EFFECT OF FLUVALINATE ON THE DEVELOPMENT AND SURVIVAL OF TWO-SPOTTED SPIDER MITE

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SUMMARY

Fluvalinate was more toxic and repellent to two-spotted spider mite (TSM), *Tetranychus urticae* Koch, larvae than to protonymph, deutonymph and adult stages. All stages were repelled by fluvalinate. The development rate of immature TSM which remained on the fluvalinate residues was reduced and the reduction was inversely related to the initial concentration applied. The relevance of these results to mite resurgence is discussed.

Keywords: *Tetranychidae*, pyrethroids, resurgence, fluvalinate, development

INTRODUCTION

The activity of miticides is usually determined by testing their effects on adult females but the immature stages are smaller and may therefore be more susceptible. Because spider mites show discrete generations, especially early in the season, applications of miticides can be timed to coincide with peak numbers of immature stages (Walker *et al* 1979). Differences in susceptibility between stages could enable application rates to be reduced which may aid integrated mite control programmes.

The susceptibility of immature spider mites to pyrethroid insecticides has not been widely investigated and neither have their effects on mite development. Some pyrethroids are repellent to spider mites and cause run-off, spin-down (Penman and Chapman 1983) and aerial dispersal (Smitley and Kennedy 1985). However, immature stages show less tendency to spin-down or aerially disperse (Smitley and Kennedy 1988) and are likely to contact more pyrethroid residues before they can escape.

Fluvalinate is currently the only pyrethroid registered in New Zealand for spider mite control; similar registrations have been granted in other countries. Fluvalinate is one of the few pyrethroids which has not caused spider mite resurgence (Penman and Chapman 1988). The objectives of this study were to examine the toxicity and repellency of fluvalinate to TSM, and its effect on mite development.

METHODS

Mite source

Populations of a TSM strain with no known exposure to chemicals in the last 5 years, were maintained on dwarf beans (*Phaseolus vulgaris*) in the laboratory under a long-day illumination period (16 L: 8 D) to prevent induction of diapause. To obtain nymphs of the desired stage, adult females from the colony were allowed to oviposit on excised dwarf bean leaves resting on cotton wool for 24 h. The females were removed and the leaves were held at 23 °C to allow development.

Ovi-larvicidal effect

The following method was used to measure the direct toxicity of fluvalinate (Mavrik Aquaflo, 24% flowable formulation) to eggs and the residual toxicity to emerging larvae.

Three adult female TSM were placed on each 18 mm dwarf bean leaf disc resting on wet cotton wool and allowed to oviposit for 24 h. The leaf discs were then sprayed with seven fluvalinate concentrations (see Table 2) or water using a Potter tower (2 ml, 55 kPa, 10 sec. settling time) and were stored at 23 °C in a controlled temperature (C.T.) cabinet. A minimum of 30 leaf discs were used per concentration. After 7 days, when

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the majority of the water-treated eggs had hatched, the number of unhatched eggs, larval mortality and run-off was assessed. The numbers of dead and run-off mites (mites that had become trapped in the water barrier around the margins of the leaf disc) were pooled and subjected to log-probit analysis to determine the concentration-mortality response. Run-off mites were included because fluvalinate is known to be a repellent compound (Penman *et al* 1986).

The experiment was repeated using three fluvalinate concentrations (0.0015, 0.005, 0.01 g/litre) and the numbers and development stages of the mites after egg hatch were recorded daily for 7 days, by which time most of the water-treated mites had reached adulthood. To estimate the development rate, each mite development stage was scored as one point and the total development points per concentration calculated each day. From these data the regression for cumulative mean development/day for the mites remaining on the leaves was calculated for each concentration. The slope, intercept and variance of the development rate for each fluvalinate concentration was compared to that for the water treatments.

Toxicity, repellency and effect on development of protonymphs, deutonymphs, and adults

Five dwarf bean leaf discs (18 mm) were placed on wet cotton wool in a Petri dish. Each Petri dish was sprayed (2 ml) using a Potter tower (55 kPa, 10 sec. settling time) and allowed to air dry. A minimum of four Petri dishes/concentration was used (see Table 3 for the concentrations). Five mites at the required protonymph or deutonymph stage were transferred onto each leaf disc. The Petri dishes were stored in a C.T. cabinet at 23 °C. After 24 hours mites were scored as alive, dead or run-off. The numbers of dead and run-off mites were pooled for the probit analysis. The development stage of each mite exposed to water or 0.001, 0.005, 0.01 and 0.1 g/litre of fluvalinate, was recorded daily for 5 days after treatment for those beginning as protonymphs and for 4 days with the deutonymphs. The development rate for the protonymph and deutonymph stages was calculated and compared by regression analysis.

RESULTS

Ovi-larvicidal effect

Fluvalinate had an ovicidal effect (33.9% mortality) at the highest concentration tested (1.0 g/litre). The LC_{50} and LC_{90} for the larvicidal effect were 0.003 and 0.02 g/litre respectively (Table 1). At the field concentration of fluvalinate recommended for TSM control (0.1 g/litre), the predicted percentage mortality and run-off for larvae from the probit analysis was 100%. At the concentrations tested, fluvalinate caused approximately equal amounts of larval mortality and run-off (Table 2).

TABLE 1: The LC_{50} and LC_{90} (g ai/litre) for larvae, protonymphs, deutonymphs and adults on fluvalinate treated leaf discs.

Stage	Larvae	Protonymphs	Deutonymphs	Adults
LC_{50}	0.003	0.344	0.136	0.201
95% C.I.	0.002-0.005	0.137-1.546	0.043-1.063	0.051-1.300
LC_{90}	0.020	13.138	19.637	20.325
95% C.I.	0.012-0.036	2.345-1306	3.880-546	2.689-11974
Slope	1.64	0.81	0.59	0.64

Development from the egg to adulthood was significantly reduced by the 0.005 and 0.01 g/litre fluvalinate treatments compared to water treatment ($P < 0.05$). At one tenth field rate no larvae reached adulthood (Table 2).

Toxicity, repellency and effect on development of protonymphs, deutonymphs, and adults

The 95% confidence intervals for the LC_{50} and LC_{90} overlapped for the protonymphs, deutonymphs and adults (Table 1). At the field concentration of fluvalinate recommended for TSM control (0.1 g/litre), the predicted percentage

TABLE 2: The percentage mortality, run-off and survival to adulthood of the total larvae tested, and the development rate per day on fluvalinate and water treated leaf discs.

Conc. g ai/litre	Mortality	Run-off	Adulthood	Development rate
0	2	1	79	1.020
0.001	1	1		
0.0015			65	0.986
0.002	15	9		
0.004	22	29		
0.005	40	38	13	0.805*
0.01	53	36	0	0.334*
0.1	52	45		
1.0	61	37		

*indicates regression lines were significantly different from untreated at $P < 0.05$)

mortality and run-off for protonymphs, deutonymphs and adults from the probit analysis was 35-45%. The main response of these stages was to run-off the leaf discs (Table 3).

The development rate of the protonymphs and deutonymphs was significantly reduced ($P < 0.05$) by the 0.005, 0.01 and 0.1 g/litre fluvalinate treatments compared to the water-treated mites. At one tenth field concentration 17% and 40% of the protonymphs and deutonymphs respectively reached adulthood and at the field concentration only 6% of the deutonymphs reached adulthood (Table 3). Deutonymphs are more likely to reach adulthood than younger stages because they only have to pass through one quiescent stage and may required less nutrition.

TABLE 3: The percentage mortality, run-off, and survival to adulthood of the total protonymphs (P), deutonymphs (D) and adults (A) tested, and the development rate per day on fluvalinate and water treated leaf discs.

Conc. g ai/litre	Mortality			Run-off			Adulthood		Development rate	
	P	D	A	P	D	A	P	D	P	D
0	3	1	0	0	1	0	92	94	0.909	0.687
0.001	0	2		1	11		85	85	0.812	0.758
0.005	3	2	8	14	25	10	28	28	0.553*	0.400*
0.01	0	2	3	8	29	24	17	40	0.488*	0.422*
0.05	4	3		13	30		1	4		
0.1	6	3	1	38	36	33	0	6		
0.5	7	7	13	43	66	48	0	0		
1.0	12		29	58		45	0			
5.0			45			47				

*indicates regression lines were significantly different from untreated at $P < 0.05$

DISCUSSION

Fluvalinate showed no ovicidal activity at concentrations around the recommended field concentrations. Greater ovicidal activity may have occurred if fluvalinate had been applied just before egg-hatch. El-Banhawy and Reda (1988) found that the susceptibility of TSM eggs to cypermethrin, cyfluthrin, fenvalerate and pyridaphenthion increased progressively towards hatching.

At the recommended field concentration, fluvalinate was highly toxic and repellent to TSM larvae which had emerged onto 6 day old residues. Furthermore, the effects of fluvalinate were assessed after most water treated eggs had hatched and even greater mortality and run-off would be expected over time. Larvae were approximately 100 times more susceptible to fluvalinate than protonymphs, deutonymphs and adults.

No larvae survived to adulthood at one tenth field rate but some protonymphs and deutonymphs reached adulthood at this concentration. These results suggest that the field concentration recommended for TSM could be reduced, particularly if applications were made just before egg hatch. This reduction may also enhance the survival of mite predators but field evaluations of the efficacy of lower rates would first be required.

The main response of the older TSM stages was to run off the leaf discs but the development of the remaining mites was reduced. By comparison, the development rate of TSM was unaffected when they were exposed to fenpropathrin for 2 days and then transferred to untreated leaf discs (Rasmy and Elsawy 1988). Therefore, it may be the fate of dispersing mites which will determine the outcome of spraying. Dispersing mites may find unsprayed areas in which to develop and then reinfest the crop as residues decline. This suggests thorough coverage with fluvalinate is required to prevent mite build up. Coverage would be particularly important in the control of immatures because they are less likely to disperse outside the crop. Targeting applications to coincide with peak numbers of larvae is likely to reduce the resurgence, if thorough coverage is achieved, because further immature development would be largely prevented.

Similar results to those reported here have also been obtained with the European red mite, *Panonychus ulmi*, the larval stage was the most susceptible to fluvalinate and development rates of all stages were reduced (J.M. Holland, unpubl.).

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REFERENCES

- El-Banhawy, E.M. and Reda, A.S., 1988. Ovicidal effects of certain pesticides on the two-spotted spider mite, *Tetranychus urticae* and the predacious mite, *Amblyseius gossypii* (Acari: Tetranychidae: Phytoseiidae). *Insect. Sci. Applic.* 9: 369-372.
- Penman, D.R. and Chapman, R.B., 1983. Fenvalerate-induced distributional imbalances of two-spotted spider mite on bean plants. *Ent. Exp. and Appl.* 33: 71-78.
- Penman, D.R., Chapman, R.B. and Bowie, M.H., 1986. Direct toxicity and repellent activity of pyrethroids against *Tetranychus urticae* Koch (Acari: Tetranychidae). *J. Econ. Entomol.* 79: 1183-1187.
- Penman, D.R. and Chapman, R.B., 1988. Pesticide-induced mite outbreaks; pyrethroids and spider mites. *Exp. and Appl. Acarol.* 4: 265-274.
- Rasmy, A.H. and Elsawy, S.A., 1988. The sub-lethal influences of some insecticides on the fecundity and development of the two-spotted spider mite *Tetranychus urticae* Koch. *J. Appl. Ent.* 105: 310-313.
- Smitley, D.R. and Kennedy, G.G., 1985. Photo-orientated aerial-dispersal behaviour of *Tetranychus urticae* Koch (Acari: Tetranychidae) enhances escape from the leaf surface. *Ann. Entomol. Soc. Am.* 78: 609-614.
- Smitley, D.R. and Kennedy, G.G., 1988. Aerial dispersal of the two-spotted spider mite (*Tetranychus urticae* Koch) from field corn. *Exp. Appl. Acarol.* 5: 33-46.
- Walker, J.T.S., Asheley, E., Wearing, C.H., Thomas, W.P. and McLaren, G.F., 1979. Timing sprays for efficient European red mite control. *Orchardist of N.Z.* 52: 289-290.