EFFECT OF PESTICIDES ON PREDATION OF SOFT WAX SCALE BY THE STEEL-BLUE LADYBIRD

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SUMMARY

Nine fungicides, five insecticides and a spreader-sticker were bioassayed on citrus leaves, to determine their effect on predation of soft wax scale (*Ceroplastes destructor*) by the steel-blue ladybird (*Orchus chalybeus*). Three copper based fungicides, cupric hydroxide, copper oxychloride and copper sulphate/hydrated lime, significantly reduced predation by adult ladybirds by 71-85%. The insecticides diazinon, mineral oil and the miticide, azocyclotin, significantly reduced predation by 54-85%. The fungicides captan, iprodione, chlorothalonil, sulphur, mancozeb and triforine; and the insect growth regulator buprofezin, an insecticidal soap and a spreader-sticker had no significant effect on predation.
Keywords: fungicides, insecticides, *Ceroplastes destructor*, *Orchus chalybeus*, predation

INTRODUCTION

Soft wax scale (*Ceroplastes destructor*) infests the leaves and green twigs of many varieties of citrus. Honeydew secreted by the scale is colonised by sooty mould fungi which can eventually coat the tree, disfiguring the fruit as well as reducing photosynthesis and yield.

Citrus growers in New Zealand have traditionally attempted to control soft wax scale by spraying with a variety of insecticides (Helson 1973). Insecticides have provided variable levels of control and soft wax scale continues to be a problem (Lo *et al* 1991). Citrus may also require regular spraying with fungicide to control several fungal diseases (Whiteside *et al* 1988). In general, insecticides are highly toxic to natural enemies whereas fungicides have a relatively low toxicity (Theiling and Croft 1988). It is possible that some of these pesticides could also have sublethal effects on natural enemies which may disrupt their feeding.

In order to develop an integrated pest and disease management (IPDM) programme for citrus in New Zealand, knowledge on which pesticides have the least harmful effects on biological control agents is required. The steel-blue ladybird (*Orchus chalybeus*) is an important predator of soft wax scale (Hely *et al* 1982; P. Lo unpubl.). This paper reports on the screening of a range of fungicides, insecticides, a miticide and a spreader-sticker for disruption to predation of soft wax scale by the steel-blue ladybird.

METHODS

The effect of pesticides on predation by steel-blue ladybirds was investigated in three laboratory experiments (Tables 1-3). First and second instar scale on selected *Citrus trifoliata* leaves were counted (100-200/leaf, 100-160/leaf and 130-160/leaf in Experiments 1, 2 and 3 respectively). All dead scale were removed. Treated leaves were either sprayed to runoff using a hand sprayer (Experiment 1), or dipped for 10 seconds into 1 litre aqueous suspensions of chemical (Experiments 2 and 3). Untreated control leaves were dipped in water. After drying, each leaf was placed in a separate Petri dish. In Experiment 1, additional dishes contained one treated and one untreated leaf. Six ladybirds were added to each dish. The ladybirds were collected from the field and held overnight without food. The dishes were kept in a controlled temperature room at 20±1°C and scale numbers assessed after 24 hours. Ladybird survival was assessed after 12 and 24 hours, and also after 4 days in Experiment 3.

Experiment 1 tested treated and untreated leaves separately, and in a separate

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experiment gave the ladybirds a choice of both treatments. Both larval and adult ladybirds were tested. There were six replicates for each treatment. Experiments 2 and 3 tested only adults with treated and untreated leaves separately, with four replicates.

Results were expressed as the percentage reduction of scale and an ANOVA of arcsin transformed data was performed. In Experiment 2, the untreated control and triforine treatment, being effectively constants, were excluded from the ANOVA. A Scott-Knott cluster analysis (Scott and Knott 1974), was used on the remaining treatments. Tukey's test was used to determine statistical significance between pairs of treatments.

RESULTS

In Experiment 1, predation by both larval and adult ladybirds was significantly ($P<0.001$) reduced on cupric hydroxide treated leaves compared with untreated leaves, in both the no choice and choice experiments (Table 1). Larvae ate significantly ($P<0.05$) more scale than adults in the choice experiment, but there was no interaction effect between ladybird stage and treatment. There was no mortality of ladybirds within 24 hours.

TABLE 1: Predation of soft wax scale by the steel-blue ladybird on cupric hydroxide (Kocide 101 WP, rate 50 g ai/100 litres) treated and untreated citrus leaves in Experiment 1.

Treatment	Mean % predation			
	No choice test		Choice test	
	Larvae	Adults	Larvae	Adults
cupric hydroxide	4	6	16	4
control	92	91	79	57
SED	6.5		11.8	

In Experiment 2, the three copper based fungicide treatments showed significantly ($P<0.05$) lower predation compared with the captan, iprodione, chlorothalonil, sulphur and mancozeb treatments (Table 2). No mortality of ladybirds occurred after 24 hours. In Experiment 3, the diazinon, mineral oil and azocyclotin treatments had statistically similar levels of predation (Table 3). These treatments significantly ($P<0.001$) reduced predation compared with buprofezin, insecticidal soap, spreader-sticker and the untreated control. There was no mortality of ladybirds within 4 days, except in the diazinon treatment. After 12 hours, 63% of the ladybirds in the diazinon treatment were dying or dead and by 24 hours this had increased to 92%.

TABLE 2: Predation of soft wax scale by adult steel-blue ladybirds on fungicide treated and untreated citrus leaves in Experiment 2.

Treatment	Rate (g ai/ 100 litres)	Mean % predation
copper oxychloride (Copper oxychloride 50WP)	150	15
cupric hydroxide (Champ 18F)	70	25
copper/lime (Boredeaux WP)	600/600	29
captan (Captan 80WP)	160	49
iprodione (Rovral 250F)	50	60
chlorothalonil (Bravo 500F)	150	69
sulphur (Microsul 80WP)	80	70
mancozeb (Dithane M-45 80WP)	160	75
triforine (Saprol 19EC)	20	99
untreated control	–	100
SED (excluding triforine and untreated)		17.6

TABLE 3: Predation of soft wax scale by adult steel-blue ladybirds on insecticide and spreader-sticker treated and untreated citrus leaves in Experiment 3.

Treatment	Rate (g ai/ 100 litres)	Mean % predation
diazinon (Diazinon 50WP)	25	15
mineral oil (Sunspray)	1%	33
azocyclotin (Peropal 25WP)	19	46
buprofezin (Applaud 25W)	12.5	97
alkylarypolyglycol ether (Citowett)	25	97
C12-C18 fatty acids (Defender 25SC)	500	99
untreated control	-	100
SED (diazinon, mineral oil, azocyclotin only)		15.6

DISCUSSION

The three copper based fungicides caused more disruption to predation by the steel-blue ladybird than other types of fungicide. In the field, this disruption could adversely affect the ability of ladybirds to control scale. This will depend on the longevity of fungicide residues and frequency of spraying. This corroborates an earlier study (cited in Hely *et al* 1982), which reported an outbreak of soft wax scale in the season after citrus trees were sprayed with copper sulphate/hydrated lime. This outbreak was attributed to reduced ladybird predation. Copper sulphate/hydrated lime has been largely superseded by other copper fungicides which are now widely used on citrus orchards.

The steel-blue ladybird feeds on first and second instar soft wax scale (P. Lo unpubl.). These stages are usually present in citrus from December to February (Lo *et al* 1991; M. Olson unpubl.). The developing fruitlets are susceptible to fungal diseases during these months (Whiteside *et al* 1988). Depending on weather, several applications of fungicide are usually needed to provide acceptable disease control. Our trials suggest that the use of copper fungicides should be avoided from about November to February, to minimise disruption to ladybird predation of the vulnerable scale stages.

The insect growth regulator buprofezin is effective against a variety of scale insects but harmless to some parasites (Yarom *et al* 1988). Our initial studies indicate that this selectivity extends to adult steel-blue ladybirds. Buprofezin was non-toxic to adults of another coccinellid *Cryptolaemus montrouzieri*, but increased mortality of juveniles (Smith and Papacek 1990). If buprofezin is also effective against the scale species that infest New Zealand citrus, then it may be highly suitable for IPDM. It is currently not registered for use on citrus in New Zealand.

Insecticidal soaps have been considered as potential alternatives to organophosphates. Puritch *et al* (1982) and Osborne and Petitt (1985) demonstrated that one soap product was selective towards the natural enemies of greenhouse whitefly (*Trialeurodes vaporariorum*) and twospotted spider mite (*Tetranychus urticae*). Although the soap product that we tested appeared to be non-toxic and non-disruptive to steel-blue ladybirds, its efficacy against soft wax scale and any phytotoxic effects on citrus must be determined before it can be recommended.

Mineral oils are widely used against citrus scales in IPDM programmes because of their low residual toxicity to natural enemies (Anonymous 1984). Our results indicate that oils may not be completely harmless, and that longer term effects on predation need to be investigated. The spreader-sticker can be regarded as non-disruptive to the steel-blue ladybird.

Organophosphate insecticides such as diazinon, are highly toxic to natural enemies (Theiling and Croft 1988). These insecticides are likely to be highly disruptive to scale predation by ladybirds. In addition, organophosphates may interfere with parasites of scale and predatory mites. Diazinon and chlorpyrifos are currently recommended for control of scale in citrus export spray programmes. The organotin miticide, azocyclotin, appeared to be less toxic to ladybirds than diazinon. It did interfere with predation, however, and could have a disruptive influence on ladybirds.

Further work is needed on the longevity of any toxic or sublethal effects to natural enemies caused by fungicides and insecticides. In addition, the less disruptive insecticides need to be evaluated for their efficacy against soft wax scale, before recommendations can be made regarding the best pesticides for an IPDM programme.

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