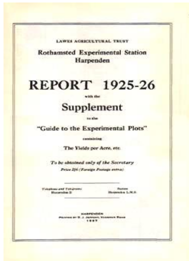
Report 1925-26 With the Supplement to the Guide to the Experimental Plots


Rothamsted Experimental Station
Harpenden
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Losses of Crops by Diseases and Pests

Rothamsted Research

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An even more efficient absorption of the nitrogen from the sewage can be obtained by allowing the effluent to flow over straw or similar material, which furnishes the bacteria with energy material, causing them to multiply rapidly and assimilate large quantities of nitrogen from the sewage.

These relationships between the nitrogenous and the non-nitrogenous constituents and between the bacteria and the protozoa, furnished the key to some of the difficulties in dealing with sewage and other effluents.

LOSSES OF CROPS BY DISEASES AND PESTS.

The loss caused to fruit growers, farmers and market gardeners, by insect, bacterial and fungus pests, is far greater than is usually realised. No precise estimate is possible, but experts of standing consider that it can hardly be less than 10 per cent. of the crop; in money terms, some £15,000,000 per annum. The trouble is likely to grow worse; improved communications tend to carry plant diseases all over the world, and no method is certain to keep them out from any country.

In order that permanently satisfactory methods of treatment may be devised, it is very desirable to know fully the life history of the fungi and insects concerned and the physiological relationships between the disease-causing organism and the host plant; also to have detailed information about :—

1. The effect of cultivation and manuring on the susceptibility of the crop to disease;
2. The factors determining the rate of increase and of decrease of insect, fungus or bacterial populations;
3. Methods of direct action, such as poisoning, and where practicable, trapping, on the organisms causing disease.

This fundamental information is being obtained, and it is being applied to the control of insect and fungus pests by :—

1. Alterations in time of sowing, methods of cultivation, or manuring;
2. Breaking the life cycle of the organisms in some way (as by the suppression of weeds or other plants that act as hosts), or, in the case of insects, taking advantage of the natural enemies, parasites, etc., that prey upon them;
3. Discovering new insecticides or fungicides that will not injure the crop, but will kill or severely check the pest.

In addition attempts are made to avoid the difficulty altogether by :—

4. Finding some variety of crop plant immune from the disease.

Of these, the first and fourth are the simplest for the farm, though direct action is sometimes possible, as, for example, the use of the fungicide Bordeaux Mixture for potato blight, and various traps for insect pests, like the flea beetle.

Modifications in methods of culture to avoid pests and diseases are already familiar to farmers, e.g., the late sowing of turnips on light land to avoid mildew, though it often causes the crop to

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suffer from drought by delaying root development. Examples recently tested at Rothamsted include the autumn sowing of beans to avoid black aphis, and the earlier ripening of barley, brought about by earlier sowing and modifications in manuring, to avoid gout fly. This is probably in most seasons the simplest way of dealing with insect and fungus pests on the farm. Dr. Davidson has studied the relationship between the manuring of broad beans and their liability to aphis attack, while in the new glass houses Dr. Brierley will investigate the way in which controlled nutrition of the plant alters its liability to fungus diseases.

No method of dealing with diseases and pests can, however, be entirely satisfactory until more is known of the conditions favouring the growth, dispersion, or migration of insect and fungus populations, and the conditions under which the intrinsic power of the organisms to cause disease becomes increased or decreased. At present great outbreaks can occur of which farmers or fruit growers had no warning, and yet there must have been factors at work causing the excessive multiplication of one out of the many forms of life in the field.

For some years past Dr. Davidson has been studying this problem of multiplication and dispersion, using the Bean Aphis as his material. During the summer period temperature and the physiological condition of the plant profoundly affect the rate of increase of the aphids. At a mean temperature of 70°F. individual aphids took about eight days to reach maturity and start reproducing: at 58°F. (mean) they took about 14 days, and at 55°F. (mean) about 20 days. On beans infected in June, after the setting of the pods, the increase in the number of aphids was 50 per cent. less than on plants six weeks younger, which were more succulent and had not reached the flowering stage. The advantage of autumn sowing is that the plants are well advanced before the winged aphids begin to migrate from the winter host to the beans.

The method of reproduction of the insect is affected by the external conditions. In nature the course of reproduction is for the mothers to hatch out from the eggs in March and give rise to a long succession of parthenogenetic generations. About October sexual forms appear for the first time, eggs are laid and parthenogenetic reproduction ceases. If, however, the temperature be maintained (as under glass house conditions), parthenogenetic viviparous reproduction goes on throughout winter, as well as the development of sexual individuals. At temperatures above about 70°F., the reproduction of the parthenogenetic forms markedly increases, but sexual forms occur more irregularly; the latter are mostly females, though many of their progenitors, the winged forms, die without reproducing. Very few males are produced, so that the normal sexual reproduction by the laying of fertilised eggs does not take place.

The sexual method of reproduction seems also to be associated with the normal winter host, which is a hard, woody plant. Sexual females not only develop much more readily on the spindle tree (the winter host) than on the beans, but in the cages they lay their eggs on the canes supporting the muslin cover rather than on the bean plant.

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Two other aphids have also been studied. The life cycle of the hop damson aphis has been traced from the hatching of the winter eggs in spring on damson trees to the appearance of the sexual forms in autumn. Winged migrants developed on damson and bullace in May. Some were transferred to hops, on which they produced generations of wingless forms until September, and then winged males and remigrants (sexual female producers). Those that had been kept on the damson and bullace reproduced so freely that they killed all the leaves.

Three species of bulb aphids were found on tulip and iris bulbs received from store houses at Covent Garden, in November, 1925. *Anuraphis tulipæ* was the most important. They reproduced rapidly on the dormant bulbs and spread up the flowering spikes of the growing bulbs, destroying them or stunting the flowers. Many winged forms were found but no sexual forms. The fact that winged males but not sexual females occur on tulip bulbs in autumn, indicates that the sexual phase is completed on another plant, used as a winter host.

Considering the multitude of pests with which our crops are beset, it is not easy to understand why any plant should ever survive. There must be natural agents preventing multiplication of insects in this country, and one possibility, which is being studied in the entomological laboratories, is that this natural control is effected by parasites of the insect pests themselves on the ancient principle that : " The little fleas have lesser fleas, and so *ad infinitum.*" There is reason to suppose that, if the parasites could be sufficiently encouraged, they would keep down the insect pests to manageable proportions. The possibilities are attractive, but the difficulties are considerable.

The sugar planters of Hawaii have had the courage to try the method. Dr. Imms visited the islands in 1925 to learn at first hand how it was answering in practice : he was favourably impressed. Authorities in New Zealand are also adopting this method in their efforts to get rid of earwigs, which have become a serious pest. Rothamsted has been asked to find parasites of the earwig and breed quantities for shipment out there. Puparia of the Tachinid parasite, *Digonochæta setipennis,* have accordingly been collected or reared, and sent out; the results will afford valuable experience for other parts of the Empire. Parasites of other pests are also being bred.

The converse problem is also attacked, from an entirely different point of view, also for the New Zealand Government. Gorse has become a serious pest, and all efforts to keep it in check have failed. A weevil, *Apion ulicis,* has been shown by Dr. Imms to destroy some 40 to 80 per cent. of the seeds on gorse shoots selected at random; some 3,000 were collected and shipped to New Zealand, where the feasibility of liberating them on to the gorse-infested regions will be tested. At the request of the entomologist to the Hawaiian Sugar Planters' Association, Dr. Imms has also transmitted a consignment of this same insect to Honolulu, with a view to attempting the control of gorse on the island of Maui. Arrangements have been concluded for collecting, breeding, studying, and shipping to New Zealand quantities of the insect, *Corœbus rubi,* to destroy the brambles which threaten to become so serious a pest there.

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Once an insect attack has begun, methods of direct action must be used to cope with it. Two types are in common use, trapping or catching by some mechanical or chemical means, and poisoning by insecticides. Trapping was successfully used against *Bourletiella hortensis,* a species of Collembola, which was found in 1926 to be injuring seedling mangolds on our farm. Laboratory studies by Mr. Davies having shown the dependence of these insects upon humidity, the trapping has to be carried out early in the morning in dry weather, when the leaves are wet with dew. Later in the day the insects leave the plants for the moister soil.

INSECTICIDES.

Two kinds of insecticides are used : stomach and contact. The former are intended to poison the food of the insects and are sprayed on the leaves which they will eat. The latter are brought into contact with their systems in some other way, either as vapours, poisonous spray-fluids, or dusts.

The search for soil insecticides, using the wireworm as the test insect, revealed a number of interesting compounds, among them naphthalene, but was checked by the difficulty that these compounds, though poisonous to the wireworms, serve as food for some of the soil organisms, and are consumed when put into the ground. No way round this difficulty has yet been found.

The work on spray insecticides has been more extensive. There are two kinds :—

1. Those used in winter, which must be strong enough to kill the eggs; fortunately, the trees are dormant, so that fairly potent materials can be used.
2. Those used in summer against the active stages of insects, some of which, such as the aphids, are easily killed. But the trees, being now in leaf, are sensitive to injury, and only those substances are useful which are fatal to the insect and harmless to the tree.

Certain vegetable products completely satisfy this requirement. Nicotine is the best known, but it is expensive. Mr. Tattersfield and Mr. Gimingham have found other vegetable products at least as effective, especially certain tropical leguminous plants, used by the natives as fish poisons. *Derris elliptica,* the Tuba root of Malay, and Haiari, from British Guiana, have yielded a poisonous resin and a colourless, crystalline substance, Tubatoxin, which is excessively poisonous to insects. Other tropical plants, *Tephrosia vogelii, T. toxicaria,* and *T. macropoda,* are also highly toxic to insects, but their poisonous principles have not yet been fully identified.

Many synthetic chemical substances have been investigated, their advantage being that they can be prepared in a pure state under rigidly standardised conditions. They are studied in their proper chemical series, without regard to whether they are yet on the market, the purpose being to draw up a specification showing the types of compound required, to which a technical chemist could work.

The hydrocarbons increase in toxicity with increasing molecular weight up to the point where certain physical properties are so modified that the substance cannot affect the insect. In the