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Proceedings 1979 British Crop Protection Conference - Pests and Diseases

# RECENT CHANGES IN THE HEALTH STATUS OF ENGLISH HOP PLANTINGS

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Summary This paper considers the contrasting effects of recent changes in cropping practices on the incidence of three viruses of hop. The increased losses now caused by hop mosaic have been more than offset by the enhanced yields due to striking decreases in the incidence of prunus necrotic ringspot and arabis mosaic viruses. These have been achieved by releasing virus-tested stocks which have been used for a high proportion of the many recent plantings.

Résumé Ce papier concerne les effets contrastants des changements récents en cultures, exercés sur l'incidence de trois viroses d'houblon. Les pertes additionnelles causées maintenant par la mosaïque d'houblon ont été plus que compensées par les rendements à la suite des diminutions remarquables dans l'incidence des viruses mosaïque de l'arabette et taches annulaires nécrotiques chez prunus. Ceux-ci on été accomplis par le développement des souches ayant un meilleur état sanitaire, lesquelles ont été utilisées pour une portion importante des nombreuses plantations récemment entreprises.

## INTRODUCTION

In the 19th Century the hop (Humulus lupulus) was grown in almost all English counties and in parts of Scotland and Wales. Plantings reached a maximum of 29,064 ha in 1878 and then declined. This decline has continued and there are now only 5,695 ha on 436 farms, mainly in Kent, Sussex, Herefordshire and Worcestershire. Nevertheless, the U.K. crop is currently worth £15 million per year, providing an indispensible ingredient for the brewing industry which has an annual turn-over exceeding £3,000 million.

There have recently been major changes in the demand for hops and in the varieties grown. This paper considers the impact of these changes on the prevalence of viruses and their effects on productivity.

## RECENT CHANGES IN HOP-GROWING

The hop is a perennial propagated vegetatively from stem cuttings. For many years the main varieties grown in England were Fuggle and the various Goldings. These old varieties still predominated in 1969, although there were also many plantings of WGV and varieties originating from the early stages of the Wye College breeding programme (Table 1).

Brewers' requirements for Golding 'aroma' hops have decreased recently, whereas there has been increasing demand for hops with a high content of the alpha-acid bittering fraction. In the U.K. extensive areas of Fuggle and Goldings have been replaced by new 'high-alpha' varieties from Wye. This trend has been reinforced by the need to introduce varieties resistant to the progressive forms of verticillium wilt that have become prevalent in many parts of Kent and Sussex.

Table 1

The main hop varieties grown in England in 1969 and 1979

| Variety | Originated | Total area (ha) 1969 | Total area (ha) 1979 |
|---|---|---|---|
| Goldings† | 1790 | 1,159 | 489 |
| Fuggle | 1861 | 2,807 | 574 |
| WGV* | 1911 | 866 | 335 |
| Bullion | 1919 | 453 | 340 |
| Keyworth's Mid-season* | 1924 | 112 | 148 |
| Bramling Cross* | 1934 | 817 | 409 |
| Northern Brewer | 1934 | 294 | 296 |
| Progress* | 1951 | 118 | 157 |
| Wye Northdown | 1961 | 2 | 936 |
| Wye Challenger | 1963 | 0 | 763 |
| Wye Target* | 1965 | 0 | 1,016 |
| Wye Saxon* | 1968 | 0 | 164 |
| Wye Viking | 1968 | 0 | 23 |
| Others | | 141 | 45 |
| Total area | | 6,769 | 5,695 |

† mosaic-sensitive * wilt-resistant

The changeover in varieties has been exceptionally rapid for a perennial crop and almost 13% of existing plantings were replaced in 1973-1974 alone. The impetus has been provided by foreign competition and by the need to improve productivity as growing costs increase.



## HOP MOSAIC VIRUS

English hop varieties segregate into two distinct groups according to their reaction to infection with hop mosaic virus (HMV). True Goldings develop conspicuous symptoms and soon die or grow so badly that they are replaced. All other varieties behave as symptomless carriers of infection and their growth and yield seem unaffected.

HMV is aphid-borne and likely to spread into Goldings and cause serious losses whenever tolerant varieties are planted nearby (Keyworth, 1947). This explains why many Goldings were being grown in 1969 at isolated sites in Berkshire, Hampshire, East Kent and North Kent. These were outside the main hop-producing areas and on many farms Goldings predominated or were grown exclusively (Table 2). Consequently mosaic was not encountered or losses were acceptable and there were few serious outbreaks.

Table 2

The number of farms growing Goldings in each main hop-growing region*

| Region | 1969 | | 1979 | |
|---|---|---|---|---|
| West Midlands | 66/211 | (1) | 43/176 | (2) |
| E. & N. Kent | 48/59 | (27) | 31/40 | (2) |
| Farnham | 15/21 | (7) | 1/14 | (0) |
| Weald | 45/285 | (1) | 18/205 | (1) |
| Total | 174/576 | (36) | 93/435 | (5) |

* Farms with Goldings as a fraction of the total number in each region. Figures in parentheses are for Golding farms with no other varieties.

The situation deteriorated with the decreased demand for Goldings and increased plantings of other varieties. These are now being grown for the first time on many Golding farms and there are only five still without tolerant varieties (Table 2). The ratio of tolerants to sensitives on farms with Goldings changed from 1359 : 1159 in 1969, to 1074 : 489 ha in 1979. This increased the 'infection pressure' on the relatively small remaining area of Goldings. Spread has also been facilitated by the decreased separation between plantings of sensitives and tolerants. Losses have increased and at some sites have become so great that whole rows or even entire plantings have been removed. Elsewhere, scattered infection occurs causing gaps where it is difficult to establish replants.

Little further can be done to decrease present losses as repeated drenches or sprays are being used already against aphids. Moreover, the choice of sites for additional plantings is restricted by the need to establish tolerant varieties on existing areas rather than incur the great expense of erecting new supporting posts and wire-work elsewhere. Growers are therefore likely to encounter continuing difficulties, inconvenience and expense due to mosaic. However, recent observations indicate that infection is seldom prevalent in Goldings unless tolerants are planted immediately alongside, without headland or other separation. Much can be achieved by at least some degree of isolation and plantings should be in compact blocks with the least possible interface between tolerants and sensitives. It may also be advantageous to use mosaic-free clones derived from meristems for any new plantings of tolerant varieties. Such clones are now available and can be grown satisfactorily alongside Goldings, provided there are no other local sources of infection. Otherwise, the meristem plants soon become re-infected and menace any Goldings nearby.

Difficulties have been experienced in evaluating the effects of mosaic on tolerant varieties because of rapid reinfection in small-plot trials. However, preliminary indications are that eliminating mosaic from tolerants does not enhance growth or yield and there is at present no justification for encouraging growers to replace existing plantings with mosaic-free material other than to decrease the risk to Goldings.

## PRUNUS NECROTIC RINGSPOT VIRUS IN HOP

Prunus necrotic ringspot virus (NRSV) causes important diseases of apple, cherry, plum, peach and apricot and also affects various woody ornamentals. The occurrence of the virus in hop was first suspected in the United States (Fridlund, 1959), but not confirmed until later (Bock, 1966, 1967). Surveys then revealed NRSV to be throughout all available clones of the main English hop varieties and the only uninfected plants were in seedling progenies or in exotic varieties at Wye (Thresh & Ormerod, unpublished). Consequently it was impossible to assess rates of virus spread or effects on growth and yield in commercial plantings.

The situation changed with the production of NRSV-free clones by culturing meristem-tips from heat-treated plants of old varieties (Vine & Jones, 1969; Adams, 1975) and by selecting uninfected plants from the earliest trial plantings of varieties being developed at Wye College. Trials at Wye soon established that NRSV-free plants outyield infected ones, mainly by an increased cone content of alpha-acid (Neve, unpublished). This enhances crop value without increasing production costs. Accordingly, NRSV-free clones have been released to growers and propagators and a major effort made to ensure that these clones are utilised (Adams, et al., 1977).

The NRSV-free selections of Wye Northdown and later varieties have already had a major impact as they have been used for a high proportion of all recent plantings (Table 3). There has been some spread of NRSV into such material, especially when grown in small plots close to infected plants. However, 1977-1978 surveys in Kent and the West Midlands revealed a generally low incidence of NRSV, even in some of the earliest plantings of Wye Northdown and Wye Challenger made 1969-1970. Consequently, there has



Table 3

Total areas of U.K. hop varieties 1969-1979 and the areas estimated to be largely free of NRSV

| Year | Total areas (ha) | | |
|---|---|---|---|
| | All vars | Latest Wye vars | NRSV-free |
| 1969 | 6,767 | 2 | 2 |
| 1970 | 6,972 | 4 | 4 |
| 1971 | 7,034 | 21 | 20 |
| 1972 | 6,822 | 123 | 116 |
| 1973 | 6,770 | 475 | 420 |
| 1974 | 6,568 | 1,234 | 1,027 |
| 1975 | 6,410 | 2,047 | 1,791 |
| 1976 | 5,925 | 2,502 | 2,255 |
| 1977 | 5,877 | 2,782 | 2,517 |
| 1978 | 5,846 | 2,907 | 2,637 |
| 1979 | 5,695 | 2,904 | 2,641 |

been a striking decrease in the losses due to NRSV and the many growers adopting the new more productive varieties have had the additional benefits arising from the improved health status of the best stocks now available. In 1976 the new varieties produced crops worth an estimated £1 million more than if NRSV had been present. Current benefits are even greater due to recent price increases and because additional plantings have come into full production. Further progress in decreasing the incidence of NRSV is likely to be slow because of the limited plantings now being made. However, there is still a need for an additional wilt-resistant variety to decrease dependence on Wye Target and supersede WGV and other old NRSV-infected varieties. Once a suitable variety emerges there are likely to be substantial plantings and an additional improvement in productivity.

## ARABIS MOSAIC VIRUS IN HOP

Arabis mosaic virus (AMV) is transmitted by the free-living nematode *Xiphinema diversicaudatum* and causes diseases of raspberry, strawberry and many other crops. Infection in hop was unsuspected until an unusual strain of AMV was shown to be solely or partially responsible for nettlehead, bare bine and severe split leaf blotch diseases (Bock, 1966; Thresh, et al., 1972). These have long been prevalent in hop and were reported by many growers questioned during 1969 and 1970 (Thresh & Ormerod, 1971).

A major factor contributing to such a high incidence of infection was the limited use at that time of Ministry-certified AMV-free planting material. About two-thirds of the plants used in all areas had been propagated locally from uncertified stocks. Many were of dubious health status and some were seriously affected by AMV. This was being introduced to new areas where hops had not previously been grown and to hop sites where populations of the nematode vector were absent or not infective (Thresh, 1978). The spread of AMV and its recurrence at affected sites were also facilitated by the common practice of replanting immediately or soon after removing the previous crop (Thresh & Ormerod, 1974).

Growers were urged to be more discriminating in choosing stocks and sites for new plantings. The response has been good and the decreased demand for hops has enabled growers to abandon some of the worst-affected sites. Others have been replanted only after fumigation or fallowing procedures to eliminate nematodes or render them non-infective (McNamara, et al., 1973). There have also been benefits from the extensive replacement of Fuggle and other old varieties by recent ones from Wye College. Many of the numerous stocks required for replanting were derived directly or indirectly from the virus-tested material supplied to Ministry-certified propagators. The major problems arising from indiscriminate propagation have been recognised and largely overcome. This has achieved a great improvement in the overall situation and there are now few reports of nettlehead or other diseases due to AMV.

## DISCUSSION

The Hops Marketing Board collects detailed statistics on changes in the varieties grown and on the yields and prices obtained. Information on the losses caused by pests and diseases is far less precise, due to the lack of fully comprehensive surveys of their occurrence in commercial plantings. Thus there is only limited quantitative evidence for some of the trends here described. However, they have become apparent from close contact with hop-growers over the last decade and are supported by the largely unpublished findings of questionnaires and pilot surveys done with the staff of Agricultural Development and Advisory Service and the Department of Hop Research, Wye College.

The results obtained provide clear evidence of the extent to which the prevalence of viruses and the losses they cause have been influenced by recent changes in cropping practices. Alterations in the composition, size and disposition of new plantings have had particularly important consequences, with contrasting effects on the three viruses considered. Hop mosaic has become increasingly prevalent but remains a nuisance to growers rather than a serious threat to production. Moreover, the increased losses due to mosaic have been more than offset by the decreased importance of prunus necrotic ringspot and arabis mosaic viruses. Their decline has been due largely to improvements in the health of the planting material released to growers. The use of such material for many of the recent plantings has brought enormous benefits far exceeding the research and development costs involved. This has greatly strengthened the economic position of U.K. growers at a critical period of increasing production costs and severe competition from imports.



## Acknowledgements

Grateful acknowledgements are due to Dr. R.A. Neve, Department of Hop Research, Wye College for unpublished information and to Mr. G. Hall of the Hops Marketing Board for data on U.K. hop plantings.

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# CONTROL OF STRAWBERRY FRUIT ROTS CAUSED BY BOTRYTIS CINEREA AND PHYTOPHTHORA CACTORUM

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Summary The dicarboximide fungicide vinclozolin, procymidone and iprodione gave the best control of *Botrytis* fruit rot, whether the causal pathogen was sensitive or insensitive to carbendazim, but all failed to control the disease when the causal pathogen was iprodione-insensitive. Using these fungicides also significantly increased leathery rot caused by *Phytophthora cactorum*. The commonly used fungicide dichlofluanid gave good control of fruit rots irrespective of the sensitivity of the pathogen isolates present.

Résumé Des fongicides à base de dicarboximide - la vinclozoline, la procymidone et l'iprodione - ont été les plus efficaces contre la pourriture des fruits provoquée par *Botrytis*, que l'agent pathogène fût sensible ou insensible au carbendazime, mais ont été tous inefficaces quand l'organisme causal était insensible à l'iprodione. L'utilisation de ces fongicides a mené aussi à une augmentation significative de la pourriture coriace causée par *Phytophthora cactorum*. Le fongicide courant dichlofluanide a montré une bonne efficacité contre les pourritures des fruits indépendamment de la sensibilité des isolats des agents pathogènes présents.

## INTRODUCTION

Many strawberries are lost through grey mould *(Botrytis cinerea)*, losses occur through flower abortion or fruit rot before or after picking. The disease is spread by airborne spores from dead and decaying parts of many plants, so making eradication extremely difficult. As infection may occur early it is necessary to use protective fungicidal sprays from before flowering onwards.

For ten years, the protectant fungicides thiram, captan, dichlofluanid and dicloran have commonly been used to control the disease on soft fruit; and all are still in use (Beever 1973; Borecka *et al.* 1973; Jordan & Richmond 1975; Jordan & Pappas 1977). The carbendazim-generating systemic fungicides benomyl, carbendazim, thiabendazole and thiophanate-methyl at first resulted in improved control of grey mould and were active against many other pathogens (Freeman & Pepin 1967; Tapley *et al.* 1969; Cole & Cox 1973; Jordan 1973). However biotypes of *Botrytis* insensitive to these fungicides are now common on strawberries as on many other plants, following the first report on cyclamen (Bollen & Scholten 1971). The incidence on strawberry and raspberry of *Botrytis* isolates insensitive to carbendazim-generating fungicides has been reported (Jarvis & Hargreaves 1973). Jordan and Richmond (1975) showed that both sensitive and insensitive isolates were able to survive successfully on strawberry debris. These changes made control of strawberry grey mould much more difficult, whereas when first introduced the carbendazim-based fungicides gave the best control. The dicarboximide fungicides iprodione, procymidone and vinclozolin offered a possible alternative and their efficacy in controlling

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