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FIELD TRIALS FOR THE CONTROL OF RASPBERRY CANE MIDGE IN SCOTLAND

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Summary HCH (20% gamma HCH e.c.) and fenitrothion (50% e.c.) were applied on three occasions in May and June at rates of 0.7 l/ha and 1.0 l/ha respectively to 0.2 ha plots of raspberries in nine commercial plantations in Scotland infested with raspberry cane midge (*Resseliella theobaldi*). Damage was assessed by counting the numbers of larvae in cane samples in July and by recording the incidence and severity of midge feeding (patch) lesions in November.

The percentage of canes affected was reduced from 38% to 24% by two sprays of HCH at 2 week intervals, starting at the end of May (when over-wintered *R. theobaldi* began to emerge) followed by one spray of fenitrothion 2 weeks later. Two sprays of fenitrothion, 2 and 4 weeks after midge emergence, were slightly more effective, and reduced damage by 49% compared with untreated canes, but HCH applied at the same stage was ineffective. The need for and timing of insecticides to control *R. theobaldi* in Scottish raspberry plantations are discussed.

Résumé Des parcelles de 0.2 ha dans 9 exploitations commerciales de framboisiers en Ecosse infestées de la cécidomyie de l'écorse furent traités au HCH (20% gamma HCH e.c.) et au fenitrothion (50% e.c.) en 3 occasions de mai à juin au taux de 0.7 l/ha et 1.0 l/ha respectivement. L'étendue des dégâts fut évaluée en énumerant le nombre de larves dans des échantillons de tiges en juillet et en notant l'incidence et l'étendue des lésions en novembre. Le pourcentage de tiges infectées fut réduit de 38% a 20% par 2 pulvérisations au HCH faites a des intervalles de 2 semaines à partir de la fin de mai (au moment de l'émergence de *R. theobaldi* après l'hiver) et suivi par une pulvérisation au fenitrothion 2 semaines plus tard. Le traitement consistant de 2 pulvérisations au fenitrothion faites 2 et 4 semaines après l'émergence du parasite fut légèrement plus efficace, les dégâts étant réduits de 40% en comparaison des tiges non traitées. Cependant, l'utilisation parallel de HCH était inefficace. La nécessité et le moment d'application des insecticides dans le but de controler le *R. theobaldi* dans des plantations écossaises seront examinés.

INTRODUCTION

The raspberry cane midge, *Resseliella theobaldi*, is an important pest in most raspberry-producing regions of Europe (Woodford & Gordon, 1978). Larvae feed in splits on young canes, and produce enzymes which alter the cell walls of the periderm (Grünwald & Seemüller, 1979). This damage is of little direct importance but when the feeding sites are invaded by pathogenic fungi (Pitcher & Webb, 1952; Labruyère &

Engels, 1963; Williamson & Hargreaves, 1979b) lesions which block part of the vascular cylinder may develop. If a cane is girdled by these lesions it may die before it can bear fruit the following year. The death of fruiting canes following midge damage to first year canes is known as midge blight (Pitcher & Webb, 1952; Williamson & Hargreaves, 1979b). Following the widespread increase of R. theobaldi in Scotland in the early 1970s (Woodford & Gordon, 1978) midge blight caused severe loss of yield in 1976 (Turner, 1977; Woodford, 1977a).

Earlier work elsewhere (e.g. Labruyère & Engels, 1963; Seemüller, 1976) showed that measures to control R. theobaldi were more successful in preventing midge blight than applications of fungicides, and Pitcher (1955) found that two sprays of gamma-HCH, applied to young canes first when R. theobaldi started to lay eggs in the spring, killed eggs, larvae and adult midges. More recently, Woodford & Gordon (1978) suggested that protective treatments with HCH were not effective, but fenitrothion gave promising results in small plot trials (Woodford, 1977 and in preparation). A failing of these trials was that sprays could be applied only against the first generation of R. theobaldi and the small treated plots were reinfested by adults of the second generation flying in from the surrounding untreated areas of the plantation at harvest time when chemical control was no longer feasible. This paper describes a larger trial done in Scotland in 1977 to compare the effectiveness and timing of sprays of HCH and fenitrothion.

MATERIALS AND METHODS

The experiment was done in nine commercial plantations which had been extensively damaged by midge blight in 1976. There were five sites near Blairgowrie (Perthshire), three near Forfar (Angus) and one in the Clyde Valley (Lanarkshire). Apart from two plantations of cv. Glen Clova (one site near Forfar and that in Lanarkshire) the experiment was done on cv. Malling Jewel. At each site spray treatments were applied to large, unreplicated plots consisting of at least 10 rows and occupying about 0.2 ha. The insecticides were used at the recommended rates for raspberry, i.e. gamma HCH (20% e.c.) (PBI Lindane 20), 12.5 g a.i./100 l; fenitrothion (50% e.c.) (Ciba-Geigy Fenitrothion 50 EC), 45 g a.i./100 l. A non-ionic wetter (Murphy Spreadite) was added to both insecticide sprays at the rate of 50 ml/100 l. A drenching spray (1100 l/ha), directed at the basal 60 cm of young canes, was applied by tractor mounted hydraulic sprayers. There were four insecticide treatments and an untreated control (Table 1). Spraying began when eggs of R. theobaldi were first found, (treatments 1 and 3) and was repeated at 2 week intervals. The presence of R. theobaldi eggs in each area was determined by examining splits made artificially in the epidermis of young primocanes starting in mid May (Gunn & Foster, 1978).

Table 1

Treatments used in spray trial

Treatment	Insecticide	Dates *		
1	HCH (a,b), fenitrothion (c)	a	b	c
2	HCH	-	b	c
3	Fenitrothion	a	b	-
4	Fenitrothion	-	b	c
5	Untreated	-	-	-

* a = 27 May (Blairgowrie), 29 May (Forfar), 1 June (Lanark); b = 15 June (Blairgowrie), 11/12 June (Forfar), 14 June (Lanark); c = 29 June (Blairgowrie), 29/30 June (Forfar), 28 June (Lanark); - = Unsprayed.

Table 2

Percentage of primocanes available to *R. theobaldi* and total number of live and dead larvae in samples from Forfar (Sites 6 - 8) and Lanark (Site 9) districts

Site No.	cv.	% of canes with splits	% of canes with wounds	1		2		3		4		5	
				L[c]	D[d]	L	D	L	D	L	D	L	D
6	M.J.[a]	18	25	0	0	1	0	0	0	0	0	18	2
7	M.J.	16	31	0	0	84	15	61	16	12	0	356	31
8	G.C.[b]	15	32	0	5	97	1	14	0	0	0	239	6
9	G.C.	22	41	0	0	0	0	0	0	0	0	1	0

a) Malling Jewel; b) Glen Clova; c) Number live larvae; d) Number dead larvae in 100 canes/treatment.

The effectiveness of the treatments was assessed in July and November. A sample of 100 primocanes, taken from the centre four rows in each treatment during the first week of July, 5 - 7 days after the final sprays had been applied, was examined in the laboratory for splits and damage and live and dead larvae. In November a further sample of 100 primocanes was collected from the centre four rows of each treatment, divided into two groups of 50 canes, and examined independently at the Scottish Horticultural Research Institute (SHRI) and at the East of Scotland College of Agriculture (Blairgowrie & Forfar sites) or the West of Scotland Agricultural College (Lanark site). The incidence and severity of lobate (patch) lesions resulting from the feeding of second generation larvae (Williamson & Hargreaves, 1979b, Plate, figure 3) on each cane was assessed by scraping off the surface layers to compare the extent of lesion damage with standard scoring maps (Williamson & Hargreaves, 1979a). At SHRI the incidence of spreading vascular lesions (stripes) (Williamson & Hargreaves, 1979b, Plate, figure 4) was also recorded.

RESULTS

In each area eggs were first found in artificial splits in the last week of May and the first sprays were applied 1 - 7 days later. Only seven larvae were found on a total of 2,000 canes from the Blairgowrie sites when samples were examined in July, but almost every cane was still intact, providing no natural splits or wound damage in which emerging midges could lay eggs. Larvae were equally rare in cane samples from Lanarkshire, although there were more potential egg-laying sites on these canes in July (Table 2). Splitting and wounding damage was more common in canes from sites near Forfar, but larvae were numerous only in two plantations. The scarcity of larvae prevents any statistical comparison of treatments but Table 2 suggests that all the treatments had some effect with the best control obtained in treatments 1 and 4, which included a late fenitrothion spray applied 4 weeks after midge eggs were first found in artificial splits.

Despite large differences between treatments and sites, for any given sample we obtained very similar estimates in November of the number of infested canes and the severity of patch lesions from independent assessments at SHRI and the Colleges. Table 3 shows the independent treatment means, and the overall treatment means, obtained by combining the results recorded at both centres. Williamson & Hargreaves (1979a) measured the area of stele affected by patch lesions in their five standard scoring classes (I to V). In the 1977 trial reported here damage was less than in previous years, the most severely affected canes being assigned to Class III. The areas of stele affected by lesions in the scoring classes, I, II and III correspond approximately to 0 - 2.5, 2.5 - 10 and 10 - 20% respectively (Williamson & Hargreaves, 1979a). Average values for patch lesions were obtained by weighting the number of damaged canes by a factor corresponding to the increase in the approximate area of affected stele in canes of each damage class, i.e.1 x number of Class I, 3 x number of Class II, 6 x number of Class III.

Although patch lesions were few and not extensive, even in the untreated plots, there were large differences in the levels of damage between farms which reflected the infestations of first generation larvae found in July (Table 2). These site differences affected the level of insecticide control obtained with each treatment, but differences between treatments were generally consistent. The percentage of canes with patch lesions (Table 3, column 3) and the mean score (column 6) for each treatment averaged over the nine sites was significantly decreased by all treatments which included fenitrothion ($\underline{P} < 0.001$ for damage scores in treatments 1, 3 and 4 compared with treatment 5). The best control was obtained by treatments 1 (two 'early' sprays of HCH, followed by one 'late' spray of fenitrothion) and 4 (two 'late' sprays of fenitrothion), both decreasing the percentage of infested canes from 38% to 24%. These treatments decreased the mean damage by 43% and 49% respectively. Treatment 2 (two 'late' sprays of HCH) was ineffective.

Table 3

Patch lesion assessment in November

Treatment	% canes with patch lesions (angular transformation)		Mean % (combined results)*	Mean patch lesion score a)		Mean score a) (combined results)
	A†	B†		A	B	
1	28.5	30.1	24.0	0.35	0.42	0.39
2	35.5	37.7	35.6	0.54	0.63	0.59
3	33.0	30.3	27.6	0.43	0.44	0.44
4	27.3	31.0	23.7	0.31	0.38	0.35
5	38.2	37.9	38.0	0.69	0.67	0.68
SED	3.47		-	0.124		0.088

a) weighted in proportion to surface of stele affected (see text).
* back-transformed to percentage from angular transformation used for analysis.
† A, B = independent assessments of damage made by SHRI (A), Colleges (B).

There were very few canes bearing stripe lesions but a Generalised Linear Interaction Modelling analysis (GLIM) showed that the proportion of affected canes differed significantly between treatments ($P < 0.001$) and sites ($P < 0.05$). The treatment-site interaction was not significant. Overall, stripe lesions were found on 3.2% of untreated canes and the proportion in treatment 2 (4.1%) did not differ significantly, but in treatments 1 (0.8%), 3 (0.8%) and 4 (1.9%) the proportion was significantly less.

DISCUSSION

In Scotland insecticides cannot be used to control R. theobaldi after the fruit picking season because the growth of young canes, which are not yet tied in, does not allow access to spray machinery. The choice and timing of insecticide treatments against the first generation of R. theobaldi in early summer is difficult because female midges start to lay eggs within a few hours of emerging, but complete emergence of all overwintered midges is prolonged over a period of three weeks or more, and the emergence period may vary considerably from year to year and from site to site (Pitcher, 1955). Insecticides therefore need to be both quick acting and persistent. Pitcher (1955) found that HCH killed eggs and larvae protected by the outer layers of the canes and, in trials in Kent, gave good control applied in early May and again 2 weeks later at peak emergence.

In our trial HCH was not effective applied 2 and 4 weeks after R. theobaldi started to emerge, and it is doubtful whether HCH applied at first emergence of R. theobaldi and reapplied 2 weeks later (as in Pitcher's experiments) would have given good control. A final spray of fenitrothion was added to treatment 1 to protect growers' plots but control was as good or better using two sprays of fenitrothion, 2 and 4 weeks after first emergence of R. theobaldi (treatment 4).

Although spray timing in each area was related to the date when eggs of R. theobaldi were first found in artificial splits, egg laying continued until mid July. Adults probably emerged and laid eggs later in some plantations, as found by Gunn & Foster (1978) in a comparison of four plantations in Lanarkshire in 1977. This may explain the less satisfactory control obtained by the early fenitrothion sprays (treatment 3) at site 7 in the Forfar area (Table 2). This was the most northerly site and being closest to the coast was probably the coolest in summer. There was a marked difference in the extent of cane splitting between the plantations in the Blairgowrie area and those in the Forfar area, about 30 km to the east. There were almost no first generation larvae of R. theobaldi in the Blairgowrie plantations because the primocanes did not start to split naturally during the emergence period.

Differences between the onset of cane splitting and the emergence of overwintering R. theobaldi in neighbouring plantations highlight the problem of deciding when to apply insecticides. Fortunately, the timing of fenitrothion sprays is not so critical because this insecticide kills feeding larvae (Woodford, 1977b). A similar chemical, fenthion, has been used successfully against second generation larvae of R. theobaldi in Poland (Niezborała, 1971) and Norway (Stenseth, 1977).

The first spray of fenitrothion should be applied within about a week of the start of natural splitting. In the absence of natural splits first generation midge attack is unlikely to warrant control measures. In some years it may be necessary to control R. theobaldi when raspberries are in flower and it is essential to direct the spray at the basal part of the primocanes to avoid harm to bees. In some seasons it may be possible to spray the whole length of canes to control raspberry beetle larvae (pink fruit stage) and R. theobaldi larvae at the same time.

Although the failure of HCH to control the recent epidemic of R. theobaldi in Scotland (Woodford & Gordon, 1978) can probably be attributed mainly to the problems of spray timing outlined above, there are also problems in obtaining adequate spray cover on raspberry canes. Williamson & Gordon (unpublished) found that the type of hydraulic sprayer used in this trial gave a poor cover on canes. Pitcher (1955) applied HCH at a volume three times greater than that used in our trial, but in one experiment he still obtained the same level of control with HCH applied at 280 l/ha instead of 3000 l/ha.

This trial provided the first opportunity for other workers to test the scoring technique for midge blight developed at SHRI (Williamson & Hargreaves, 1979a). Independent assessments of damage in the divided samples showed no significant differences and allowed us to make comparisons between treatments and sites using the combined estimates of damage. The results showed that effective insecticidal control of R. theobaldi can decrease the severity of patch lesions and, incidentally, provide further evidence for the association between patch lesions and larval feeding damage. Williamson & Hargreaves (1979a) estimated the potential severity of midge blight from the extent of patch lesions and found that yield was unaffected until lesions covered more than 20% of the stele surface on the basal 30 cm of cane (corresponding to classes IV and V in their scoring system). Because of the low incidence of R. theobaldi and patch lesions in 1977 cane death resulting from midge blight was markedly decreased throughout Scotland and we did not attempt to compare yields or cane death in different insecticide treatments. However, a count of the few dead and wilted fruiting canes at Lanark and two of the Forfar sites in May and June, 1978 showed that there were more than twice as many dead canes in the untreated plots as in the insecticide-treated plots and fewest dead canes in plots treated with fenitrothion. We could not establish the cause of cane failure at that time of year but it may have been related to the incidence of stripe lesions which, unlike patch lesions, may increase in area during the winter (Hargreaves & Williamson, 1978).

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RESISTANCE TO PESTICIDES IN DAMSON-HOP APHID AND RED SPIDER MITE ON ENGLISH HOPS

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Summary From 1966 to 1979, damson-hop aphids and common spider mites were collected from hop gardens and their responses to pesticides were compared in bio-assays with susceptible stocks. Resistance in the aphid has become high to most but not all organophosphates (OPs), is still low to several carbamates, and in 1978-79 developed to endosulfan but not to pyrethroids. Resistance in the mite was high to all OPs and often to dicofol, and was low to carbamates, but those available are poor acaricides; there was no resistance to cyhexatin and very little to tetradifon. The need for integrated control methods is stressed, and especially for effective selective aphicides as an essential component.

Résumé Depuis 1966 jusqu'au présent, on a recueilli les échantillons du Phorodon humuli et du Tetranychus urticae dans les houblonnières pour accomplir au laboratoire les tests standardisés de résistance. Cas du puceron, il y a un chiffre élevé de résistance contre la plupart des insecticides organo-phosphorés et jusqu'au present moins élevé contre quelques carbamates. Depuis 1978-1979 il y a eu la résistance contre le endosulfan mais pas encore contre les pyréthroids. Cas de l'acarien la résistance est élevée contre touts les produits organo-phosphorés et souvent contre le dicofol. Elle est bas contre la plupart des carbamates mais ceux-ci qui sont disponible ne sont pas efficace. Il n'y a pas eu de la résistance contre le cyhexatin et guère contre le tetradifon. On discute la nécessité pour la lutte intégrée, surtout pour les insecticides sélectif.

INTRODUCTION

Pesticides are essential for the control of damson-hop aphid, Phorodon humuli, and red spider mite, Tetranychus urticae, in English hop gardens and yards. Both pests are capable when uncontrolled of destroying crops, and with conventional pest control the contribution from natural enemies is minimal. Whereas the aphid is a serious pest every year, the spider mite is usually widespread only in hot dry summers. Control of the aphid is therefore the primary consideration. The effects of aphicides, and also fungicides, on the spider mite are potentially important. This paper reviews work on the development of resistance in both pests as a basis for future strategy in pest control.

MATERIALS AND METHODS

With both aphid and spider mite the resistance levels quoted are based on laboratory bio-assays which involved comparisons with standard susceptible stocks.

Damson-hop aphid: Samples were collected from sites in Kent, the West Midlands, and a susceptible stock obtained from wild hops remote from commercial spraying in the north of England. They were cultured on potted hops isolated in an insectary.

Aphids were sprayed in a Potter tower with serial concentrations of each insecticide under test. After treatment the aphids were transferred to clean foliage, so in effect only the contact action of insecticides was tested. Further details of the test method are given in Muir (1979).

Spider mite: Samples from hop gardens were cultured on dwarf French beans in cages in an insectary for at least one generation before testing. Standard susceptible and resistant strains were maintained on isolated leaf cultures which were used as nuclei for subsequent mass-rearing on beans in cages. Most bio-assays were on adult female mites using a modified taped-slide technique (Voss, 1961); ovicidal effects, as with tetradifon, were tested using eggs laid on leaf 'squares' of French bean (Cranham, 1974).

RESULTS AND DISCUSSION

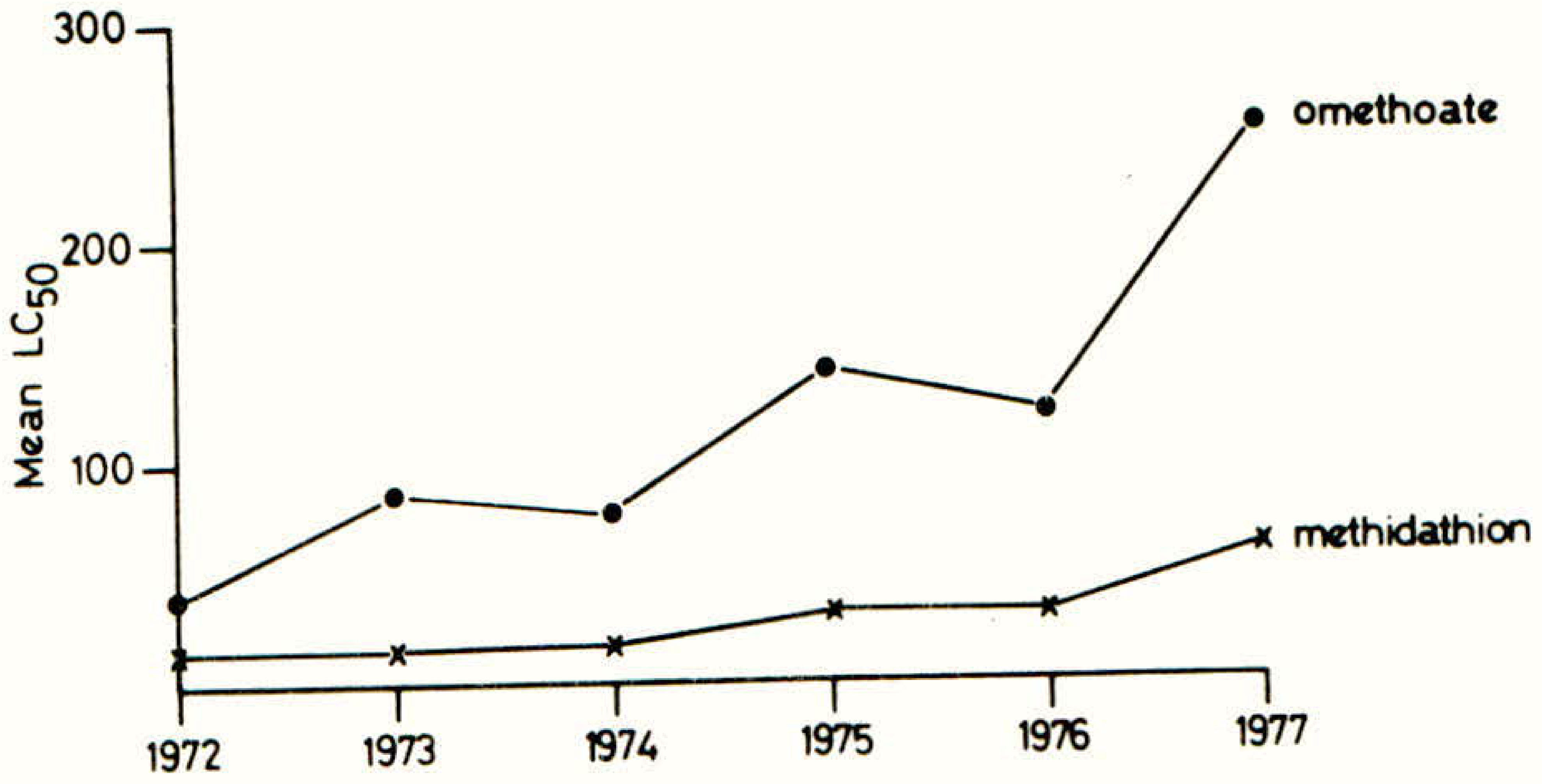
Damson-hop aphid

By the early 1960s, growers were experiencing difficulties in control with demeton-S-methyl after six or more years' use. Resistance in a field stock collected in 1965, compared with a stock which had been lab-reared without selection since 1963, was confirmed by assays.

Resistance to demeton-S-methyl in samples collected in both Kent and the West Midlands increased from a mean LC_{50} of 40 mg/l in 1966 to 96 mg/l in 1970, and again from 100 mg/l in 1974 to 144 mg/l in 1975. Samples from areas remote from commercial spraying with insecticides, in the north of England and Co. Clare, Eire, gave LC_{50}s of 4 and 5.5 mg/l respectively, and for a sample from a hop garden in Kilkenny, Eire, which had received a few insecticide sprays, the LC_{50} was 23 mg/l (Muir, 1979).

Aphids resistant to demeton-S-methyl were found to be cross-resistant to omethoate from the year of its introduction and the level of resistance followed the same trends as resistance to demeton-S-methyl (Fig. 1). In Czechoslovakia, Hrdý and Zelený (1966) reported resistance to thiometon; this insecticide had not been used in England but here also there was marked resistance to it (Table 1).

Fig. 1. The mean concentration in mg/l required to kill 50% of the test aphids in different years



Methidathion was an effective aphicide when introduced in 1970. By 1975, there was a small but significant increase in resistance and in 1976 growers were experiencing problems of control (Fig. 1). Resistance to the OP, acephate, introduced in 1973, appeared in 1975.

In the routine monitoring there was no evidence for resistance to mephosfolan, methomyl or endosulfan; although field evidence of a high level of resistance to endosulfan at one locality was confirmed by assays in 1978. This became more widespread in 1979.

Table 1 gives the mean values of the LC_{50} and the resistance factors for a number of insecticides. The R-factors for demeton-S-methyl, omethoate and thiometon are high, 26-50, whereas the ratios for other OPs, carbamates, endosulfan and permethrin are low, 2-5.

The following candidate pesticides were found to possess high activity to resistant stocks of *P. humuli* but their field performance was poor:-

> azinphos-ethyl and -methyl, chlorpyrifos and chlorpyrifos-methyl, 2-(1, 3-dithiolane-2, yl) phenyl-N, N-dimethyl carbamate, ethiofencarb, heptenophos, sophamide, thiocarboxime and triazophos.

Twenty other candidate pesticides were found to possess little activity to *P. humuli* and had poor field performance; these included fenitrothion, malathion and pirimicarb.

Table 1

The LC_{50} in mg/l and resistance factors of resistant strains for some OPs, carbamates, endosulfan and permethrin

	LC_{50} resistant strain mg/l	Resistance factor (1)
OPs with high resistance ratios at LC_{50}		
Demeton-S-methyl	118	29
Omethoate	93	26
Thiometon	188	50
OPs with low resistance ratios at LC_{50}		
Acephate	475	5
Carbophenothion	63	7
O-ethyl-O-3(methyl-6-pyridyl)-phenyl thionophosphate	41	4
Mephosfolan	13	2
Mecarphon	90	6
Methamidophos	77	3
Methidathion	22	4
Carbamates		
2(4, 5-dimethyl-1, 3-dioxolan-2-yl)-phenyl-N-methyl carbamate	195	2
O-(methyl-2-propinylamino)-phenyl-N-methyl carbamate	63	2
S-methyl N-(carbamoyloxy) thioacetimidate	47	5
Methomyl	100	6
Nitrilacarb	70	8
Endosulfan	118	2
Permethrin	9	2

(1) Ratio of LC_{50}s for resistant and susceptible stocks.

Thus in England, resistance in P. humuli has developed particularly to the OPs, though not to mephosfolan, and there appears to be only low levels of resistance so far to the carbamates, including methomyl, propoxur, and nitrilacarb. The synthetic pyrethroids, which are highly active, provide an alternative group to the OPs and carbamates.

In practice, any failure to control the aphid is first countered by raising the rates of application and by repeating the spraying. Table 2 shows that the recommended rates of application for 1976 are higher than the LC_{95}s determined in the laboratory by bio-assay, and should control even resistant aphids if they are exposed to the spray. The problem of relating laboratory results to field performance of a pesticide is complex and involves innate toxicity, persistence, trans-laminar effects and spray application methods. Aphids on hops are a difficult target and in practice all parts of the plants are not equally exposed to treatment. Aphids which find 'shelter' from the spray survive to recolonise the plants, and resistance favours survival.

Table 2

Comparison of the commercial concentrations (high-volume) of insecticides and the estimated LC_{95} in 1976. The table also shows the years of introduction and when resistance was reported

	% a.i.	Commercial conc. in mg/l	LC_{95} mg/l	Year of introduction	Year resistance reported
Demeton-S-methyl	58	870	540	1954	1965
Methidathion	40	900	92	1970	1975
Propoxur	50	750	-	1970	-
Endosulfan	35	700	267	1971	1978
Methomyl	25	750	447	1971	-
Omethoate	57.5	1150	338	1972	1973
Acephate	75	1125	1020	1973	1975
Synthetic pyrethroids	2.5-25	20-25	-	1978	-

Red spider mite

This pest was virtually absent from English hops for many years following the introduction, c. 1952, of OP insecticides for controlling the aphid. In 1968-9, local infestations of highly OP-resistant mites appeared and these quickly became widespread. The resistance, shown to be controlled by a single major gene, involved large R factors for all the OPs tested (Cranham, 1974). For instance, the R factors were 21 - 27 X for demeton-S-methyl, 31 X for methidathion and 64 X for omethoate, acephate and mephosfolan. Thus none of the OPs being used on hops, nor any that were likely to be used, would provide any control of the spider mite.

In 1970, certain OP-R field strains were slightly hypersusceptible in laboratory assays to some carbamates, including methomyl, thiocarboxime, oxamyl and formetanate. This unusual instance of 'negative cross-resistance' did not persist in the field, however, and further tests in 1974 showed that some OP-R field strains were exhibiting resistance 2-4 X to the first three compounds and c. 40 X to formetanate.

The carbamates available for use as foliar sprays on hops, such as methomyl and propoxur, are poor acaricides. In contrast, aldicarb, used only as granules for soil application, has a strong acaricidal effect when the systemic uptake is good. However, uptake and the consequent insecticidal effects are often poor in hops and the chemical is not likely to be widely used. Strong resistance to aldicarb can arise, as shown by strains of spider mite on all-year-round chrysanthemums under glass but none was found in mite strains on hop despite the low levels of resistance to other oxime carbamates. Nitrilacarb, as a foliar spray, was shown to be an effective acaricide with no more than a 2 X R-factor in OP-R mites; unfortunately this material has not become commercially available in the U.K. Summarising, the carbamates currently available can contribute very little to spider mite control on hops, but new candidates with acaricidal action may prove to have low R factors and be effective on both aphids and mites.

The only specific acaricides cleared by the Pesticides Safety Precautions Scheme for use on hops are dicofol, tetradifon and cyhexatin. Resistance to dicofol was not found in 1970 and 1974, but became widespread by 1976, especially in gardens where it had been used for three or more years. There was evidence of slight resistance to tetradifon in only two samples but the other thirteen tested were fully susceptible. Since 1976, the status of resistance to these two specific acaricides has not been monitored. The incidence of the pest has been rather low in 1977-79. Growers who experienced failures with dicofol may have adopted cyhexatin, cleared for use in 1977. The combination product of dicofol and tetradifon appears generally to have given good control. There is some evidence that resistance to dicofol is unstable when the selection pressure is relaxed. There is no evidence of resistance to cyhexatin, which is equally effective on susceptible and all resistant strains.

CONCLUSION

Control of both aphid and spider mite depends at present on a few pesticides, a precarious situation in view of the probability of further resistance development. In the case of spider mites, there is a relative abundance of acaricidal groups and the problem arises because so few have been cleared for use on hops: efforts should be made to obtain clearance for additional groups. Because of the few insecticidal chemical groups, and the unlikelihood of new ones being developed, the situation for aphid control is the most critical. 'Breakdown' of the OPs mephosfolan and methidathion would almost certainly at present result in intensive use of decamethrin, thus in turn increasing the likelihood of resistance to all pyrethroids.

Integrated control of the aphid was pioneered by work at Wye College and was based on the use of an early-season mephosfolan drench and of anthocorids as natural enemies. Largely due to the vagaries of anthocorid appearance, and to difficulties in monitoring and deciding on chemical intervention, success with this system in commercial gardens has so far depended more on good luck than judgement. Nevertheless, a durable solution to the problems of control by pesticides alone is most unlikely, and hence an intensification of effort on the integrated approach is essential. Perhaps the greatest single contribution that could be made in this direction would be a selective aphicide of low toxicity to natural enemies and effective in the difficult circumstances of the hop garden.

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