EFFICACY AND TIMING OF INSECTICIDES FOR THE CONTROL OF SAN JOSÉ SCALE ON APPLE

P.W. SHAW[1], S.J. BRADLEY[2] and J.T.S. WALKER[2]

The Horticultural and Food Research Institute of New Zealand Ltd.,
[1]Nelson Research Centre, P.O. Box 220, Motueka
[2]Hawke's Bay Research Centre, Private Bag 1401, Havelock North

ABSTRACT

Applications of lime sulphur, mineral oil, neem and the insect growth regulator, fenoxycarb were compared to diazinon and chlorpyrifos for control of San José scale. Lime sulphur, fenoxycarb and neem significantly reduced fruit infestation by scale insects at harvest relative to untreated trees but not to the same extent as the organophosphate insecticides, diazinon and chlorpyrifos. Mineral oil (1%) gave a level of control intermediate between these two groups of treatments. A second trial compared November applications of two rates of oil with chlorpyrifos. The only treatment to significantly reduce scale incidence on fruit in late January was the 2% rate of oil. A third trial examined the effectiveness of two dates of oil application in late summer. Application on 24 February reduced the incidence of scale infested fruit more than applications on 8 March. This was possibly due to dead scale still being present on the fruit.

Keywords: San José scale, mineral oil, fenoxycarb, neem, application timing.

INTRODUCTION

With the adoption of integrated fruit production (IFP) in New Zealand and the associated shift away from the routine use of organophosphate (OP) insecticides, several previously minor pipfruit pests, including scale insects, have increased in importance (Walker *et al.* 1997). Infestation of pipfruit by scale insects in summer can prevent export certification of crops making the development of alternative selective pesticides a priority within the IFP programme.

The most common species of scale insect infesting pipfruit crops in Nelson and Hawke's Bay is San José scale (SJS, *Comstockaspis perniciosus* (Crawford)). Greedy scale (*Hemiberlesia rapax*) also occurs but is less common (Richards 1960; Timlin 1964; Walker *et al.* 1998). There are three generations of San José scale a year with associated peaks of crawler release in summer, although low numbers of crawlers may be released at other times (Collyer and van Geldermalsen 1975). Current SJS control in IFP systems relies on the use of mineral oil, applied to orchard trees at the green-tip stage either alone or in combination with insecticide. Additional OP insecticide applications may be required in mid-summer to protect the crop from infestation by later generations of scale insects either surviving inside the orchard or, more frequently, from crawlers blown in from surrounding host plants (Shaw *et al.* 1997; Anon. 1998; Walker *et al.* 1998). This paper reports the results from three trials, which investigated the efficacy of alternatives to OP insecticides, two rates of mineral oil and two application dates of mineral oil for spring/summer scale control.

METHODS

Trial 1

This trial was conducted on a block of cv. Braeburn apples at the HortResearch Nelson Research Centre during the 1998-99 season. Six treatments, plus an untreated control, were applied either once (29 January) or twice (29 January and 18 February),

timed to coincide with the peak second generation SJS crawler release period. Treatments and product rate per litre were chlorpyrifos (Chlorpyrifos 50W, 0.5 g), diazinon (Diazinon 50W, 1 g), mineral oil (Shellspray, 10 ml), lime sulphur (FIL Lime Sulphur, 30 ml), fenoxycarb (Insegar 25WP, 2 g) and neem extract (Neemix, 0.5 ml). Insecticides were applied by hand-lance at approximately 5 litres per tree (ca 3000 litres/ha) to each of seven single tree replicates per treatment arranged in a randomised complete block design. At harvest (30 March 1999), 100 fruit from each tree were examined for scale infestation. Because of wide tree to tree variability in scale infestation, trees within each treatment were ranked from lowest to highest incidence of scale. This relative scale incidence was used as a factor instead of replicate in the data analysis. Arcsine transformed percent fruit infestation data was analysed using GLM-ANOVA and Fisher's LSD test. Back transformed mean percentage fruit infestation figures are presented in Table 1. The factorial analysis of results excluded the untreated control and used product, number of applications, rank and the product by application interaction as factors.

Trial 2

A block of cv. Braeburn at HortResearch's Havelock North Research Centre was used for this trial. Approximately 10% of fruit in this block had been infested with SJS at the previous harvest. Two rates of mineral oil (Excel, 1% and 2%) were compared with chlorpyrifos (0.5 g/litre) and an untreated control. Treatments were applied by hand-lance on 23 November 1999 at the same rates as Trial 1. Four single tree replicates in each treatment were determined using infestation rates from the previous season's harvest data in an attempt to ensure similar levels of SJS in each treatment. One hundred fruit per tree were assessed on 27 January 2000 for scale infestation as in Trial 1, and for russet using ENZAFRUIT grade standards. Percent fruit infestation data were arcsine transformed for analysis and the back-transformed mean percentage infestation values are presented in Table 2. Data was analysed using GLM-ANOVA with treatment and relative scale incidence as factors. Fisher's LSD test was used to determine significant treatment differences.

Trial 3

This trial focused on late summer timing of mineral oil application for scale control and was conducted using the same trees as in Trial 2, plus additional trees with known scale infestation levels. The trial was a 2×2 factorial with combinations of no treatment or treatment with mineral oil (Excel, 2%) on 24 February and/or 8 March 2000 giving a total of four treatments. Each treatment was replicated six times. One hundred fruit per tree were harvested on 5 April 2000 and assessed for scale infestation. Data were arcsine-transformed and analysed by GLM-ANOVA using application dates as factors.

RESULTS AND DISCUSSION

Trial 1

The effectiveness of six products for summer control of scale insects are shown in Table 1. The aim of the timed spray treatments was either to reduce crawler production by controlling mature scale or to kill SJS crawlers by direct spray contact or through residual activity of the products, to prevent crawlers settling on the fruit. No attempt was made to distinguish live from dead scales found on the fruit at harvest and only infested fruit figures are presented in Table 1. Although small numbers of greedy scale were found on fruit, inclusion of this data did not affect the overall result and are not presented.

All products significantly reduced the incidence of scale on fruit ($P < 0.001$) compared to the untreated control. Diazinon and chlorpyrifos were the most effective treatments with 0.2% scale infestation. Fruit sprayed with mineral oil had more scale than in the diazinon treatment but did not differ significantly from chlorpyrifos. Fruit sprayed with neem, fenoxycarb or lime sulphur had approximately 1% infestation but this was not significantly different from mineral oil.

Over all the products combined, there was no reduction in scale infestation from a second spray application. This varied greatly between products resulting in a

significant product × application interaction. Diazinon, fenoxycarb and neem had more scale infested fruit in those trees sprayed twice. The reverse occurred with the other products. The high tree to tree variation in scale infestation within the block probably influenced this result. There was a significant difference (P<0.001) between the least and most heavily infested ranked trees (blocks). The highest ranked trees averaged 3.9% infested fruit while the least infested tree was zero in almost every treatment (mean 0.01%).

TABLE 1: Mean fruit infestation (%) by San Jose Scale at harvest in Trial 1. Figures not followed by the same letter are significantly different (P<0.05).

Factor	Treatment	Product rate/litre	SJS infested fruit	
Product			(P<0.001)	
	chlorpyrifos	0.5 g	0.21%	ab
	diazinon	1 g	0.19%	a
	mineral oil	10 ml	0.62%	bc
	lime sulphur	30 ml	1.07%	c
	fenoxycarb	2 g	1.16%	c
	neem extract	0.5 ml	1.11%	c
	control		3.10%	[1]
Applications			(P>0.05)	
	29 Jan 1999		0.63%	a
	29 Jan & 18 Feb 1999		0.68%	a
Product Application interaction[1]			(P<0.05)	

[1]The untreated control was significantly different from all insecticide treatments, but was not included in the factorial analysis.

Trial 2

The levels of scale-infested fruit in this investigation were lower than would be expected at harvest. Only the 2% mineral oil treatment had a significantly lower percentage of scale infested fruit compared to the other treatments and the untreated control (Table 2).The chlorpyrifos treatment did not reduce fruit infestation in this trial despite Trial 1 and other studies showing it to be effective. Bower (1987) found that a single chlorpyrifos application used at the start of the first summer generation of crawlers gave effective control of SJS while Reissig *et al.* (1985) found that two applications10-14 days apart during each generation of crawlers provided the best control and prevented fruit infestation. Bower (1987) reported that one application of 2 or 3% dormant oil was as effective as chlorpyrifos applied against SJS crawlers. In this trial there was a significant benefit from the higher rate of oil which reduced fruit infestation by more than ten fold compared to the 1% rate (P<0.05).

Treatments in Trial 2 were aimed at controlling the first summer generation of SJS crawlers in late November. This is the first generation of SJS that can infest fruit. Control at this time may be important in reducing the risk of crawler infestation in late summer arising from host plants within and adjacent to orchards blocks.

The November treatments were applied during a russet-sensitive period, although cv. Braeburn is generally less russet-prone than some other cultivars. The highest incidence of russet was in the 2% oil treatment but none of the treatments resulted in any significant increase in unacceptable fruit russet (Table 2). While there was little evidence of oil-induced phytotoxicity in this trial, applications of mineral oil close to some fungicides (e.g. dodine, captan and lime sulphur) are phytotoxic. Therefore careful use of 2% mineral oil in summer may provide an alternative to less selective insecticides such as chlorpyrifos for scale control.

TABLE 2: SJS infested fruit (%) in Trial 2 on 27 January 2000. Figures not followed by the same letter are significantly different (P<0.05).

Treatment	SJS infested fruit		Fruit with unacceptable russet	
untreated control	0.9%	b	1.4%	ab
chlorpyrifos 0.5 g/litre	0.9%	b	1.2%	ab
Excel oil 1%	1.3%	b	0.1%	a
Excel oil 2%	0.1%	a	3.7%	b

Trial 3

Scale crawlers are released over a long period in summer making correct timing of treatments difficult. The aim of this trial was to assess the effect of different times of late summer oil application for SJS control. Application on 24 February, was effective in reducing the level of scale infested fruit at harvest (Table 3). The March application was not significantly different to the untreated control. Interpretation of results was complicated because only the presence of scale on fruit was recorded and no assessment was made of living or dead scale. The later application may not have reduced the incidence of scale infested fruit if dead scale were still present, while the earlier application allowed more time for dead scale to be removed.

Mineral oil controls scale insects mainly by smothering which prevents respiration. The results show that oil is most effective in preventing fruit infestation in summer if it is applied in February, which is the main period of crawler release from gravid female scales. Results from this trial also indicate that the timing of a late summer oil application to reduce fruit infestation by SJS is more critical than the number of applications, where scale populations are resident in the orchard, as in these trials. In orchards exposed to wind-blown crawlers (e.g. from infested shelter trees), it is important to control scale on these hosts or treat the block with a product that prevents crawler settlement. Control of established scale insects on fruit is too late and will result in packhouse downgrading of fruit, even if the scales are dead.

TABLE 3: Mean SJS infested fruit (%) found on 5 April 2000 in Trial 3.

Timing	Treatment	SJS infested fruit
24 February 2000		P<0.05
	untreated	1.8%
	2% Excel oil	0.3%
8 March 2000		P>0.05
	untreated	0.7%
	2% Excel oil	1.2%

CONCLUSIONS

Summer applications of lime sulphur, fenoxycarb and neem show some activity against SJS, but were not as effective as either chlorpyrifos or diazinon in reducing scale infestation on fruit at harvest. Summer use of mineral oil, especially if used at 2%, may give effective control of potential scale infestation in late summer. The primary objective of the IFP pest management programme on pipfruit is to enhance the use of beneficial insects by decreasing OP insecticide use and using selective pesticides. The use of mineral oil for scale control in summer is an effective alternative to these less selective pesticides. More work is required to examine the appropriate timing and factors influencing crop phytotoxicity.

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