TOXICITY OF SYNTHETIC PYRETHROID INSECTICIDES TO PHYTOPHAGOUS ORCHARD MITES

R. B. CHAPMAN and D. R. PENMAN

Lincoln College, Canterbury

Summary

Toxicities of the synthetic pyrethroid insecticides, cypermethrin, decamethrin, fenvalerate and permethrin and the organophosphorus insecticide azinphos-methyl to twospotted spider mite (*Tetranychus urticae*) and European red mite (*Panonychus ulmi*) were determined by laboratory slide-dip tests. All pyrethroids showed a similar level of toxicity with emulsifiable concentrate formulations being more toxic than corresponding wettable powder formulations. An organophosphorus resistant strain of twospotted spider mite was more susceptible to all synthetic pyrethroids than was a strain which had no previous history of exposure to insecticides.

INTRODUCTION

Synthetic pyrethroid insecticides, a new group of compounds with a diverse range of favourable properties, are being evaluated for control of arthropod pests in a wide variety of situations (Elliott *et al* 1977). Their exceptional insecticidal activity, photostability and residual properties make them suitable crop protection insecticides and already they are being evaluated for control of insect pests on various crops in New Zealand. Their introduction to deciduous fruit tree crops is primarily aimed at controlling lepidopterous pests and, while the application rates for these insecticides are considerably lower than for presently used organophosphorus (OP) insecticides, good control of these pests can be achieved. The other component of the pest complex on these crops is phytophagous mites. In commercial orchards where regular applications of OP insecticides are used to suppress leafrollers and codling moth, adequate control of phytophagous mites is not achieved with these sprays because they have developed resistance to these compounds. As a consequence, specific miticides (e.g. cyhexatin) must be applied at intervals throughout the growing season to maintain mite populations below damaging levels.

In orchards where OP insecticides have been replaced by synthetic pyrethroid (SP) insecticides, outbreaks of phytophagous mites have been recorded (Hall 1977; Baker 1978; Hoyt *et al* 1978; Zwick and Fields 1978). Several explanations have been forwarded: SP insecticides are highly toxic to predaceous phytoseiid mites (Roush and Hoy 1978; Wong and Chapman 1979) and thus the elimination of predators may allow phytophagous mite populations to develop unchecked, and/or, these insecticides may affect the biochemistry of the leaf in a way that is favourable to the mites and which increases their fecundity as was suggested by Breese and Highwood (1977).

The aim of this study was to determine the toxicity of a number of synthetic pyrethroids to the two most important species of phytophagous mites, the European red mite and the twospotted spider

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mite, by laboratory techniques to provide a basis on which to interpret field observations.

METHODS

Sources of mites

Two strains of twospotted spider mite and a single strain of European red mite were collected for testing. Organophosphorus resistant strains of both species were collected from commercial apple orchards (cv Red Delicious) from the Loburn district, Canterbury while a strain of twospotted spider mite having no known exposure to insecticides was collected from a soybean crop, Lincoln College, Canterbury.

Test method

Toxicities of the candidate compounds were determined by attaching 30 adult female mites to glass microscope slides with double-sided adhesive tape and dipping them for 5 sec in a range of serially diluted solutions (5-7 concentrations) which resulted in mortalities within the range of 5-95%. All dipping was performed at room temperature ($21 \pm 2^\circ\text{C}$) and treated slides were held at $25 \pm 1^\circ\text{C}$ and 70-80% RH for 24 h before mortality was assessed. The resulting dosage mortality data was subjected to log probit regression analysis (Finney 1952). All tests were completed using commercially formulated products and, where available, both emulsifiable concentrate (EC) and wettable powder (WP) formulations were used (Table 1).

TABLE 1: Toxicities of synthetic pyrethroid insecticides and azinphos-methyl to European red mite and twospotted spider mite.

Insecticide and formulation		LC ₅₀ g/litre	95% confidence limits for LC ₅₀	slope
TWOSPOTTED SPIDER MITE: (OP SUSCEPTIBLE STRAIN)				
azinphos-methyl	50 % WP	0.239	0.178-0.322	2.28
cypermethrin	40 % EC	1.571	1.148-2.149	1.91
decamethrin	2.5% EC	0.125	0.095-0.165	2.10
fenvalerate	10 % EC	0.644	0.496-0.835	2.51
fenvalerate	20 % WP	2.951	2.279-3.821	2.36
permethrin	50 % EC	0.315	0.233-0.427	2.05
permethrin	25 % WP	1.121	0.838-0.151	1.86
TWOSPOTTED SPIDER MITE: (OP RESISTANT STRAIN)				
azinphos-methyl	50 % WP	2.57	2.08 -3.19	4.05
cypermethrin	40 % EC	0.062	0.041-0.093	1.68
decamethrin	2.5% EC	0.023	0.017-0.032	1.90
fenvalerate	10 % EC	0.012	0.009-0.016	2.02
fenvalerate	20 % WP	0.215	0.158-0.293	2.08
permethrin	50 % WP	0.063	0.047-0.084	2.40
permethrin	25 % WP	0.364	0.266-0.498	2.02
EUROPEAN RED MITE: (OP RESISTANT STRAIN)				
azinphos-methyl	50 % WP	1.81	1.50 -2.2	3.92
cypermethrin	40 % EC	0.008	0.006-0.012	1.93
decamethrin	2.5% EC	0.013	0.009-0.019	1.80
fenvalerate	10 % EC	0.005	0.003-0.010	1.26
fenvalerate	20 % WP	0.041	0.031-0.053	2.73
permethrin	50 % EC	0.041	0.031-0.055	1.26
permethrin	25 % WP	0.086	0.059-0.13	1.30

RESULTS

The relationships between log doses and probit mortalities for each insecticide tested against the two strains of twospotted spider mite and the single strain of European red mite are depicted graphically in Fig. 1. Comparison of equitoxic doses (LC_{50} values) derived from these analyses can be made from Table 1.

FIG 1: Dosage mortality lines for twospotted spider mite and European red mite with synthetic pyrethroid insecticides. (↑ Suggested field application rate for synthetic pyrethroid insecticides.)

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Several clear trends can be observed by inspecting both Fig. 1 and Table 1. The similarity in the ascending order of toxicities of the SPs to the OP resistant strains of twospotted spider mite and European red and the almost complete reversal in the order of toxicities in the OP susceptible strain of twospotted spider mite indicate that both species respond similarly to this group of compounds. The strain of twospotted spider mite which had no history of exposure to insecticides, while it was relatively susceptible to azinphos-methyl, was considerably more tolerant of most of the SPs tested.

Little information can however be gained regarding the relative toxicities of the active ingredients of the various formulations since the proportion of solvents (in the case of EC formulations) and surfactants vary. Thus, the apparently high toxicity of decamethrin may reflect nothing more than the greater quantity of organic solvent in the test solution which could possibly aid penetration of toxicant into the mite. This was supported by a further observation that WP formulations were considerably less toxic (4.6 - 17.9x) than equivalent EC formulations by direct contact action.

Where a suggested field application rate of 0.05 g/litre (5g/100 litres) is considered, evidence from Fig. 1 would indicate that the SPs will give poor control of OP resistant strains of both species and virtually no control of OP susceptible strains of twospotted spider mite.

DISCUSSION

To provide definitive information about the acute toxicity of synthetic pyrethroid insecticide to phytophagous mite species was considered desirable in view of the reports describing the various effects these compounds have on such mites. While the results indicate that fenvalerate EC is the most toxic to the resistant strains of both species, there is, in all probability, little difference in toxicity between the four SPs tested. This may not be surprising when the molecular structures are considered and reveal only slight changes to the isobutyl side chain of the acid moiety. However, these changes can have considerable effects with other target species (Elliott *et al* 1978). Clearly these compounds will not be efficient miticides against the species in question at the rates currently suggested for field use. Any attempt to rank the compounds on toxicity from the data in Fig. 1 and Table 1 will likely lead to erroneous conclusions about structure-activity relationships since the EC formulations tested varied widely in % active ingredients and solvent content. Careful examination of Table 1 shows the toxicity of the formulated product tends to increase along with the proportion of solvents making up the formulation. Even where WP formulations of different insecticides are compared, the nature of surfactants and particle size may also influence results markedly.

More noticeable however are the differences between the two strains of twospotted spider mite. It would appear that a strain of this species which has had no previous exposure to insecticides has a higher natural tolerance to these SPs relative to a strain selected for resistance to an OP insecticide. For example, the OP resistant strain which is ca 11x more resistant to azinphos-methyl than the OP susceptible strain, is ca 53x more susceptible to fenvalerate EC (lesser values for other SPs and formulations, except decamethrin). A case of resistance-enhanced, induced-susceptibility or negatively correlated cross resistance is thus demonstrated, and has been confirmed by further studies not reported here. While the implications of this phenomenon would appear attractive in manipulating resistance to insecticides in this group of mites, the enhanced level of susceptibility is not sufficiently low to be of practical advantage. Interestingly, a similar

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observation has been recorded for predator mites, which are significantly more resistant to OPs than their prey (Roush and Hoy 1978; Wong and Chapman 1979) and are also highly susceptible to SP insecticides. This would suggest similar biochemical and genetic factors are operating and may be of practical value when considering the establishment of SP resistant predator strains for use in integrated mite control programmes where SPs are the dominant insecticide rather than OPs.

Published reports describing field trials which have monitored the effects of SP insecticides on phytophagous mite populations all show remarkably similar trends (Baker 1978; Hoyt *et al* 1978; Zwick and Fields 1978; Breese and Highwood 1978). The SP often gives good results early in the trial, but four to six weeks after treatment, resurgences of population numbers have been experienced, even where predator mites are not present. Furthermore, Hoyt *et al* (1978) showed a significant increase in mite numbers occurred with increased rates of permethrin. Thus it is clearly not a case of elimination of predators causing mite outbreaks.

The SPs tested in this study are clearly shown to possess poor acaricidal activity and would be unlikely to give adequate control of these phytophagous mites at the suggested field rate of around 0.05 g/litre (5g/100 litres), despite the observation that OP resistant strains of twospotted spider mite are more susceptible to SPs than OP susceptible strains.

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