

## TOXICITY AND REPELLENCY OF INSECTICIDES TO ORIBATID MITES INFESTING KIWIFRUIT

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### SUMMARY

Laboratory bioassays were conducted to investigate the delayed knockdown and repellency effects of pyrethroid insecticides on oribatid mites found on kiwifruit. Direct toxicity and/or repellent activity was demonstrated. Permethrin + pirimiphos-methyl caused significant mite mortality but had no repellency, whereas deltamethrin had a strong repellency effect on mites but relatively poor direct toxicity. Fluralinate had intermediate toxicity and repellency activity.

**Keywords:** kiwifruit, oribatid mite, pyrethroid, toxicity, repellency

### INTRODUCTION

Oribatid mites are occasionally found infesting kiwifruit harvested in some orchards. When high numbers are present on fruit they must be removed before the fruit can be exported. Some growers have reported that applications of permethrin + pirimiphos-methyl (Smith and Graham 1980) have lowered the incidence of oribatid mites on fruit at harvest. However, Kilsby and Steven (1983) were unable to find any reduction in the incidence of mites on vines treated with this insecticide. In contrast, Anon. (1980) demonstrated that regular applications of deltamethrin reduced infestation of kiwifruit vines by a variety of mites including oribatids. Steven and Lofroth (1987) conducted a laboratory bioassay to screen a range of insecticides for direct toxicity against an oribatid mite. Some activity was found for permethrin, pirimiphos-methyl and oil but they concluded the level of control provided by these materials used at field rates was insufficient to reduce fruit infestation by oribatids. However, pyrethroid insecticides may affect the incidence of two-spotted mite (*Tetranychus urticae*) infesting fruit crops by repellent activity (Penman *et al* 1981) as well as direct toxicity. This paper reports on some laboratory investigations of the direct toxicity and repellent activity against oribatid mites of several pyrethroid insecticides which are either registered or have been evaluated for use on kiwifruit.

### METHODS

All of the mites used in these experiments were *Ingella bullager* except for those used in the bioassay of repellent effects of residues on fruit which were *Pseudoceratoppia microsetosa*. The mites were collected from kiwifruit vines in an unsprayed orchard at Paeroa. The insecticides used for testing were deltamethrin (Decis 2.5% emulsifiable concentrate), fluralinate (Mavrik 24% suspension concentrate), permethrin (Ambush 50% emulsifiable concentrate) and permethrin + pirimiphos-methyl (Attack — 2.5% permethrin + 47.5% pirimiphos-methyl emulsifiable concentrate).

#### Direct toxicity

The effect of the insecticides on mite mortality was initially tested using insecticide-treated filter paper. Treatments using permethrin are shown in Figure 1. Other treatments were control (water) and aqueous suspensions of fluralinate used at 0.048, 0.096, 0.240 and 0.480 g/litre and permethrin + pirimiphos-methyl at 0.013, 0.025, 0.050, 0.125 or 0.250 g of permethrin + 0.238, 0.475, 0.950, 2.375 or 4.75 g of pirimiphos-methyl respectively. Each treatment was replicated 5-10 times. Filter paper (9 cm Whatman No.2) was fitted into the lids of 9 cm plastic petri dishes whose flanges and burrs had been removed to ensure a tight fit to prevent mites from escaping.

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Treatment suspensions (0.4 ml) were then dripped over the entire filter paper surface with a pipette ensuring uniform coverage. The paper was then dried with a hand-held drier. After 1-2 h, ten mites were placed in each petri dish. The base was tightly fitted into the lid from above to ensure the mites were securely caged and then stacked and weighted down. Mite mortality was assessed daily for 1 week by gently prodding mites with a fine camel hair brush. Mites that did not move their legs were considered dead.

The effect of plant material on miticidal activity was assessed using treated kiwifruit leaves. The treatments are shown in Table 1. Each treatment was replicated 6-8 times. Discs were cut from fresh kiwifruit leaves to fit the lid of a 9 cm petri dish. The discs were dipped for 5 seconds in the insecticide suspensions and allowed to air dry. The discs were then placed in the lid of petri dishes from which all of the flanges and burrs had been removed. Then oribatid mites were placed onto the leaf disc and the petri dish base was then fitted into the lid from above and pressed into the leaf surface in order to obtain a tight fit. Mortality was assessed by gently prodding legs to check for movement 4 and 7 days after the bioassays were set up.

#### Repellency

In the initial bioassays to assess repellency, half of a Whatman 9.0 cm No. 2 filter paper was treated with 0.2 ml of an aqueous suspension of insecticide and allowed to dry. As oribatid mites have a strong tendency to hide in crevices, the filter paper was folded to form a rectangle with the four folded portions enclosing a central square arena. Ten replicates each of a petri dish containing treated filter paper were prepared per treatment. Treatments are shown in Table 2. Ten adult oribatid mites were then placed in the central arena. After 1 h, the location of the mites, whether on or off the filter paper but still on the petri dish base or elsewhere in the petri dish was determined.

A test to determine repellency of insecticide residues on the fruit of kiwifruit was modified from a technique used by Penman *et al* (1981). Instead of using leaf discs, a kiwifruit fruit top was used as an arena. Unsprayed kiwifruit of a similar size had their sepals trimmed off to provide uniformity and were then dipped and gently agitated for 2 min in insecticide suspensions. Treatments are shown in Table 3. Spreader/wetter (Citowett 25 ml/100 litres) was added to all treatments to ensure thorough wetting of the fruit. After dipping, fruit were stood with stalk end uppermost and left overnight to air-dry. The following morning, the top of each fruit (with a surface area of ca. 2500-3500 mm<sup>2</sup>) was cut off and individually placed in a petri-dish filled with water. A single oribatid mite was then placed on the calyx region of each fruit. There were 42 replicates per treatment, each consisting of a kiwifruit top infested with one mite. The location and mortality of the mite on each fruit was then observed daily for 3 days. Mortality was assessed by gently prodding the legs of immobile mites and those which failed to respond were regarded as dead.

Mortality was corrected using Abbott's formulae and data from all experiments were analysed by logit analysis.

## RESULTS AND DISCUSSION

### Direct toxicity

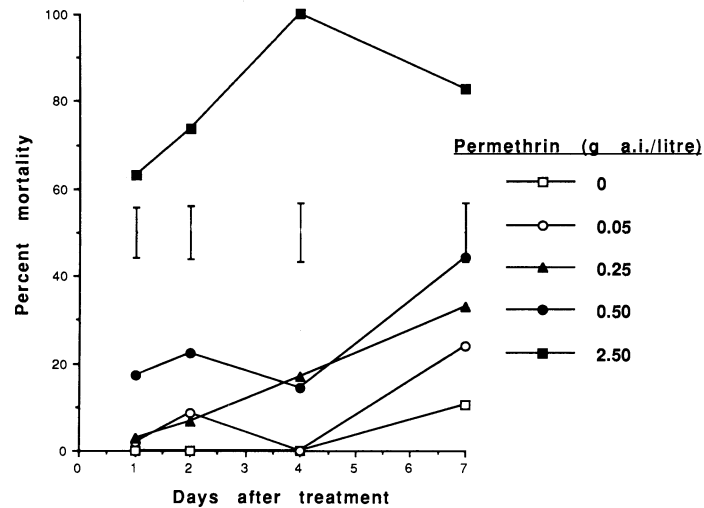
Permethrin had a significant ( $P < 0.001$ ) effect on mite mortality with a rate effect evident (Fig. 1). For some treatments, the level of mortality continued to rise with increasing exposure for up to 4 days. Both fluvalinate and permethrin + pirimiphos-methyl increased mite mortality, although fluvalinate to a lesser extent, e.g. mortality of mites exposed for 7 days to filter paper treated with fluvalinate used at 0.048, 0.096, 0.240 and 0.480 g/litre was 16.0, 17.9, 14.1 and 24.1% respectively. After 4 days exposure, to 0.013 + 0.238, 0.025 + 0.475, 0.050 + 0.950, 0.125 + 2.375, or 0.250 + 4.75 g of permethrin + pirimiphos-methyl, mortality was 16.7, 87.5, 70.0, 100 and 100% respectively.

After 4 or 7 days exposure to treated kiwifruit leaves, mite mortality (including moribund) on treated leaves differed significantly ( $P < 0.001$ ) from the untreated control (Table 1). Mortality was much greater for mites exposed to permethrin + pirimiphos-methyl than with fluvalinate.

**Repellency**

After 1 h exposure, a significant ( $P < 0.001$ ) proportion of the oribatid mites had moved off the filter paper treated with deltamethrin or fluvalinate (Table 2). The mites remaining on the filter paper showed no significant difference in distribution between the treated and untreated sides. By comparison, the treated side of the filter paper was the side where mites were most commonly found in permethrin + pirimiphos-methyl treatment. For example, 26.9, 33.0 and 50.0% of the total number of mites in each petri dish were found on the treated half of the deltamethrin, fluvalinate and permethrin + pirimiphos-methyl treatments respectively. This may be due to the initial lethal activity of permethrin + pirimiphos-methyl which slowed the locomotory activity of oribatid mites on the treated surface (i.e. rendering the mites moribund).

**Fig. 1:** Effect of rate of permethrin and exposure period on percent mortality of oribatid mites (*Ingella bullager*) on treated filter paper. Bars represent SED calculated using two maximum SE values.



**TABLE 1:** Corrected mortality (Mean  $\pm$  se) of oribatid mites (*Ingella bullager*) exposed to insecticide-treated kiwifruit leaf discs for 4 or 7 days.

Treatment	Rate (g ai/litre)	Percent mortality	
		4 days	7 days
fluvalinate	0.048	33.9 (5.5)	44.4 (6.2)
permethrin + pirimiphos-methyl	0.025	98.5 (1.4)	100
	0.475		

**TABLE 2:** Percentage (Mean  $\pm$  se) of oribatid mites found in different places within petri dishes after 1 h exposure to insecticide treated filter paper.

Treatment	Rate (g ai/litre)	On treated side*	Off filter paper**
untreated			14.0 (3.5)
deltamethrin	0.013	52.9 (7.0)	49.0 (5.0)
fluvalinate	0.048	55.9 (6.5)	41.0 (4.9)
permethrin + pirimiphos-methyl	0.025	58.1 (5.3)	14.0 (3.5)
	0.475		

\* Percentage of mites on filter paper; \*\*percentage of all mites in dish.

On treated fruit only deltamethrin (Table 3) gave any indication of repellency with a relatively greater proportion of mites moving off the fruit and being lost or drowned compared with untreated, although the difference was not significant ( $P > 0.05$ ). No repellency from fluvalinate-treated fruit was apparent. This result differs from that found with the treated filter papers (Table 2) and from those of Hern *et al* (1988) who found that fluvalinate repelled adult female two-spotted spider mites (*T. urticae*) from treated kiwifruit.

When oribatid mites were exposed to the insecticide-treated kiwifruit permethrin + pirimiphos-methyl had a highly significant ( $P < 0.001$ ) effect on mortality (Table 3) as also found on treated kiwifruit leaves (Table 1). No such effect was found for fluvalinate, although this may be a reflection of the short exposure period and its relatively slower activity (Table 1). Fluvalinate and pirimiphos-methyl + permethrin appeared to reduce mite mobility as they did in the repellency experiment using treated filter paper (Table 2). Thus, a greater proportion of mites were found close to the point of release (calyx) than elsewhere. For example, after 2 days 24, 24, 38 and 43% of the mites on the untreated, deltamethrin, fluvalinate and pirimiphos-methyl treatments were found on the calyx or ridge of hairs surrounding the calyx.

**TABLE 3: Cumulative percentage of mites killed (Mean  $\pm$  se) and repelled (Mean  $\pm$  se) (drowned or missing) after 1-3 days exposure to treated kiwifruit.**

Treatment	Rate (g ai/litre)	Exposure period (days)		
		1	2	3
<b>Percentage repelled</b>				
untreated		7.1 (4.0)	21.4 (6.3)	23.8 (6.6)
deltamethrin	0.013	11.9 (5.0)	31.0 (7.1)	31.0 (7.1)
fluvalinate	0.048	11.9 (5.0)	19.1 (6.1)	23.8 (6.6)
permethrin + pirimiphos-methyl	0.025 0.475	2.4 (2.4)	19.1 (6.1)	23.8 (6.6)
<b>Percent mortality</b>				
deltamethrin	0.013	0.0	3.4 (3.4)	0.3 (3.5)
fluvalinate	0.048	0.0	0.0	0.0
permethrin + pirimiphos-methyl	0.025 0.475	0.0	32.4 (8.0)	74.2 (7.9)

#### CONCLUSIONS

These laboratory bioassays have demonstrated that pyrethroid insecticides can have mortality and repellency activity against the oribatid mites which occasionally occur on kiwifruit vines. Thus when these insecticides are used regularly in spray programmes there should be a reduction in the level of fruit infestation by oribatid mites at harvest. However, any potential benefits of using pyrethroid insecticides in kiwifruit orchards needs to be considered in relation to their adverse effects on the predatory mites which control two-spotted spider mite (*T. urticae*) in shelter belts (Workman and Martin 1987).

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