TEFLUBENZURON AND PHOSALONE ALONE OR IN COMBINATION FOR PEST CONTROL ON KIWIFRUIT: II. CATERpillARS, SECONDARY PESTS AND CONTAMINANTS

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SUMMARY

Field trials were conducted in Waikato and Tauranga kiwifruit orchards during 1986-87 to evaluate the effect of teflubenzuron and phosalone, used alone or in combination, on leafrollers, leafhoppers and mites. Treatments using teflubenzuron and/or phosalone were less effective than phosmet in preventing fruit damage, infestation or contamination by lepidopterous pests, sooty mould or mites. Teflubenzuron was the only sprayed treatment which failed to prevent fruit infestation with live leafroller and *Stathmopoda* spp. larvae and pupae. Oribatid mites were the dominant family of mites found on phosmet-treated vines. A more diverse mite fauna, similar to that of unsprayed vines, was found on vines treated with teflubenzuron only.

Keywords: teflubenzuron, phosalone, kiwifruit, leafroller, passionvine leafhopper, mites.

INTRODUCTION

Leafrollers are key pests of kiwifruit, while secondary pests include two species of *Stathmopoda* and the passionvine leafhopper (*Scolypopa australis* (Walker)). Mites are the most common contaminants on harvested fruit (Steven 1990). Broad-spectrum insecticides applied at regular intervals throughout the growing season control key and secondary pests and reduce the incidence of contaminants. However, these insecticides may also prevent the establishment of biological control agents inside orchards (Staubli *et al* 1984; Haas 1987). Use of insecticides with a narrower range of activity may allow greater reliance on biological control of kiwifruit pests. Evaluation of these insecticides must ensure that secondary pests and contaminants are also kept to within commercially acceptable levels. Two candidate insecticides are the organophosphate phosalone and the insect growth regulator teflubenzuron. Phosalone is known to have activity against leafrollers, leafhoppers (Haas 1987), thrips (Teulon and Penman 1987) and mites as well as being relatively harmless to biological control agents (Staubli *et al* 1984). Teflubenzuron has demonstrated activity against leafrollers (Suckling *et al* 1985) and thrips (Kubota 1989).

This paper reports on field trials to evaluate phosalone and teflubenzuron, used alone and in combination, against leafrollers, secondary pests and contaminants. The effects of these experimental treatments on armoured scale insects recorded in the same trials have been reported by Tomkins (1992).

METHODS

The trial layout and methods of treatment application at two sites are described by Tomkins (1992). Treatments are listed in Table 1.

Fruit damage and infestation or contamination was determined on 50 fruit harvested at random from each vine on 27 and 29 January, and 100 fruit per vine harvested on 15 and 12 May, at Tauranga and Rukuhia respectively. Fruit were stored at 4°C prior to microscopic examination.

These data were subjected to ANOVA and logit regression analysis. Analyses were not performed on data where damage or numbers of insects for all sprayed

Proc. 45th N.Z. Plant Protection Conf. 1992: 156-161

treatments was very low or zero.

RESULTS

Leafrollers and *Stathmopoda*

The level of fruit damage on unsprayed vines by lepidopterous larvae or pupae at Rukuhia increased between January (Table 1) and May (Table 2). At the end of the season in May, although all sprayed treatments had a significantly lower ($P < 0.001$) level of fruit damage compared with the unsprayed, but only the phosmet-treated fruit had an acceptably low level of damage. The level of fruit damage on phosalone-treated (75 g/100 litres) vines was reduced by combining the insecticide with teflubenzuron for fruit harvested in January, but not the end of the season in May.

The number of lepidopterous larvae or pupae on unsprayed fruit at Rukuhia was higher in January (Table 1) than May (Table 2). Lepidopterous larvae and pupae found on fruit sampled from unsprayed vines at both sites in January were predominantly leafrollers with small numbers of *Stathmopoda*. In May, *Stathmopoda* were the most common Lepidoptera found on unsprayed fruit.

Of treated vines, only those treated with teflubenzuron yielded fruit infested by lepidopterous larvae and pupae (Tables 1, 2). These infestations were comprised of similar numbers of leafrollers and *Stathmopoda*.

Parasitoids

Unhatched pupal cocoons of a solitary *Apanteles* spp. were found on Rukuhia fruit in January from unsprayed vines and those treated with both rates of teflubenzuron. Similarly, hatched cocoons of this species were found on unsprayed fruit sampled in May from both sites.

TABLE 1: Percentage of fruit damaged or infested and numbers of lepidopterous larvae or pupae/100 fruit harvested on 29 January and 27 January 1987 at Rukuhia and Tauranga respectively.

Treatment ^a	Rate g ai/ 100 litres	% Damaged or infested ^b		Live larvae or pupae/100 fruit ^c	
		Rukuhia	Tauranga	Rukuhia	Tauranga
unsprayed	-	46.1(4.4)	16.7(6.4)	2.0 (7.5)	1.0(3.2)
phosmet (Imidan 75WP)	112.5	0	3.4(2.9)	0	0
teflubenzuron (Nomolt 15SC)	7.5 10.0	12.2(2.6) 15.5(2.8)	- -	0.3(1.4) 0.4(1.5)	- -
phosalone (Zolone 30WP)	75.0	5.9(2.0)	2.5(2.8)	0	0
teflubenzuron + phosalone	3.8 45.0	2.8(1.3)	2.7(2.6)	0	0.4(1.9)
teflubenzuron + phosalone SED	6.3 74.0	0.4(0.6)	-	0 0.48	- 0.80

^a applications, for Rukuhia and Tauranga respectively were: pre-flowering (14 and 17 November); post-blossom (12 and 8 December); 14-21 days later (27 and 23 December 1986); at 3-4 weekly intervals until withholding period (10 and 12 January, 9 and 9 February, 12 and 17 March and 6 and 8 April 1987);

^b s.e. in brackets;

^c log (X+1) transformed with back-transformed means in brackets. SED's apply to transformed data.

TABLE 2: Percentage of fruit damaged or infested and numbers of lepidopterous larvae or pupae/100 fruit harvested in 12 May and 15 May 1987 at Rukuhia and Tauranga respectively.

Treatment	Rate g ai/ 100 litres	% Damaged or infested ^b		Live larvae or pupae/100 fruit ^b	
		Rukuhia	Tauranga	Rukuhia	Tauranga
unsprayed	-	49.6(2.6)	26.8(3.7)	3.9	0.3
phosmet	112.5	1.8(0.7)	5.6(2.6)	0.0	0.0
teflubenzuron	7.5	15.1(1.7)	-	0.0	-
	10.0	17.0(1.8)	-	0.2	-
phosalone	75.0	5.0(1.0)	5.6(2.6)	0.0	0.0
teflubenzuron + phosalone	3.8 45.0	4.7(1.1)	9.3(3.3)	0.0	0.0
teflubenzuron + phosalone	6.3 75.0	5.3(1.2)	-	0.0	-

^a s.e. in brackets;^b untransformed.**Passionvine leafhopper**

Fruit contamination by sooty mould, growing on honey-dew produced by the leafhoppers, increased considerably between January and May (Table 3). None of the insecticide treatments prevented fruit contamination by sooty mould. At Rukuhia, the level of fruit contamination was lower, although not significantly, on vines treated with phosmet in comparison with the other sprayed treatments.

TABLE 3: Percentage^a of harvested fruit with sooty mould.

Treatment	Rate g ai/ 100 litres	Rukuhia	Tauranga	Rukuhia	Tauranga
		27 January	29 January	12 May	15 May
unsprayed	-	6.1(2.2)	2.0(0.3)	21.5(4.0)	13.1(3.7)
phosmet	112.5	2.0(1.4)	1.9(0.4)	15.0(3.7)	13.2(3.6)
teflubenzuron	7.5	6.0(1.9)	-	25.9(4.1)	-
	10.0	4.0(1.8)	-	26.1(4.1)	-
phosalone	75.0	6.3(2.2)	1.9(0.3)	30.8(4.3)	18.2(4.2)
teflubenzuron + phosalone	3.8 45.0	9.8(2.9)	1.7(1.6)	25.5(4.2)	10.0(3.1)
teflubenzuron + phosalone	6.3 75.0	3.5(1.7)	-	30.2(4.8)	-

^a s.e. in brackets.**Mites**

The level of mite infestation on fruit harvested in May was similar or higher on sprayed vines compared with fruit from unsprayed vines (Table 4). Representatives from five families of mites were found on fruit harvested in May (Fig. 1). The mite fauna on unsprayed vines at Rukuhia was dominated by oribatids and phytoseiids. At Rukuhia, there was no apparent pattern of change to the mite fauna associated with

Fig. 1: Percent composition of families of mites found on fruit harvested in May 1987.

insecticide application. At Tauranga, oribatids, phytoseiids, glycyphagid and tenuipalpid mites were all well represented on fruit from unsprayed vines. The mite fauna on fruit from all of the sprayed treatment vines at this site, became strongly dominated by oribatids.

TABLE 4: Percentage of kiwifruit infested by mites^a and numbers of whirlygig mite (*Anystis baccarum*) cocoons per 100 fruit harvested on 12 May and 15 May 1987 at Rukuhia and Tauranga respectively.

Treatment	Rate g ai/ 100 litres	% Fruit infested ^b		No. of <i>A. baccarum</i> cocoons/100 fruit ^c	
		Rukuhia	Tauranga	Rukuhia	Tauranga
unsprayed	-	4.0(1.5)	2.0(1.6)	2.1(8.3)	2.5(13.4)
phosmet	112.5	6.6(2.1)	10.5(3.6)	0	1.1(0.3)
teflubenzuron	7.5	6.0(1.7)	-	2.2(9.1)	-
	10.0	5.0(1.6)	-	2.9(17.7)	-
phosalone	75.0	3.1(1.2)	8.1(3.2)	1.4(4.1)	0.8(2.5)
teflubenzuron	3.8	6.1(1.8)	2.3(1.7)	0.8(2.4)	1.3(3.9)
+ phosalone	45.0				
teflubenzuron	6.3	3.8(1.5)	-	0.9(2.6)	-
+ phosalone	75.0				
SED				0.31	0.51

^a composition of mite families infesting fruit is shown in Fig. 1 ;

^b s.e. in brackets;

^c loge (X+1) transformed with back-transformed means in brackets. SED's apply to transformed data.

Significant differences ($P < 0.001$ at Rukuhia and $P < 0.05$ at Tauranga) were found between treatments in the numbers of cocoons of the predatory whirlygig mite *Anystis baccarum* occurring on harvested fruit (Table 4). The level of fruit infestation by these cocoons was lowest on fruit harvested from phosmet-treated vines but was also reduced by phosalone when used alone or in combination with teflubenzuron. On vines treated only with teflubenzuron, the incidence of whirlygig mite cocoons on fruit was similar to that of unsprayed vines.

DISCUSSION

Both phosalone and teflubenzuron used alone or in combination, at the rates tested, were unable to provide acceptable control of key (see also Tomkins 1992) or secondary pests of kiwifruit. Although teflubenzuron did not provide commercially acceptable pest control, its use demonstrates potential for using insecticides which act specifically on pests, allowing biological control agents to survive inside sprayed orchards and possibly assist pest control.

The side-effects of applying broad-spectrum insecticides such as phosmet in comparison with more specific acting teflubenzuron were shown by changes in the mite faunal composition. Phosmet appeared to have no effect on oribatid mites as previously shown by Steven and Lofroth (1987) but applications did reduce the incidence of other families of mites including whirlygig mites. This resulted in a shift in the mite faunal composition to one dominated by oribatid mites. Ferguson and Stratton (1978) also noted changes in the mite family composition on vines following applications of broad-spectrum insecticides. In contrast, teflubenzuron, and to a lesser extent phosalone, allowed a more diverse range of mites to survive, some of which like the phytoseiids and whirlygig mites are predatory (Baker 1983) and could have a potentially beneficial role.

These trials also illustrate the potential effects of changes in the current pest control measures used for kiwifruit on the incidence of pests and their control. Two examples relate to the incidence of *Stathmopoda* spp. and the passionvine leafhopper. Sampling fruit in January and May revealed that even though most fruit damage by leafroller larvae occurs shortly after flowering (Wearing *et al* 1980), large amounts of fruit infestation and damage can also occur later. The presence of *Stathmopoda* as the dominant lepidopteran on fruit at harvest suggests that these larvae, probably originating from the second generation (Steven 1990), may have played a significant role in the late season fruit damage. Applications of phosmet between January and May prevented fruit infestation by *Stathmopoda* and this late season damage. *Stathmopoda* larvae therefore appear to be secondary pests controlled by sprays intended for armoured scale insects and leafrollers. Thus, care needs to be taken in future changes to kiwifruit pest management, such as the reduction in late season insecticide applications for armoured scale control, to ensure that control of both secondary and key pests is maintained. Similarly, the increase in sooty mould contamination of fruit between January and May demonstrates the importance of insecticide applications between these months for passionvine leafhopper control.

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