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THE SPREAD AND CONTROL OF NETTLEHEAD AND RELATED DISEASES OF HOP

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The 17 000 acres of hops in England are grown on about 550 farms which produce an annual crop of 10 000 tons, worth £7–8 million. Yields and production costs are greatly affected by pests, fungi, and virus diseases which have long been widespread and serious. Nettlehead disease has been known since 1574 and split leaf blotch since 1926. Both diseases and the condition known as 'bare bine' or 'spidery hop', are caused partly or wholly by arabis mosaic virus. This is distributed in many of the stocks being propagated within the hop-growing areas and is spread through the soil by the dagger nematode*—*Xiphinema diversicaudatum* (Micol.). The information recently obtained is of great importance to growers attempting to avoid the present losses caused by nettlehead and related diseases.

Hop diseases associated with arabis mosaic virus

SPLIT LEAF BLOTCH

Symptoms are virtually confined to the variety Fuggle and all clones are affected to some extent. Each year plants develop one or two leaves with yellow oily blotches, which tend to split (Fig. 1). In some plants the symptoms become severe, affect a sequence of leaves and lead to decreased growth and crop. This distinguishes severe blotch, which is a graft-transmissible disease, from slight blotch, which probably is not.

* Subsequently referred to as *Xiphinema* because the approved common name of this nematode (eelworm) is not well known and is seldom used.

FIG. 1
Severe split leaf blotch symptoms in leaf of variety Fuggle.

FIG. 2
Vein clearing, enations and leaf distortion caused by nettlehead disease.

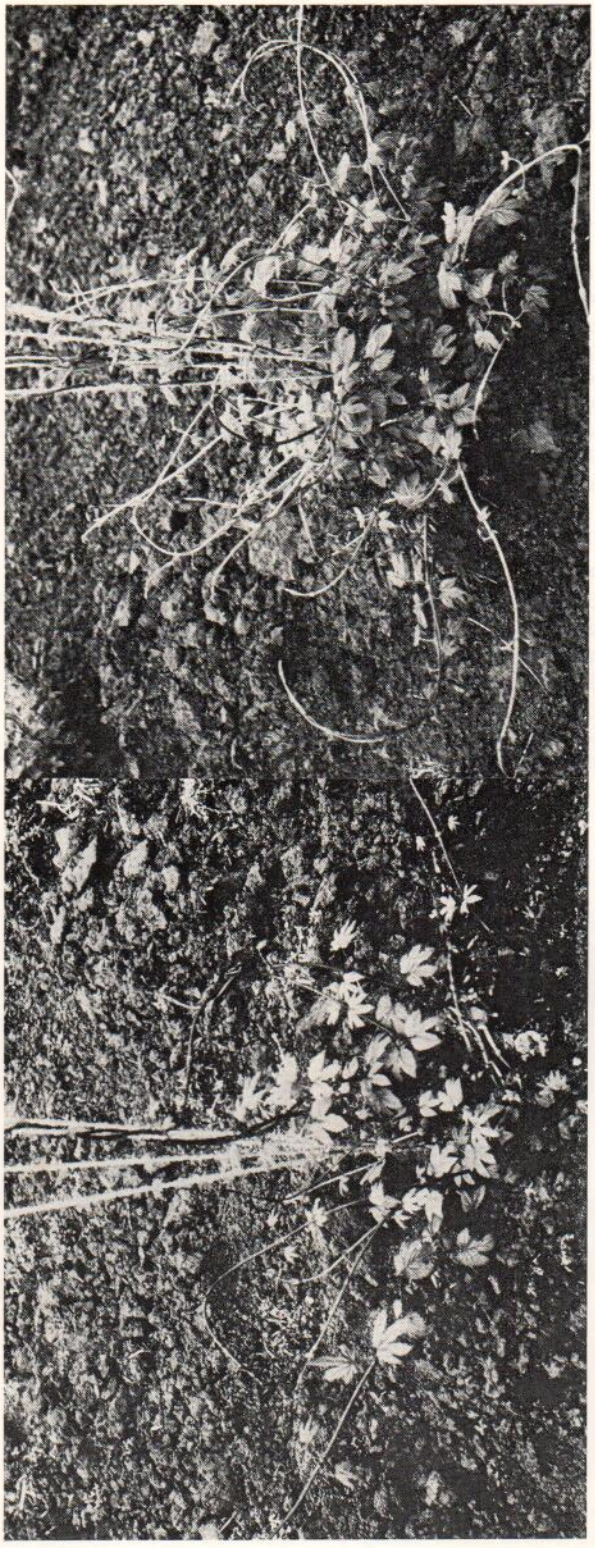

FIG. 3
The bare bine condition (left) compared with normal growth (right) of variety Northern Brewer as growth commences in spring.

Slight blotch occurs in a few scattered plants in all areas by mid-summer, whereas severe blotch tends to be localized and is always associated with the presence of arabis mosaic virus. This virus is not present in symptomless Fuggle plants or those with slight symptoms.

Severe split leaf blotch is widespread in Fuggle and its total effect on the national crop is probably greater than that of nettlehead, which though more damaging, is much less common.

BARE BINE OR SPIDERY HOP

Affected plants are weak as growth commences in the spring. They have a spidery, bare appearance compared with normal hills (Fig. 3). Few shoots develop and these have a characteristic curvature, dark colour and small, retarded leaves. The difference disappears within a few days as the plants are 'pulled' and 'trained' to remove coarse, weak, and excess shoots.

Fuggles with bare bine invariably contain arabis mosaic virus and later in the season develop severe blotch and possibly nettlehead. Bare bine plants of other varieties also contain this virus and some develop nettlehead. The majority become symptomless, except for the bare bine appearance, which recurs each spring.

Bare bine is just as common in other varieties as severe blotch is in Fuggle and the total effect on crop must be substantial. The only available data are for the variety Bullion, used by R. A. Neve and F. R. Thompson in experiments at Wye College. The virus decreased total yields of alpha acid in this variety by 30% in each of two successive seasons.

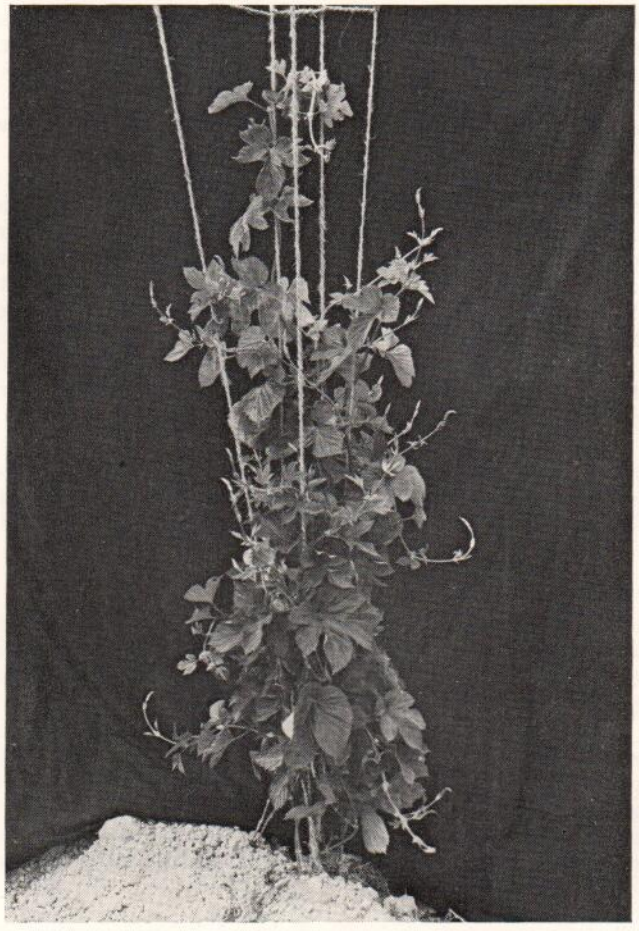

FIG. 4

Nettlehead-diseased hop with rolled leaves and shoots falling away from the supporting strings.

NETTLEHEAD

Affected plants develop stiff, erect shoots that fail to climb (Fig. 4). The internodes are short and the leaves develop a vein clearing or mottle with small leafy outgrowths (enations) from the undersides of the mid-rib and main veins (Fig. 2). There is a characteristic upward-rolling of the leaves. Plants tend to recover temporarily in hot weather.

Varieties are affected to different degrees. Fuggle and W.G.V. develop very severe symptoms and stunting, whereas infected plants of less sensitive varieties reach the top of the wirework in hot summers and produce a small crop.

The detection and distribution of arabis mosaic virus

The strain of arabis mosaic virus occurring in hop is an unusual one that is difficult to detect by the standard method of infecting glasshouse test plants. Fortunately, it can be detected in the sap from young leaves or shoots by a serological method. This is quick and reliable, except in very hot weather or late in the growing season.

Serology has been widely used for several seasons to establish the association of this virus with the three diseases mentioned. Moreover, tests on propagation material have shown the virus to be widespread in some of the stocks raised in the hop-growing areas. By contrast, infection has been found only once in the carefully selected stocks, grown in isolation in East Anglia, which qualify for the 'A plus' certificate of the Ministry of Agriculture.

Transmission of nettlehead and the hop strain of arabis mosaic virus by *Xiphinema*

Nettlehead disease often reappears and spreads slowly at the same site in successive crops. Outbreaks are most common alongside hedgerows, where hedges have been removed (Fig. 5) and when hops follow permanent pasture or orchards (Fig. 6). These features suggested that infection is soil-borne, but early attempts to show this were unsuccessful. Moreover, the first hop soils examined contained only a few nematodes of species known to transmit viruses in other crops.

The situation changed when substantial numbers of *Xiphinema* (Fig. 7) were found by J. J. M. Flegg in soils where nettlehead was spreading. This prompted experiments in which nematodes have infected many hops and other plants with arabis mosaic virus. Nettlehead disease was also transmitted to some of the hop seedlings artificially infested with *Xiphinema* obtained from a hop garden or from boxes of infested soil containing nettlehead plants. These results establish the importance of *Xiphinema* in hop soils. They also explain previous observations, because this nematode can persist even in bare soil and spreads slowly amongst its host plants. It is numerous in hedgerow soils and often occurs in smaller numbers in permanent pasture or orchard land, but seldom where arable crops are grown.

Control

Advice to growers has, until recently, been limited by inadequate information on the cause and spread of nettlehead and related diseases. The situation is transformed with the information now available. This should make it possible to cut production costs and increase yields per acre.

PLANTING MATERIAL

Growers have long been urged to plant 'A plus' certified sets instead of the unselected 'A' or the uncertified material available locally. This advice was justified by the low level of nettlehead in 'A plus' plantings. Nevertheless, two-thirds of all plantings made in 1968–69 and 1969–70 were of unselected stocks (see *Report for 1970*, p. 169).

The superior performance of 'A plus' sets can now be explained by their initial freedom from arabis mosaic virus. The use of this material for all new plantings would avoid introducing infection to the many areas apparently free from *Xiphinema*, or to populations of the nematode not already carrying virus.

The common practice of heeling-in planting stock temporarily in headlands should be avoided because of the high risk of infection by *Xiphinema* from neighbouring hedgerows.

SITE

Growers usually have some latitude in the choice of site for new plantings, especially at times of over-production and contracting acreage. With the additional criteria now available they can choose those sites that are least likely to become infected.

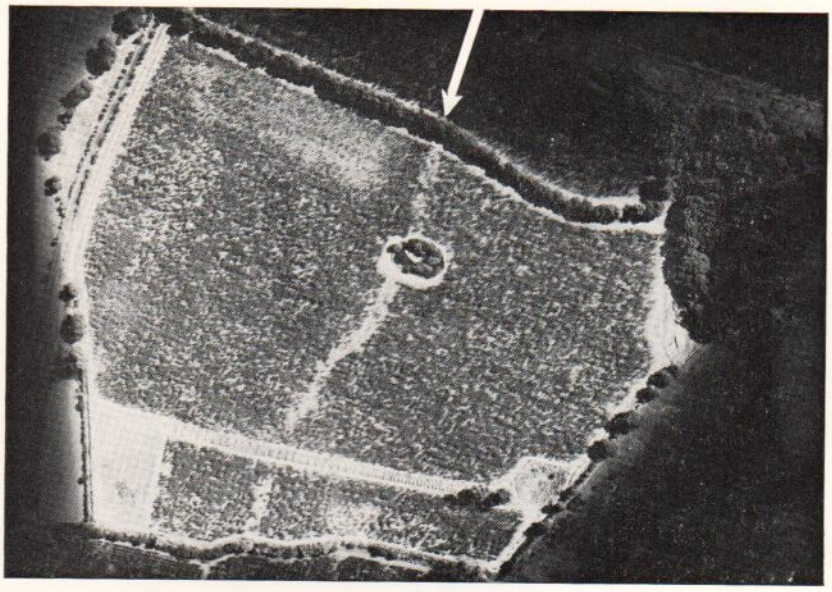

FIG. 5

Aerial photograph showing weak growth and gaps caused by nettlehead prevalent along the line of a former hedgerow (arrowed).

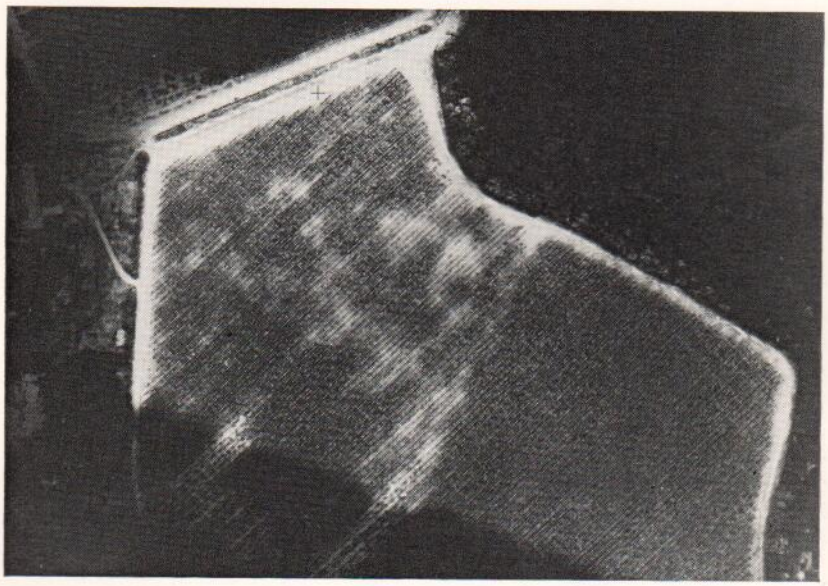

FIG. 6

Aerial photograph showing many gaps and patches of weak growth in hops established on old pasture land (left) compared with normal growth on land previously arable (right).

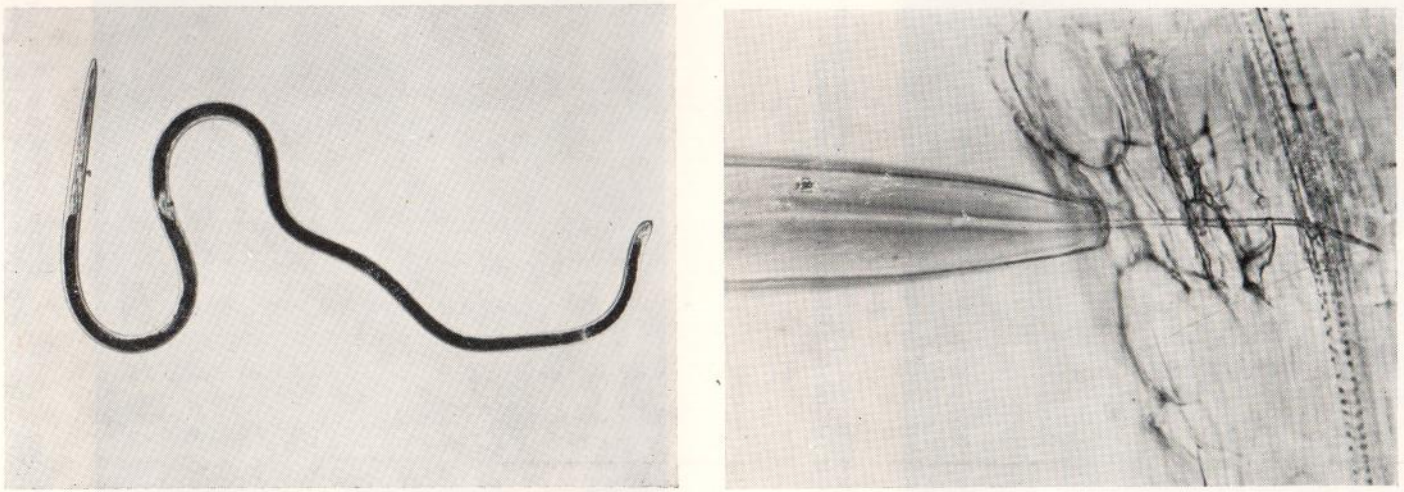

FIG. 7

The dagger nematode—*Xiphinema diversicaudatum*, ×50 (left) with details (right) of feeding spear in position in plant root tissue.

FIG. 8
Fumigation of small plots with D-D by hand-injector guns.

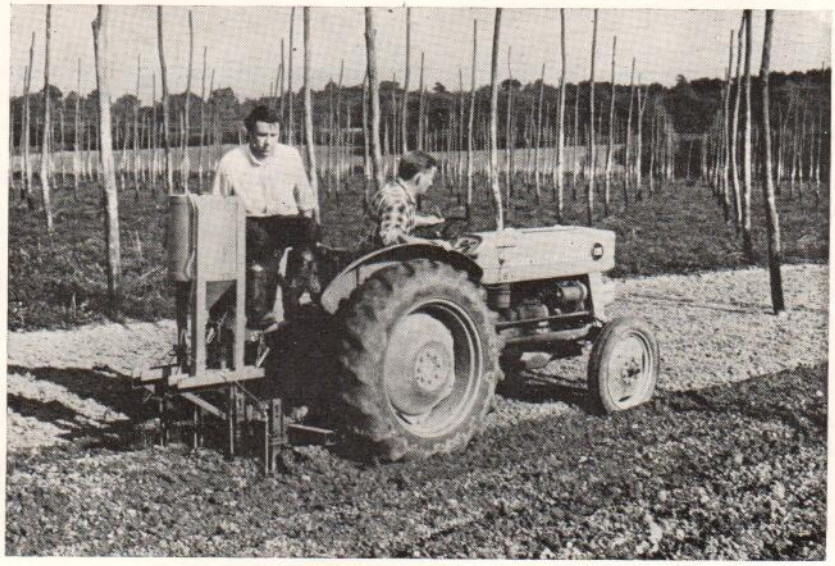

FIG. 9
Fumigation of larger plots with D-D by Auchincruive injector. Note the careful preparation of the soil to a good tilth to facilitate penetration of the fumigant.

Considerable use is already being made of the facilities of the Agricultural Development and Advisory Service for sampling soils to assess numbers of *Xiphinema*. Unfortunately there is no simple method of determining whether any nematodes found are carrying the hop strain of arabis mosaic virus. There are also difficulties in that few samples can be collected in relation to the huge volume of soil in a field and the nematode is often patchily distributed.

Nevertheless, it is usually possible to locate the relatively few sites where *Xiphinema* is a potential hazard. When such sites have a previous history of blotch, nettlehead, or bare bine they should not be used for hop-growing until an effective fumigation or other preplanting technique is developed. Sites with *Xiphinema* but with no previous history of hop cultivation are also best avoided until it is possible to assess the risks involved for hops. On no account should they be planted with anything other than 'A plus' material.

Xiphinema does not seem to thrive on hop roots. Few hop sites have the high numbers found in some other crops and many gardens are free or only slightly infested. Growers do not seem to have had much difficulty in finding *Xiphinema*-free land for new plantings of Wye Northdown. Indeed, the present high level of disease seems to be due mainly to the continued use of infected planting material, rather than to spread by nematodes.

FALLOWING AND CROP ROTATION

Fallowing and crop rotation are unlikely to eliminate the vector from hop soils because it can feed and reproduce on the roots of many different crops and weeds and can survive long periods in bare soil. Nevertheless, the virus does not persist through the larval moult and adult nematodes probably do not retain virus for life. In one trial, infectivity fell markedly in bare soil two years after removing nettlehead-infected hops. Similar trends were seen at other trial sites in Kent and in the West Midlands. This justifies the long-established practice of a few growers who fallow nettlehead land for two years before replanting. Such a long interval is not always possible, especially at times of great demand for hops. The immediate replanting of many infected sites in 1968–69 and 1969–70 gave *Xiphinema* every opportunity to survive and remain infective (see *Report for 1970*, p. 169). We do not yet know whether a longer interval between crops will provide sufficient advantage to justify the expense nor whether alternative crops can be grown.

FUMIGATION

Some growers must retain the wirework in certain areas and continue hop production despite the likelihood of nettlehead recurring. Hence a successful fumigation technique to eliminate *Xiphinema* is desirable, even though it may be expensive and require special soil preparation.

Nematicides are already used to control the vectors of some virus diseases. Satisfactory control will be much more difficult with hop, because it is a deep-rooted perennial often grown in very heavy clays. *Xiphinema* may occur to considerable depths and one individual per 200 ml soil sample is equivalent to about 12 000 around a single root system.

Some success has been achieved in trials sponsored by the Hops Marketing Board. An autumn application of a mixture of dichloropropene and dichloropropane (D-D) by hand injection (Fig. 8) at 25 gal/ac effectively controlled nematodes in some plots and halved the overall incidence of nettlehead and arabis mosaic virus in the second growing season, compared with untreated controls. A similar application at the rate of 50 gal/ac was even more effective and the number of *Xiphinema* occurring at a depth of 24 in. was only 2% of that in untreated plots.

The original small-scale trials and the first results of later ones have justified bigger experiments on the injection of larger plots by tractor-drawn machines of the type developed for nursery, potato and sugar beet land (Fig. 9). These machines have also been tried by growers on areas of several acres.

FUTURE PROSPECTS

Present measures are intended primarily to avoid disease. There is no practical method of curing infected plants in the field and no evidence of resistance or tolerance to virus or nematode that could be exploited by plant breeding. Only limited advice can be offered to growers to avoid the recurrence of infection at badly infested sites, but current studies on fallowing and fumigation may be successful. Meanwhile, sites and setts for all new plantings should be selected much more carefully than hitherto.