LIME SULPHUR FOR ARMOURED SCALE AND LICHEN CONTROL ON KIWIFRUIT

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SUMMARY

Dormant season applications of 3.5 and 7% lime sulphur on kiwifruit gave good control of lichen but poor control (< 18% kill) of all stages of laticia scale (*Hemiberlesia laticia*). Lime sulphur treated wood prevented greedy scale (*Hemiberlesia rapax*) crawler settlement for at least 47 and 85 days after spraying at the 3.5 and 7% rates respectively. It is recommended that a 3.5% lime sulphur spray be applied to kiwifruit vines in late August specifically to control lichen and to prevent the establishment of armoured scale crawlers on wood in spring.

INTRODUCTION

A dormant season application of 7% lime sulphur is currently recommended to control armoured scale and lichen on kiwifruit. Earlier laboratory and field studies have reported good control of greedy scale using lime sulphur (Ferguson and Wallace 1979; Sale 1979, 1980). Recent laboratory toxicity studies, however, showed lime sulphur to have relatively low toxicity to greedy scale, with diazinon being 16 times more toxic at label rates (Blank and Olson 1987, 1989).

The objectives of this study were to carry out field investigations on the effect of lime sulphur on lichen control, scale control and scale crawler settlement so that future recommendations on the use of lime sulphur could be made.

MATERIALS AND METHODS

Lichen control

Mature kiwifruit vines which had not received any lichen control since planting in 1983 were used for this trial. Vines were selected which had similar amounts of lichen. McDonalds lime sulphur (15% sulphur as polysulphides in the form of aqueous sulphates) at 7 and 3.5 litres of product/100 litres of water were compared with an unsprayed control with four replicates (vines) in each treatment. Lime sulphur was applied on the 31 August 1988 using a knapsack sprayer. Vines were sprayed past the point of runoff to ensure complete coverage (3 litres/vine). The weather was fine at spraying. Samples of lichen were collected from the bark of unsprayed vines for identification. Detailed assessments of lichen control were made 3 months after spraying.

Scale control

This study used a block of 5 year old kiwifruit vines planted at 2.75 m spacings in Kerikeri which were due to be destroyed to allow the planting of another crop. Vines had not received any insecticide sprays over the 1987/88 season but had been sprayed with lime sulphur in August 1987. Vines had a relatively even infestation of scale on the 1 and 2 year old wood.

McDonalds lime sulphur at 7 and 3.5 litres of product/100 litres of water, was compared with diazinon (Basudin 80 EC), 48 g/100 litres water as a standard, and an untreated control. Plots comprised two female vines and four treatments were replicated three times in a randomised block design. Treatments were applied to the vines on 2 August 1988 using a solo knapsack with a number 5 disc and 25 core and were sprayed to runoff to ensure complete coverage (2.5 litres/vine). The weather was fine at spraying and was dry for the following 5 days.

Scale mortality was assessed by destructively harvesting 1 and 2 year old wood from the vines 49, 57 and 64 days after spraying for replicates one, two and three

Proc. 42nd N.Z. Weed and Pest Control Conf.

respectively. Harvested wood was kept in plastic bags in a cool store (4 °C) for up to 7 days before being assessed. The mortality and stage of scale were assessed under a microscope. At least 35 scale for each stage, except for white caps which were in low numbers on some plots, were assessed from each plot giving a total of approximately 420 scale per treatment. Mature scale (458) were collected from untreated plots for identification of species as described by Lo and Blank (1989). A precise analysis of results was done using logit analysis, but for presentation purposes an analysis of percentage mortality was also carried out. Percentage mortalities were corrected for natural mortality in untreated controls using Abbott's formula (Busvine 1971).

Scale crawler settlement

Five year old female kiwifruit vines which had not received any dormant season pesticide sprays were used for this trial. FIL lime sulphur (15% sulphur as polysulphides in the form of aqueous sulphates) at 7 and 3.5 litres of product/100 litres of water were compared with an unsprayed control. There were four replicates (vines) for each treatment. Lime sulphur was applied on the 31 August 1988 using a solo knapsack sprayer with a number 5 disk and 25 core. The wood was sprayed to the point of runoff to ensure complete coverage (4 litres/vine). Conditions were fine and warm during spraying.

In order to test greedy scale crawler settlement 1 year old wood was harvested from treated and untreated vines at regular intervals. This was cut into 80-90 mm lengths using the wood between buds. Crawlers from a laboratory colony of greedy scale were brushed onto the pieces of wood which were then suspended from the lid inside a plastic pot (550ml). Wood infested with crawlers was held at 20 °C for 4 days after which the numbers of live white cap stages were counted and live or dead crawlers were estimated.

RESULTS

Lichen control

The southern side of all vines were encrusted in a vigorous lichen growth before treatments were applied. The most abundant species present was *Ramalina celastri* (Sprengel) which occupied approximately 75% of total lichen cover. This species was greyish green and protruded from the bark like clumps of seaweed. Other species commonly found included *Parmotrema perlatum* (Huds.) and *Xanthoria parietina* (L.) which formed flattened circular to irregularly shaped spots as well as *Usnea rubicunda* (Stirton) which formed a mass of fine filaments and protruded from the bark. At least another seven species were present in trace amounts.

Soon after spraying with lime sulphur all species of lichens became bleached, changing to white, yellow or pink, and were "papery" in appearance. These lichens although dead still remained attached to the bark 3 months after spraying, but could be easily pulled or scraped off. There was no difference between the effect of the full or half rate of lime sulphur on lichen control.

Scale control

Latania scale was the dominant armoured scale species present at the Kerikeri site comprising 96.3% of the population with greedy scale comprising 3.7% of the population.

Lime sulphur did not significantly increase scale mortality relative to the untreated (Table 1). After correcting for natural mortality the 7% lime sulphur gave an 18% kill and the 3.5% lime sulphur a 0% kill. Diazinon gave significantly ($P < 0.001$) higher levels of scale mortality than the untreated. After correcting for natural mortality diazinon gave an 82% kill of all stages of scale.

Scale crawler settlement

Soon after being placed on the wood the yellow crawlers stopped moving and commenced spinning the protective silken cover which distinguishes it as a settled white cap stage. It was difficult to distinguish between a crawler which had just died and the early settled stage as both are yellow and have the same features. In order to distinguish between live and dead crawlers therefore, the wood was held for 4 days by which time the settled white cap stage was fully developed with a white silken cover.

TABLE 1: The effect on *latania* scale mortality of an August application of lime sulphur and diazinon to kiwifruit.

Treatment	% Mortality					Corrected % Kill All stages
	White cap	Yellow cap	Black cap	Mature	All stages	
diazinon	89	96	90	84	90	82
lime sulphur 7%	48	76	52	40	54	18
lime sulphur 3.5%	27	72	50	23	42	0
untreated	35	68	56	26	44	—
SED (approx)	8	6	7	7	6	—

The levels of settlement of greedy scale crawlers (i.e. numbers of white caps) on untreated and lime sulphur treated wood is shown in Table 2. A high level of settlement was achieved on untreated wood throughout the period of this trial. Lime sulphur treated wood prevented settlement of crawlers for at least 47 days at the half rate and 85 days at the full rate.

The rainfall over the September and October period of 230 mm was sufficiently high to indicate that the protection given by lime sulphur against crawler settlement is not diminished by high rainfall.

TABLE 2: The effect of a dormant season lime sulphur spray on greedy scale crawler settlement on kiwifruit wood as measured by the development of white caps.

Days after spraying	Numbers of white caps			SED
	Untreated	Lime sulphur 3.5%	Lime sulphur 7%	
1	25	0	0	9
12	47	0	0	23
23	57	1	0	12
36	102	1	0	9
47	77	1	1	29
61	41	10	2	8
75	50	26	4	17
85	23	16	2	6
99	34	24	42	14

DISCUSSION

One of the major uses of lime sulphur on kiwifruit is to control lichen growth on wood. Lichens do not cause any direct injury to the vines. They utilise the bark surface as a substrate for attachment and obtain their nutrients from the air or from functionless tissue on the bark surface. Lichens may, however, be harmful in an indirect way by sheltering armoured scale insects from sprays as well as harbouring other organisms such as oribatid mites.

This study confirms the effectiveness of lime sulphur sprays as a means of controlling lichen growth and adds to our current knowledge by demonstrating that half rates are equally effective as full rates.

The other major use of lime sulphur on kiwifruit, to control armoured scale, has been the subject of much conjecture amongst growers and their advisors. It is commonly believed that lime sulphur killed the scale either directly, or indirectly by lifting the protective covering so that a second organophosphate spray would be effective if used within 14 days (Anon. 1985). This field trial showed conclusively that lime sulphur has a low level of toxicity to established armoured scale on kiwifruit. The levels of control obtained, particularly with the immature stages, were much less than were achieved in laboratory dipping studies and confirms the danger of extrapolating

directly from laboratory toxicity tests to the field situation (Blank and Olson 1989). Most importantly, however, the superior toxicity of diazinon compared to lime sulphur was confirmed. The 82% kill obtained with diazinon in this study was higher than the 46 and 62% kills obtained by Blank *et al* (1985) and the 39% kill (corrected for natural mortality) obtained by Tomkins *et al* (1986) in other field studies.

Two different armoured scale species were used in these studies. Latania scale was used in the field trial and greedy scale in the laboratory toxicity tests. In the absence of any detailed toxicity comparison between the two species it would appear lime sulphur has a low toxicity to both species.

The major advantage of lime sulphur for armoured scale control was in preventing crawler settlement on the wood. The long lived nature of this protection means that a dormant season spray of lime sulphur will prevent crawler settlement on the wood in spring. Obviously, once bud break occurs and untreated leaves and new season canes become available for settlement the degree of protection particularly from aerially dispersed crawlers will be diminished. Crawlers originating from adult scale harbouring on woody parts of the vine are still likely to be killed as they crawl across the lime sulphur treated surfaces.

Given that the major effects of lime sulphur are to kill lichen and to prevent crawler settlement, and that the half rate was almost as effective as the full rate, then the half rate should be recommended for grower usage. It may be advantageous to apply the lime sulphur spray in late August or early September so as to extend the period of protection as far into the spring as possible. Care would need to be taken to ensure that late applications of lime sulphur are not phytotoxic to the buds, particularly of male vines, which begin to swell in late September prior to bud break.

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