EUROPEAN RED MITE RESISTANCE TO ORGANOTIN MITICIDES IN HAWKE'S BAY APPLE ORCHARDS

R.B. CHAPMAN, D.R. PENMAN and J.T.S. WALKER*

Entomology Department, Lincoln College, Canterbury
**Entomology Division, DSIR, Private Bag, Havelock North*

SUMMARY

European red mite was collected from a number of Hawke's Bay apple orchards to determine levels of cyhexatin resistance. Laboratory bioassays showed three populations to be 6.3, 13.4 and 21.9 times more resistant to cyhexatin than a susceptible population. A discriminating concentration of 0.06 g ai/litre cyhexatin was used to assess the occurrence of resistance in a further seven orchards. In all but one case, some resistance to cyhexatin was suspected to occur. Field control failures have also been noted at some orchards indicating the need for a resistance management programme.

INTRODUCTION

Organotin miticides have been used to control two-spotted mite (TSM), *Tetranychus urticae*, and European red mite (ERM), *Panonychus ulmi*, in apple orchards since the early 1970s. Three organotin chemicals (cyhexatin, azocyclotin and fenbutatin oxide) were available but fenbutatin oxide has now been withdrawn from sale in New Zealand. Before the establishment of integrated mite control (IMC) programmes using insecticide-resistant phytoseiid mites, an average of 3.8 miticide sprays per season were applied by Nelson apple growers in 1975-76 to control spider mites (Penman and Ferro 1977). By 1980-81 this average had fallen to 2.1 sprays per season (Hancox and Penman 1982), presumably due to the widespread adoption of IMC in this district (Wearing *et al* 1978). A similar survey of Hawke's Bay orchardists has also been carried out and during 1978-79 an average of 2.9 and 3.1 miticide sprays were used per season on early and late apple varieties respectively (J.T.S. Walker, unpublished).

One consequence of repeated use of chemicals to control insect and mite pests is resistance and, once it reaches a certain level, control failures can occur. A limited survey of ERM populations from throughout New Zealand to test for cyhexatin resistance was carried out in 1980 but no case of resistance to this chemical was substantiated (Chapman and Penman 1982). Another survey was initiated in 1986 following reports of difficulties in controlling ERM in some Hawke's Bay apple orchards. The results of initial tests for cyhexatin resistance in ERM and recommendations for further investigation of this problem are presented in this paper.

METHODS

The study was conducted in two parts depending on the origin of ERM and the test method used. Information regarding spray programmes and, in some instances, field efficacy of organotin miticide applications was obtained from the orchardists at whose properties ERM were collected.

Concentration-mortality tests

ERM eggs collected during winter 1986 from four Hawke's Bay apple orchards were sent to Lincoln College and stored at 4 °C until spring. Separate populations were then established on young peach trees (cv. 'Golden Queen') grown in polybags in a laboratory (c. 22 °C). After about 6 weeks, sufficient adult females were available for testing. A colony of ERM was found locally on some apple trees (cv. 'Sturmer Pippin'), which, as far as was known, had not been sprayed with organotin miticides. This was also maintained in the laboratory as a strain for comparison with the sprayed populations.

Adult females were exposed to residues of cyhexatin (Plictran 600F) on 18 mm diameter peach (cv. 'Golden Queen') leaf discs placed on damp filter paper in a petri dish. Ten females were placed on each disc and a minimum of five discs were treated with each concentration. A minimum of four concentrations and a water-treated control were tested with each population. All leaf discs were treated in a Potter spraying tower, operated at 70 kPa, using 1.5 ml of solution and allowing a 10 second settling time. Petri dishes containing the leaf discs and ERM were held at 21-23 °C for 48 h after which the mortality of females (failure to walk after light prodding) was determined.

All data were subjected to log-probit analysis using the computer programme POLO (Russell *et al* 1977) to determine median lethal concentration values.

Discriminating-concentration tests

Leaves infested with ERM adult females were collected from a number of Hawke's Bay apple orchards during January and February 1987 and air-freighted to Lincoln College. Samples of these mites were exposed to cyhexatin residues sprayed onto 18 mm diameter peach leaf discs at a concentration of 0.06 g ai/litre. The results of concentration-mortality tests showed that this concentration was sufficient to kill all susceptible ERM. A minimum of five discs, each with 10 adult females, was tested and compared with a similar control group on untreated discs. When sufficient mites were available, an additional set of discs sprayed with 0.12 g ai/litre cyhexatin (lowest recommended field concentration) was also prepared. Post-treatment conditions and mortality asessment were as described previously. Percentage mortalities were corrected using Abbott's formula (Abbott 1925) to account for control group mortality.

RESULTS

Use of organotin miticides

Table 1 summarises the periods of organotin use, average numbers of applications per year and the types of organotin miticides used by the orchardists involved in this study. Some orchardists had used organotin miticides for up to 14 years and, overall, an average of 2.5 sprays were applied per year. Azocyclotin was the most frequently used miticide (52% of applications) followed by cyhexatin (26%) and fenbutatin oxide (4%). Eighteen percent of the organotin miticides applied could not be positively identified.

TABLE 1: Use of organotin miticides (cy = cyhexatin, az = azocyclotin, fo = fenbutatin oxide, ui = unidentified) in the orchards surveyed for European red mite resistance.

Orchard	First use	Chemicals used (No. of sprays) cy	az	fo	ui	Total number of sprays	Mean number per year
Gudsell	1975	10	2	3	5	20	1.7
Smith, A.B.	1977	11	46	—	—	57	5.7
HNRO	1981 +	6	—	—	—	6	1.0
Ryan	1975*	5	10*	—	15*	30	2.5
Williams	1976	—	19	—	8	27	2.5
Duncan	1975	10	1	—	—	11	2.2
Smith, A.L.	1977*	—	19	4	4	27	2.7
Wellwood	1977*	13	—	—	10	23	2.3
Howard	1974	10	23	2	—	35	2.9
Jobey	1974	8	5	1	—	14	1.2

* = estimate, + = new block established 1980.

Concentration-mortality tests

Median lethal concentration (LC_{50}) values for cyhexatin tested against three ERM populations from Hawke's Bay and a susceptible population from Canterbury are listed in Table 2. All LC_{50} values were significantly different from each other as determined by the non-overlap of 95% confidence intervals. The resistance ratios (LC_{50} resistant population/LC_{50} susceptible population) were 6.3, 13.4 and 21.9 for Gudsell, Smith and HNRO populations respectively.

TABLE 2: Responses of European red mite populations to cyhexatin (concentration-mortality test).

Orchard	LC_{50} g ai/litre	95% CI	Slope	SE
Gudsell	0.075	0.053-0.094	2.70	0.54
Smith, A.B.	0.161	0.131-0.188	4.01	0.80
HNRO	0.263	0.215-0.321	2.24	0.34
Susceptible	0.012	0.009-0.014	5.44	1.10

TABLE 3: Responses of European red mite populations to cyhexatin (discriminating -concentration test).

	Corrected percentage mortality	
Orchard	0.06 g ai/litre	0.12 g ai/litre
Ryan	3	34
Williams	56	—
Duncan	31	—
Smith, A.L.	28	34
Wellwood	29	6
Howard	35	43
Jobey	89	100

Discriminating-concentration tests

The responses of seven ERM populations from Hawke's Bay to the discriminating concentrations of cyhexatin are listed in Table 3. In all but one instance (Jobey), less than 100% mortality was caused by these concentrations suggesting that a proportion of several ERM populations in Hawke's Bay is less susceptible to cyhexatin and would survive recommended field concentrations.

DISCUSSION

Using conventional laboratory bioassays, resistance to pesticides by arthropod pests can only be detected once it has developed to a level where discrete dosage-mortality responses for resistant and susceptible populations can be determined. Once resistance reaches this level, field control failures may occur at recommended field rates. However, small changes in dosage — mortality responses do not always imply field control failures. Therefore, in the analysis of any case of resistance, spray history information, laboratory bioassay and field efficacy data should be examined. The results of the present study are considered from these viewpoints.

Most orchardists involved in this study had used a combination of organotin miticides, and applied on average 2-3 sprays per season for 10 or more years. This group, therefore, differs little from the orchardists previously surveyed in Hawke's Bay (J.T.S. Walker unpublished). The exceptions in Table 1 are A.B. Smith who has made an average of 5.0 organotin applications per year since 1977 and Jobey who has applied only one spray per season since 1978, except for the 1986-87 season when two were applied. The block from which ERM were sampled in the Havelock North Research Orchard (HNRO) had also received only one spray per season since its establishment in 1980 but other parts of HNRO have been sprayed with up to 12 organotins since 1976. These results clearly indicate that there has been a long period of organotin selection pressure in most orchards.

The results of the concentration-mortality tests (Table 2) showed that there was a detectable difference in response to cyhexatin between a susceptible ERM population and those collected from three Hawke's Bay apple orchards. Ignoring the atypical circumstances of the HNRO, the highest level of resistance (Table 2, Smith) was found to be associated with the highest frequency of miticide use (Table 1). By comparison, Gudsell had used only half the number of miticides and the mites collected from his property showed half the level of resistance (by comparing LC_{50} values). It is also interesting to note that the relative difference between a susceptible population and one from Gudsell's has not changed markedly since 1980 when a 4.3-fold difference between LC_{50} values was noted (R.B. Chapman, unpublished). Table 2 further indicates that the use of both azocyclotin and cyhexatin has contributed to the selection of organotin resistance in ERM, but since only cyhexatin was tested no conclusions about the levels of azocylotin resistance can be made. The results in Table 2 also show some remarkable similarities to those recorded for TSM resistance to cyhexatin in Australia (Edge and James 1986). Using the same flowable formulation of cyhexatin, they found resistance factors of 2.8-12.2 for various populations. Recently ERM resistance to cyhexatin has also been detected from populations in the USA (Welty *et al* 1987) and Canada (Pree and Wagner 1987).

The results of the discriminating-concentration tests (Table 3) indicate that some ERM resistance to organotins may be present in other orchards although no information about the level of resistance is provided. It is significant that mites which had been exposed to the lowest selection pressure (Jobey) were all killed by the lowest recommended field concentration, whereas in all other cases some survival occurred. It appears that 0.06 g ai/litre of cyhexatin was an adequate concentration to indicate cyhexatin resistance in ERM populations. It is also close to the 0.05 g ai/litre discriminating-concentration used by Edge and James (1986) to detect cyhexatin resistance in TSM.

While the scope of this paper precludes any detailed discussion about the efficacy of organotin sprays in individual orchards, it was evident from leaf samples sent during the summer that many ERM were surviving applications of miticides. Detailed mite counts at the HNRO block confirmed the poor control achieved by cyhexatin applications (J.T.S. Walker, unpublished). It therefore appears that resistance in some ERM populations has reached a level sufficient to cause partial control failure.

This initial study of ERM resistance to cyhexatin has indicated a number of other aspects that require further investigation. In particular, the patterns of cross resistance between organotin miticides and the relative susceptibilities of immature ERM should be determined. Refinement of the bioassay and the discriminating-concentration methods would also aid assessment and management of this problem.

CONCLUSIONS

European red mite has developed some resistance to organotin miticides in a number of Hawke's Bay apple orchards which have been exposed to these chemicals for long periods. Further studies are required to determine the level and extent of organotin resistance in this and other apple-growing localities. A resistance management programme to maintain the useful life of organotin miticides is desirable and should be investigated.

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