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PROBLEMS CAUSED BY WILD AND REGENERATING HOP PLANTS

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Summary Wild hop plants, including many males, are widely distributed in Britain, being particularly numerous in areas of commercial plantings. This creates difficulties for hop growers intending to eradicate male plants so as to adopt the foreign practice of producing 'seedless' cones.

Many hop seedlings appear when diseased or unwanted hop plantings are grubbed and there is much regeneration from debris remaining in the ground. This leads to the adulteration of varieties and to the carry-over of virus infection between successive plantings. It is essential to eliminate all regeneration growth when attempting to prevent the recurrence of nettlehead and related diseases by fallowing; a practice that facilitates the loss of virus from the nematode vectors in the soil.

Le houblon sauvage se trouve largement réparti dans les Iles Britanniques et particulièrement dans les zones à production commerciale. Ceci crée des difficultés pour ceux des producteurs de houblon désirant se passer de pieds mâles, adoptant ainsi la pratique étrangère de production de cones sans graine.

Quand des plantations de houblon maladiées ou par ailleurs indésirables sont arracheés, de nombreux semis de houblon apparaissent et il y a de plus croissance de nombreuses tiges à partir des debris restés dans le sol. Ceci conduit au mélange des variétés et à la contamination virale entre plantations successives. Il est particulièrement important d'éliminer les pousses issues des débris aussi rapidement que possible lors de la mise en jachère, afin d'éviter la réapparition du nettlehead ("tête d'ortie") et des maladies semblables. La mise en jachère est une pratique qui facilite la perte du virus par le nématode vecteur dans le sol.

INTRODUCTION

The hop (Humulus lupulus L., Cannabinaceae) is grown in many temperate countries to provide cones containing the alpha-acid resins required by the brewing industry. There were 16,735 acres of commercial plantings on 496 farms in England in 1973, when the crop totalled

10,280 tons, worth approximately £10 million. This represents approximately 9% of total world production, which is dominated by the U.S.A. and West Germany.

Growers in all regions encounter serious problems due to the occurrence of 'wild' and seedling hops and to regeneration from previous plantings. Such growth acts as a source of disease and the frequent appearance of seedlings and other 'rogues' leads to the adulteration of varieties. Moreover, the widespread distribution of male hop plants causes difficulties to English growers intending to follow foreign practice and grow seedless hops. Various aspects of these problems are now considered, with emphasis on the importance of regeneration growth in the epidemiology of nettlehead and related virus diseases.

THE DISTRIBUTION OF HOP IN THE BRITISH ISLES

Hop pollen occurs in peat deposits and the hop is listed in the current British flora as native and widely distributed in Europe and western Asia. It has been recorded in the Channel Islands, in 100 of the 114 vice-counties in Great Britain and in 23 of the 40 in Ireland (Clapham *et al.*, 1952).

The hop is a dioecious perennial with a similar habit of growth to bryony (*Bryonia dioica* Jacg.), *Convolvulus* spp. and clematis (*Clematis vitalba* L.). It is commonly found with these species and also elsewhere in hedgerows and thickets. Many of the plants occurring in these situations originate from commercial plantings that previously were much more numerous and more widely distributed than at present.

Hop growers often throw unwanted plants and debris into hedges or onto waste ground and male plants have sometimes been established in hedgerows to provide the few cuttings per acre required to accompany new plantings. Numerous 'wild' hop plants also develop from seed dislodged from the cones at harvest. Many other seeds are carried by birds or scattered by wind, especially when surplus hops or those on young plants are left unpicked. Clearly, there have been numerous opportunities for the hop to escape. Once plants are established in natural habitats they are extremely persistent, which accounts for their common occurrence, even in areas remote from present plantings.

HOP PLANTINGS IN BRITAIN

Hops have been used in brewing since the twelfth century and have been produced in Britain since the early sixteenth century. The acreage expanded rapidly and by 1870 hops were being grown in forty English counties, eight in Wales and five in Scotland as far north as Aberdeen (Burgess, 1964). However, cultivation in Wales and Scotland ceased in 1871 and 1874, respectively. The peak of 71,789 acres was reached in 1878, with a subsequent decrease in acreage due to better utilization of hops by brewers and to the introduction of improved varieties, cultural practices and control measures against pests and diseases.

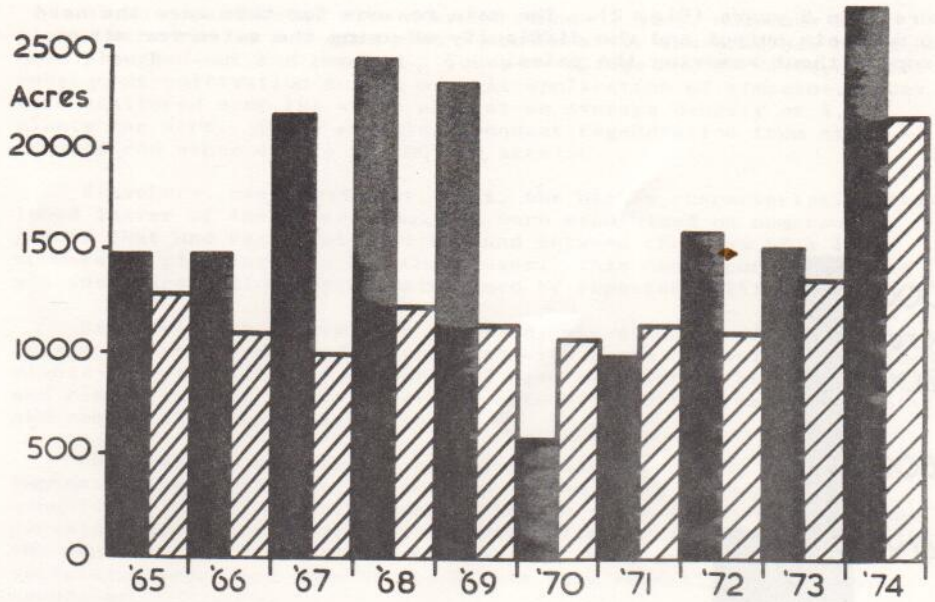

Fig. 1. Total hop acreages grubbed (solid) and planted (shaded) in England each winter from 1964-1965 to 1973-1974.

The acreage in England has fluctuated recently around 17,000 acres, restricted to Kent, Sussex, Herefordshire and Worcestershire, apart from a few plantings in Hampshire and Surrey and one in Berkshire. Annually there are only slight changes in total acreage, but there is much grubbing and replanting (Fig. 1). The spread of the progressive form of verticillium wilt disease in Kent and Sussex has necessitated a change from wilt-sensitive to wilt-tolerant varieties on many Weald farms. Other plantings, particularly in the West Midlands, have had to be grubbed and replaced because of nettle-head and/or split leaf blotch diseases. In all regions there has recently been a change to high-yielding varieties that has been encouraged by E.E.C. replanting grants. This accounts for the particularly great turnover in the winters of 1972-1973 and 1973-1974, when 16% of the entire acreage was replaced (Fig. 1).

HOP PLANTINGS AND REGENERATION

Mature hop plantings require expensive permanent posts and wire-work to facilitate stringing and growers tend to replant existing areas rather than plant fresh sites. From the results of a questionnaire sent to all growers it was established that 88, 69 and 81% of all plantings in the winters of 1968-1969, 1969-1970 and 1972-1973, respectively, were on land with a recent history of hop cultivation. In all districts and in each winter, many grubbed sites were replanted immediately and few had been fallowed or used for other crops for

more than 2 years (Fig. 2). The main reasons for this were the need to maintain output and the difficulty of using the sites for other crops without removing the poles.

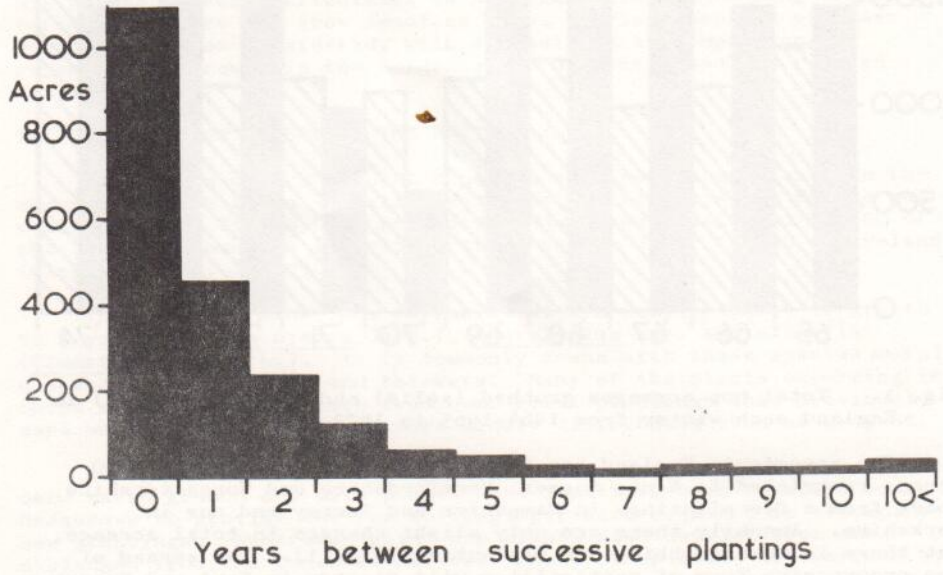

Fig. 2. The total acreage established at sites with a previous history of hop cultivation in relation to the nominal hop-free interval between plantings.

The repeated use of the same sites with little or no interval between successive plantings facilitates the growth of seedlings and regeneration from debris left in the ground at grubbing. Established hop plants have an extensive root system and a large perennial 'crown' of stem tissue at soil level. Severed roots do not produce adventitious shoots, but there is much growth from the buds on stem runners and from even quite small pieces of crown.

Deep ploughing, rotovation or lifters or diggers are used for grubbing and large pieces of debris are usually collected and dumped or burned. Inevitably many viable stem-pieces and seeds are left. It is seldom difficult to find seedlings and/or regeneration growth in the year after grubbing and these reappear in subsequent years unless special precautions are taken.

At an experimental site near Horsmonden, Kent, numerous hop plants occurred in a 1-acre plot 6 months after the original hills had been ploughed-out and removed. Young seedlings had survived, despite subsequent cultivation and an overall application of simazine. They were scattered over the whole area at an average density of 4,000 plants per acre. There was also abundant regeneration from stem runners and other debris (2,500 per acre).

Elsewhere, near Goudhurst, Kent, the highly characteristic five-lobed leaves of the variety Bullion were recognized on numerous plants that had regenerated within and between the rows of a later commercial planting var. Wye Challenger. This had occurred despite a 1-year bare fallow period maintained by repeated cultivation.

Similarly, at a farm near Hereford, where shoots of the original Fuggle variety were found intertwined with those of newly established plants of Wye Challenger. There had been no interval between grubbing and replanting, but several previous attempts had been made to identify and remove all regeneration growth.

Observations at a former hop garden near Headcorn, Kent, emphasize the persistence of the hop in seemingly uncongenial conditions. After several years of arable crops (including rape and cereals) there were numerous hop shoots climbing the stalks and within the stubble of a stand of wheat. Many of the plants had cones containing seeds and some of the plants were recently established seedlings.

The regeneration and persistence of hop plants at the various recorded sites was in no way exceptional and commercial growers regularly encounter similar difficulties. These are likely to increase with the increased use of simazine and non-cultivation techniques and with the current emphasis on immediate replanting.

PROBLEMS CAUSED BY WILD AND REGENERATING HOPS

1. The Adulteration of varieties

Hop plants are produced by propagating cuttings from cropping sites or from special sources. It is difficult to avoid the admixture of varieties and contamination by seedling 'rogues'. Such adulteration remains a long-standing problem of ever-increasing importance as the range of varieties, their health status and their reaction to pests and diseases become increasingly diverse.

Special 'A plus' certified stocks are raised in isolation outside the main hop-growing areas to decrease the risk of disease. For certification, all wild hop plants must be removed within 200 yards. The main reason for this is to decrease the amount of pollen in the locality and hence the number of seeds that reach the propagation areas.

The many propagators in the hop-growing areas cannot take these precautions, yet they provided approximately two thirds of all the plants used in recent years. Many cuttings are taken from (or grown on at) sites previously used for hop cultivation and where regeneration growth is likely to occur. It is possible to eliminate 'rogues' and seedlings with a highly characteristic leaf-form or stem

pigmentation. However, this requires considerable skill and experience and in practice some varieties are virtually indistinguishable.

2. Unwanted pollination

Traditional British practice is to grow 'seeded' cones by interplanting females with a small proportion of males. Thus the numerous males amongst the wild plants around hop plantings are of little significance and no attempt has been made to locate or remove them. The situation is different in all other hop-growing countries, where determined efforts have been supported by legislation to eliminate all males and so produce 'seedless' cones. These are smaller and lighter than comparable seeded ones, but contain a higher proportion of alpha-acid resins.

The future policy in England is uncertain but growers in at least some districts are likely to dispense with males within the next few years. Several growers have already eradicated males from within and around their plantings in an attempt to grow seedless hops in experiments sponsored by the Hops Marketing Board. Other growers are still deciding future policy and those in Herefordshire and Worcestershire may be producing seedless hops by 1978. The distribution of males in and around these plantings is being recorded, pending a final decision and information on the best method of eliminating males and on the time of year when this is best done.

Males within hop plantings are usually labelled and they can be removed without major difficulty by the grower concerned, who can also eradicate wild hops elsewhere on the farm. It will be much more difficult, expensive and, in some instances, almost impossible to eliminate all wild hops from entire districts. Many plants occur deep within hedgerows, thickets or woodland and cannot be removed cheaply and without causing considerable damage unless a very selective herbicide is developed. Any large-scale operation over a wide area will require the good-will and voluntary co-operation of many other landowners and of the general public. Prohibitive legislation may be difficult to introduce and enforce.

The results of the H.M.B. trials (Table 1) emphasise the difficulties involved in producing cones with a seed content below the 2% dry weight standard customary in other E.E.C. countries. At the most isolated site, away from any other plantings, the average seed contents of two varieties was $<2\%$ in each of the two years. Elsewhere the results were much less satisfactory, although seed contents were invariably much lower than the 12 - 26% typical of seeded cones. The 2% tolerance was exceeded in half the growths sampled at sites outside the main hop-producing areas of Worcestershire and Kent. Similarly with all the growths sampled on adjacent farms down-wind from a major hop-growing district in Kent. These results indicate that except at very isolated sites there are only limited prospects of producing seedless hops from current varieties by local eradication.

Table 1

Number of growths with cones having an average seed content <2% dry matter*

Farms		1971	1972	1973	Total
Hants and Berks	(1)	-	2/2	3/3	5/5
Worcestershire	(1)	-	3/4	3/4	6/8
Kent: outlying areas[x]	(7)	6/21	20/27	10/30	36/78
Kent: other areas	(5)	-	0/17	0/16	0/33

* Expressed as a fraction of the total number of growths sampled in the H.M.B.-sponsored seedless hop trials on fourteen different farms involving a total of thirteen varieties.

[x] At some sites seed contents were influenced by pollen introduced for pollination trials on four farms in 1971 and on one in 1972 and 1973.

3. Virus sources

The recent changeover in hop varieties has coincided with an improvement in the health status of planting material. Clones of the latest Wye College varieties have been selected for their freedom from prunus necrotic ringspot virus (NRSV) that occurs throughout all older varieties (Thresh and Ormerod, 1974). There will be a further improvement with the introduction of clones derived from meristem-tips that have been freed from NRSV and two other viruses (hop mosaic and hop latent) that occur throughout the most important varieties (Adams, 1973).

Consequently, wild hops and those surviving from old plantings will be foci of infection for the spread of NRSV, hop latent and hop mosaic viruses to later and healthier plantings. At the Cranbrook and Hereford sites, for example, (p. 327) the regenerating shoots of the original varieties contained NRSV, whereas the replants were not infected initially.

Seedlings and regeneration growth from previous plantings are of special significance in the epidemiology of nettlehead and other important diseases associated with arabis mosaic virus (AMV). Infection is transmitted by a free-living 'dagger' nematode (Xiphinema diversicaudatum Micol.) that has a wide host range and persists between successive hop plantings, even if the interval between them is a prolonged one of several years (Thresh and Pitcher, 1971).

Nettlehead tends to be prevalent alongside hedgerows and where hedges have been removed. The nematode vector thrives best in such undisturbed soil and the wild hop plants that occur commonly in hedgerows may have been the initial source of AMV. This virus is seed-borne and there is also a record of the seed-transmission of nettlehead.

AMV is only retained a few months by its vector and bare fallowing is effective in preventing the recurrence of infection at sites where disease occurred previously (McNamara et al., 1973). The success of this technique depends on using AMV-free planting material and on the efficiency with which debris remaining in the ground is eliminated before or soon after it begins to regenerate. Otherwise the nematodes remaining in the soil re-acquire virus and spread is resumed. This occurred at the Horsmonden and Cranbrook sites (p. 327), where some of the regenerating shoots showed symptoms of nettlehead and many contained AMV. The Headcorn record of hop plants in wheat suggests that virus can so persist for years and reinfect any subsequent hop plantings.

DISCUSSION

Outside the areas of commercial production the wild hop is a minor constituent of the local flora of no economic significance to growers, except at the few isolated sites (mainly in East Anglia) where 'A plus' certified planting material is produced. Within the main hop-producing areas the many wild male plants that occur will be an important hazard in any future attempts to produce seedless cones.

Meanwhile there is a well-known risk of varieties being adulterated by seedling 'rogues' or by regeneration growth from debris remaining after removing diseased or otherwise unwanted plants. The further risk of viruses being perpetuated in this way between successive plantings is now apparent. The problem is likely to become more acute with the general adoption of clones of improved health status. Growers have been warned of the hazards involved and especially when nettlehead sites are grubbed and replanted immediately. Current practices (p. 326) must be reassessed and it will be necessary to consider more carefully than hitherto the method, and efficiency of grubbing. A suitable herbicide is needed to prevent or eradicate regeneration growth and promote the rapid degeneration of stems and roots remaining in the soil. Thus it may be possible to increase the effectiveness of control by fallowing and perhaps decrease the minimum period required to avoid reinfection.

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