestation if adequately supplied with organic manure. Although the eelworm content of the soil is increased by the cultivation of potatoes, the change of cropping, coupled with the manuring, seems to eliminate the second disease-producing factor, in the absence of which eelworm has a comparatively slight effect in reducing the yield.

It has been estimated, from figures supplied by growers, that on rich land with a moderate eelworm content, but where a four-course rotation has prevented the symptoms of "potato-sickness" from appearing, a profitable yield of potatoes may be expected, although this may be from one to three tons per acre less than the yield from similar but uninfected fields. It is not known whether this four-course system can be repeated indefinitely with satisfactory

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results where very heavy infections exist, but it should prove successful in cases of moderate infection. Here again secondary factors such as type of soil and available organic manure are of considerable importance.

Heavy applications of farm-yard manure applied in the rows at the time of planting has given improved yields as compared with other methods of manuring, more particularly where artificial fertilisers are used alone. This method ensures that the first roots can make some growth before being attacked by the eelworms, which gives the plants a better chance of tolerating eelworm damage. It has been suggested that heavy manuring combined with early lifting would decrease the eelworm population of soil, provided the roots were collected and burnt, but in practice it has been shown that after such treatment the eelworm content of slightly infected soil is actually increased by at least 100 per cent. owing to the impossibility of removing all the roots.

As we see it, the present position with regard to the control of eelworm trouble on potatoes is that, pending the discovery of some method whereby the eelworm can be eliminated from infected land, the only measure which can be adopted by growers, to avoid financial loss upon the actual crops and grave damage to the land, is the consistent use of four, or preferably six-course rotation. If the use of the special grass ley now under trial proves satisfactory, it will be possible, at least in some districts, to use it in the rotation for one or two years to reduce the eelworm content of the soil more rapidly. The effect of enforced rotation in infected areas would not only lessen the financial loss sustained by the individual grower, but would check the depreciation of land values and would limit production.

With regard to the spread of eelworm throughout the country, investigations have shown that the most fertile source of distribution to new districts has been by the use of seed potatoes grown in infected land. Cysts have been found in the fragments of loose soil in potato bags and adhering to the tubers, in sufficient quantities to produce an appreciable infection in previously clean land within a single season. An average of seven cysts per tuber has been found in such a sample of seed, and as each cyst may contain several hundred eggs, the rapidity with which the eelworm has spread is amply accounted for.

If it is quite impossible to place restrictions on the sale of seed from infected land, it would surely be practicable to grant certificates to clean seed where these were applied for by growers. The recognition of *Heterodera schachtii* on the growing plant is an easy matter, and might well be undertaken by the horticultural inspectors of the Ministry. If supplies of certified clean seed were available from even a few firms of reputable growers, and greater publicity were given to the dangers of eelworm infection either in the daily press or weekly papers devoted to horticulture, sufficient interest would probably be aroused to check the spread of the disease. There can be little doubt

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that farmers and small-holders who have once suffered from infected land would welcome the possibility of guarding against the introduction of infection to clean land. It is hoped that a method of cleaning seed potatoes will shortly be available so that the demand for clean seed should not exceed the supply. The adoption of similar measures is being strongly advocated in Germany, although only a comparatively small area of that country is infected. In Sweden legislation has been carried out to prevent the importation of seed potatoes from countries known to be infected with the eelworm. Small areas of Schleswig-Holstein which were known to be infected with the potato strain of the eelworm were returned to pasture after the war through the action of the Danish Government, with the result that to-day there is no eelworm problem in Denmark. Are we to admit that the Danish agriculturist has the monopoly of foresight and of courage ?