TOXICITY OF LIME SULPHUR TO ARMOURED SCALE

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SUMMARY

A laboratory dipping technique showed that lime sulphur at the label rate was toxic to immature stages of greedy scale (*Hemiberlesia rapax*) but was only moderately toxic to mature scale. A comparison with the diazinon LC_{50} and LC_{90} values of Blank and Olson (1987) showed diazinon was 16 times more toxic to scale than lime sulphur at label rates. The strategy of dipping in diazinon 16 days after lime sulphur did not markedly increase mortality relative to diazinon alone.

INTRODUCTION

Lime sulphur has been recommended in the MAF export spray programme for kiwifruit as a dormant season spray for control of greedy scale and lichen from 1980/81 onwards. The inclusion of the lime sulphur spray originates from the laboratory screening trials of Ferguson and Wallace (1979). In their tests lime sulphur gave 87 to 92% mortality of mature greedy scale which was not significantly different from the mortalities achieved by the most effective group of insecticides which included diazinon. Sale (1979, 1980) found that winter applications of 7% lime sulphur gave 82.5% control of scale.

The MAF export spray programme recommends the lime sulphur spray be followed 10 days later by an organophosphorus spray such as diazinon or chlorpyrifos. It has been suggested that the lime sulphur softens and lifts the scale covering allowing the penetration and contact action of the following diazinon spray which enhances the killing action of both sprays (Anon. 1985).

The objective of this study was to carry out detailed laboratory investigations on the toxicity of lime sulphur to greedy scale.

MATERIALS AND METHODS

The toxicity testing procedure employed in this study was similar to that described in detail by Blank and Olson (1987) which was used to determine the toxicity of diazinon to greedy scale. Greedy scale infested potatoes were dipped for 5 seconds in a range of lime sulphur (McDonalds Lime Sulphur, 15% sulphur as polysulphides in the form of aqueous sulphates) concentrations in addition to a control which was dipped in water. Potatoes were held at $20 \pm 2^\circ\text{C}$ for 14-21 days before mortality assessment.

Determination of 10 day old white cap dose responses were obtained from four test runs carried out on separate occasions. Each test run involved six-10 concentrations of insecticide as well as the water control and there were two-three repeats (potatoes) per dose. Mortality was assessed from 50-100 scale per potato. Determination of the yellow cap, black cap, mature and mother scale dose responses were obtained from one-two test runs using potatoes with a mixed age scale population. Each test run involved 8-15 insecticide concentrations but only six-seven doses were evaluated for any one scale stage. There were two or four repeats per run and mortality was assessed for 50 scale stages per repeat.

Log probit regression analysis was used to calculate LC_{50} and LC_{90} critical doses and 95% confidence intervals. This analysis took into account Abbott's formula (Busvine 1971) for correcting for control mortality which did not exceed 16%.

The effect of a single dip of 3.5 and 7% lime sulphur, diazinon (Basudin 80EC), 48 g/100 litres, and a control dipped in water were compared with lime sulphur treated scale which were dipped for a second time, 16 days later, in diazinon (48 g/100 litres). Potatoes with a mixed age scale population were used for this trial. Mortality was

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assessed 37 days after the first dip from 25 yellow cap, black cap and mature scale from each potato. Some potatoes which had been cut in half went rotten and were discarded leaving an unequal number of replicates (from four to seven) per treatment.

RESULTS

The plots of the logarithm of the lime sulphur concentration against corrected percentage mortality on a probit scale for each of the greedy scale stages tested are presented in Figure 1. The critical concentration levels and slopes are presented in Table 1. The mature and mother scale required 4 to 14 times higher lime sulphur concentrations to obtain the equivalent LC_{50} or LC_{90} of the 10 day old white caps. Lime sulphur at currently recommended label rates (7 litres product/100 litres) killed 92-95% of white cap and yellow cap, 87% black cap, 60% mature and 44% mother stages.

Fig. 1: Plots of the logarithm concentration of lime sulphur (litres product/100 litres) against percentage mortality for white cap, yellow cap, black cap, mature and mother stages of greedy scale.

TABLE 1: Critical concentration levels, 95% confidence intervals, slopes of the logarithm concentration probit regression curves, and total numbers of greedy scale stages tested (n) using lime sulphur.

Stage	n	LC_{50} (95% CI) (litres/100 litres)	LC_{90} (95% CI) (litres/100 litres)	Slope $\pm$ SE
white cap	11,730	0.6 (0.5-0.7)	5.6 (5.1-6.0)	1.34 ± 0.02
yellow cap	1,480	0.9 (0.8-1.0)	4.2 (3.3-5.6)	1.93 ± 0.14
black cap	1,950	1.2 (1.1-1.4)	9.1 (7.6-11.3)	1.47 ± 0.07
mature	1,580	4.9 (4.4-5.5)	24.0 (19.8-30.0)	1.86 ± 0.10
mother	1,560	8.5 (7.6-9.6)	40.1 (32.0-53.1)	1.90 ± 0.11

TABLE 2: The effect of diazinon (48 g ai/100 litres) and lime sulphur alone or followed 16 days later by a second dip of diazinon on the corrected mortality of black cap, mature and mother scale stages.

First dip	Second dip	% Mortality		
		Black cap	Mature	Mother
diazinon	—	90	88	72
lime sulphur 3.5%	—	80	59	30
lime sulphur 7.0%	—	84	40	41
lime sulphur 3.5%	diazinon	87	82	75
lime sulphur 7.0%	diazinon	86	83	84
SED (approximate)	—	4.6	6.3	6.5

The effect on corrected scale mortality of diazinon on lime sulphur with and without a second diazinon dip is shown in Table 2. A single dip of diazinon gave significantly ($P < 0.01$) higher levels of mortality of mature and mother scale than lime sulphur. Mortality of lime sulphur treated mature and mother scale was significantly ($P < 0.01$) increased following a second diazinon dip, but there was no significant increase in scale mortality using the two chemicals compared to diazinon alone.

DISCUSSION

Care must be taken in extrapolating the results of these laboratory toxicity tests directly to the field situation. For example, the dose of chemical applied to the scale using a 5 second dip may be quite different (many times higher?) than is achieved by spraying in the field. These laboratory toxicity tests are, however, most useful for comparing the relative toxicity of chemicals and hence predicting field efficacy. The toxicity of diazinon to greedy scale has previously been investigated using similar procedures to this study (Blank and Olson 1987). A comparison of critical concentration levels from this show diazinon to be several hundredfold more toxic than lime sulphur to greedy scale. In order to predict field efficacy it is more useful to compare each chemical relative to field rates as shown in Table 3. At currently recommended label rates diazinon is on average 16 times more toxic than lime sulphur to greedy scale. This finding, therefore, differs from the preliminary screening trial of Ferguson and Wallace (1979) which suggested these chemicals were of a similar level of effectiveness.

TABLE 3: A comparison of the relative toxicity of diazinon and lime sulphur at label rates to greedy scale using the LC_{50} and LC_{90} data from this study and from Blank and Olson (1987).

Stage	Ratio label rate: LC_{50}			Ratio label rate: LC_{90}		
	Diazinon	Lime sulphur	Relative toxicity	Diazinon	Lime sulphur	Relative toxicity
white cap	160	12	13	28	1.3	22
yellow cap	80	8	10	15	1.7	9
black cap	69	6	12	17	0.7	24
mature	44	1.4	31	8	0.3	27
mother	9	0.8	11	0.4	0.2	2

It is difficult to understand why a diazinon spray is recommended 10 days after the lime sulphur spray. We saw no evidence of the lime sulphur softening or lifting the scale cover and there was little improvement in scale mortality using the combination of the two chemicals 16 days apart compared with diazinon alone. Further work is required to establish if there is any risk of interaction between sprays.

The results of this study in combination with field studies has enabled recommendations to be made on the use of lime sulphur on kiwifruit (Blank and Olson 1989).

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