Effect of abamectin on citrus rust mite *Phyllocoptruta oleivora* and brown citrus rust mite *Tegolophus australis* and the scale natural enemies *Aphytis lingnanensis* and *Chilocorus circumdatus* on oranges

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Summary

The miticide abamectin (combined with 0.2% petroleum oil) controlled the rust mites *Phyllocoptruta oleivora* (Ashmead) and *Tegolophus australis* Keifer at 0.0018, 0.0027 and 0.0045 g a.i. L^{-1} (10, 15 and 25 mL of 1.8% emulsifiable concentrate per 100L respectively) for 20 weeks in a trial conducted on late Valencia oranges at Nambour, Queensland during January–June 1997. There were no significant differences in mite mortality between rates or methods of application (airblast or hand-sprayed). Fenbutatin oxide was also effective but *P. oleivora* reinfested the airblast treatments after 16 weeks. Neither miticide affected abundance of larvae, pupae or adults of the predatory ladybird *Chilocorus circumdatus* Gylenhall. Abamectin, at all three rates caused significant mortality of adults of the scale parasitoid *Aphytis lingnanensis* Compere when they were exposed to freshly sprayed leaves for 24 hours. There was no significant residual effect one and two days after spraying. Fenbutatin oxide caused no mortality of *A. lingnanensis*.

Parasitoids which survived contact with fresh deposits of abamectin parasitized fewer oleander scale than those which were untreated or exposed to fenbutatin oxide. There was no significant residual effect on the percentage of scales parasitized by *A. lingnanensis* exposed one day after spraying.

Introduction

Citrus rust mite *Phyllocoptruta oleivora* (Ashmead) and brown citrus rust mite *Tegolophus australis* Keifer are the two most serious mite pests of citrus in Queensland and coastal New South Wales. *T. australis* also occurs to a lesser extent in citrus along the Murray River and in the Murrumbidgee Irrigation Area. *P. oleivora* is a cosmopolitan species, while *T. australis* is native to eastern Australia (Smith *et al.* 1997). Predatory phytoseiid mites (particularly *Euseius victoriensis* Womersley) are important in controlling the mites (Smith *et al.* 1997) but miticide applications, especially for *P. oleivora*, are often required. Fenbutatin oxide is currently the most-used miticide for this purpose but it is becoming less effective, particularly against *P. oleivora*. Other less effective miticides used include sulphur (which is also disruptive to phytoseiids and scale parasitoids) and dicofol and mancozeb (both disruptive to phytoseiids).

In this trial, abamectin (a mycelial extract of *Streptomyces avermitilis*) at three dosage rates was compared with fenbutatin oxide against *P. oleivora* and *T. australis*. Data was also collected on the effect of the treatments on the ladybird *Chilocorus circumdatus* Gylenhall, an important predator of citrus snow scale *Unaspis citri* (Comstock) and on *Aphytis lingnanensis* Compere, an important parasitoid of red scale *Aonidiella aurantii* Maskell.

Materials and methods

Miticide treatments applied are detailed in Table 1. Formulations of the miticides used were:

- fenbutatin oxide (Torque®) a 500 g L^{-1} emulsifiable concentrate and
- abamectin (Avid®) an 18 g L^{-1} emulsifiable concentrate.

Lovis petroleum oil was included in the abamectin treatments at 200 mL per 100 L. Fenbutatin oxide was applied at 40 mL per 100 L (0.16 g a.i. L^{-1} or 200 ppm), and abamectin at 10, 15 and 25 mL per 100 L (0.0018, 0.0027 and 0.0045 g a.i. L^{-1} or 1.8, 2.7 and 4.5 ppm). Methidathion (used only in laboratory tests on *A. lingnanensis*) was a 400 g L^{-1} emulsifiable concentrate used at 0.5 g a.i. L^{-1} or 500 ppm.

Mite trial

The trial design was a randomized block of 13 treatments with three replicates. The trees were 12 year old, 3 m high late Valencia oranges growing at the Maroochy Horticultural Research Station, (MHRS), Nambour. Each plot consisted of two trees. Treatments were applied on 9 January 1997 using a tractor driven airblast sprayer (delivering two volume rates of 10 L and 20 L per tree) or a hand-held spray pistol operated from the tractor pump at a pressure of 1000 kPa (20 L per tree).

Mite numbers were assessed on 8 January (pre-treatment), 16 January (1 week), 6 February (4 weeks), 6 March (8 weeks), 3 April (12 weeks), 1 May (16 weeks) and 2 June (20 weeks). Live mites (both species) were counted in one field of view of a ×10 hand lens (about 5 cm^2) on the inside and outside surfaces of each of 50 fruit in the pre-treatment count and 25 fruit in the post-treatment counts.

The fruit were randomly selected from the adjacent halves of each of the two-tree plots within the row to minimize the effect of spray-drift. Fruit were sampled from low and high positions on the tree and from inside and outside the canopy.

Chilocorus circumdatus

Assessments were made pre-treatment and 1 week and 12 weeks after treatment of the numbers of *C. circumdatus* preying on citrus snow scale on the trunk and limbs. The numbers of adults, pupae and larvae observed in a two minute search per tree were recorded and averaged between the two trees per plot.

Aphytis lingnanensis (mortality of adults)

Laboratory tests were conducted on *A. lingnanensis* with abamectin and fenbutatin oxide. Freshly emerged adults reared on oleander scale *Aspidiotus nerii* Bouche, cultured on butternut pumpkins, were used in these tests. The three rates of abamectin (used without oil), fenbutatin oxide, methidathion (a commonly used scalicide) and a control (water) were applied to small branches (with their leaves) with a hand-held atomizer to six 2 m high Washington navel oranges. The trees were exposed to the weather, but there was no rainfall during the experiment.

Parasitoids were subsequently exposed to the leaves at intervals after treatment in clear plastic tubes 8 cm long and 3 cm in diameter. These tubes (with holes either end) were connected to a central plastic conduit through which fresh air was continuously pumped to minimize any fumigant effects from the pesticides.

One randomly selected leaf (about 21 cm^2) was placed in each of the tubes together with 25–150 adult parasitoids. A 3 cm square piece of waxed grease-proof paper coated with very fine pure honey drops was added to each tube to provide nourishment for the wasps. Four replicates were conducted for each time interval.

The first parasitoids were exposed when leaves were still wet. Live and dead

Table 1. Effect of abamectin and fenbutatin oxide on the mean number of live *P. oleivora* per citrus fruit (5 cm²) MHRS January–June 1997.

Miticide	Rate[A] (mL 100 L⁻¹)	Applic. method	Spray volume (L per tree)	Weeks after spraying 0	1	4	8	12	16	20
abamectin	10	airblast	10	7.50 a	0.20 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 c
abamectin	15	airblast	10	5.40 a	0.27 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 c
abamectin	25	airblast	10	4.63 a	0.20 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 c
fenbutatin oxide	40	airblast	10	5.07 a	0.27 b	0.00 b	0.00 b	0.00 b	20.90 b	21.90 b
abamectin	10	airblast	20	5.07 a	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 c
abamectin	15	airblast	20	4.93 a	0.07 b	0.03 b	0.00 b	0.00 b	0.00 b	0.00 c
abamectin	25	airblast	20	6.67 a	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 c
fenbutatin oxide	40	airblast	20	7.26 a	0.27 b	0.00 b	0.00 b	0.00 b	6.33 b	1.20 c
abamectin	10	handspray	20	5.87 a	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 c
abamectin	15	handspray	20	6.80 a	0.30 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 c
abamectin	25	handspray	20	9.03 a	0.00 b	0.03 b	0.00 b	0.00 b	0.00 b	0.00 c
fenbutatin oxide	40	handspray	20	5.30 a	0.23 b	0.00 b	0.00 b	0.00 b	0.20 b	0.00 c
untreated				6.33 a	6.17 a	5.50 a	6.47 a	6.13 a	62.53 a	76.33 a
LSD (P=0.05)				7.85	2.13	2.67	0.86	0.62	30.34	18.03

[A] 200 mL of Lovis petroleum oil per 100 L added to each abamectin treatment.
Means within columns followed by different letters are significantly different.

Table 2. Effect of abamectin and fenbutatin oxide on the mean number of live *T. australis* per citrus fruit (5 cm²) MHRS January–June 1997.

Miticide	Rate[A] (mL 100 L⁻¹)	Applic. method	Spray volume (L per tree)	Weeks after spraying 0	1	4	8	12	16	20
abamectin	10	airblast	10	5.13 a	0.20 b	0.00 b	0.00 b	0.07 b	0.00 b	0.00 b
abamectin	15	airblast	10	4.37 a	0.17 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b
abamectin	25	airblast	10	7.10 a	0.40 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b
fenbutatin oxide	40	airblast	10	6.73 a	0.03 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b
abamectin	10	airblast	20	4.93 a	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b
abamectin	15	airblast	20	5.93 a	0.50 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b
abamectin	25	airblast	20	6.63 a	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b
fenbutatin oxide	40	airblast	20	8.30 a	0.27 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b
abamectin	10	handspray	20	6.50 a	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b
abamectin	15	handspray	20	9.80 a	0.50 b	0.10 b	0.00 b	0.07 b	0.00 b	0.00 b
abamectin	25	handspray	20	7.43 a	0.00 b	0.07 b	0.00 b	0.00 b	0.00 b	0.00 b
fenbutatin oxide	40	handspray	20	6.50 a	0.27 b	0.00 b	0.00 b	0.00 b	0.00 b	0.00 b
untreated				8.53 a	4.80 a	3.87 a	6.57 a	3.20 a	1.80 a	3.83 a
LSD (P=0.05)				6.28	1.64	0.24	0.74	0.45	0.58	0.82

[A] 200 mL of Lovis petroleum oil per 100 L added to each abamectin treatment.
Means within columns followed by different letters are significantly different.

parasitoids were counted after 24 hours. The tubes were then replaced and fresh leaves (spray deposit one day old) , wax paper and parasitoids added to them. Mortality was assessed after a further 24 hours. The procedure was repeated the following day when the spray deposit was two days old.

Aphytis lingnanensis (effect on parasitism of A. nerii)

A second set of trees was resprayed with the same three rates of abamectin, fenbutatin oxide and a control (water). Four freshly sprayed leaves from each treatment were placed in each of five separate well ventilated 500 mL plastic containers. Approximately 1000 *A. lingnanensis* adults were added to each container and a 5 cm square of grease-proof paper with fine honey droplets. After 24 hours exposure, live parasitoids were transferred to small cages covering sections of oleander scale on butternut pumpkins. The oleander scale was 45 days old and suitable for parasitism by *A. lingnanensis*. Each cage consisted of a small clear plastic 30 mL cup (4 cm diameter at top tapering to 2 cm at base and 4 cm high). The lidless cup was inverted and attached to the pumpkin using Blutac® and the gaps were sealed with melted paraffin wax. A fine gauze window was inserted into the base for ventilation and the perimeter cut to allow it to be folded back to allow introduction of the parasitoids. Twenty five parasitoids of each sex were placed in each cage together with a 2 cm square of grease-proof paper with honey droplets and the lid sealed with a small strip of tape. The cage treatments were replicated four times. Four butternut pumpkins were used with one replicate for each treatment on each pumpkin. The parasitoids were left in the cages for 48 hours and then removed.

Parasitism (percentage of scales with *A. lingnanensis* pupae present) was assessed two to three weeks after exposure. The number of unparasitized scales was also recorded.

This procedure was repeated exposing *A. lingnanensis* adults to leaves 24 hours after spraying.

Results

Results from the field and laboratory trials were subjected to ANOVA and are shown in Tables 1–5.

Mite trial

All of the miticide treatments reduced numbers of both species to a low level seven days after treatment and to zero in most cases within four weeks (Tables 1 and 2). The treatments were all significantly different from the control but not from each other until 20 weeks by which time the airblast-applied 10 L treatment of fenbutatin oxide was heavily reinfested with *P. oleivora*. All three rates of abamectin applied by airblast sprayer or by hand-pistol gave excellent control of both species for up to 20 weeks.

Chilocorus circumdatus

None of the treatments had a significant effect on the abundance of *C. circumdatus* at either 1 or 12 weeks after spraying (Table 3).

Aphytis lingnanensis

All three abamectin rates caused significant mortality when adult parasitoids were exposed to freshly-sprayed leaves (Table 4). There were no significant differences in survival between abamectin treatments and the controls when sprayed leaves were held for one or two days before presentation to parasitoids (Table 4).

Surviving *A. lingnanensis* females (exposed to fresh spray for one day) showed a significantly lower parasitism rate in oleander scale (Table 5) for all three abamectin rates compared to the control and fenbutatin oxide. This effect did not occur when parasitoids were exposed to one day- old spray residues.

Table 3. Effect of abamectin and fenbutatin oxide on the mean number of *C. circumdatus* (adults, larvae and pupae) recorded in two minutes per citrus tree at MHRS January–May 1997.

Miticide	Rate[A] (mL 100 L^{-1})	Applic. method	Spray volume (L per tree)	Weeks after spraying 0	1	12
abamectin	10	airblast	10	7.00 a	6.67 a	5.00 a
abamectin	15	airblast	10	3.67 bc	3.00 b	5.67 a
abamectin	25	airblast	10	4.33 abc	3.33 ab	9.33 a
fenbutatin oxide	40	airblast	10	5.33 abc	5.00 ab	5.67 a
abamectin	10	airblast	20	3.00 c	3.00 b	6.33 a
abamectin	15	airblast	20	5.33 abc	5.67 ab	9.00 a
abamectin	25	airblast	20	4.67 abc	4.00 ab	3.33 a
fenbutatin oxide	40	airblast	20	3.67 bc	3.67 ab	8.00 a
abamectin	10	handspray	20	6.67 ab	5.67 ab	8.33 a
abamectin	15	handspray	20	6.67 ab	6.67 a	6.67 a
abamectin	25	handspray	20	5.00 abc	5.00 ab	6.00 a
fenbutatin oxide	40	handspray	20	3.33 c	2.33 b	3.67 a
untreated				4.33 abc	4.00 ab	6.00 a
LSD (P=0.05)				3.17	3.46	9.84

[A] 200 mL of Lovis petroleum oil per 100 L added to each abamectin treatment.
Means within columns followed by different letters are significantly different.

Table 4. Effect of abamectin, fenbutatin oxide and methidathion on survival of adult *Aphytis lingnanensis* on freshly sprayed citrus foliage and on foliage held for one or two days after spraying.

	Rate (mL 100 L^{-1})	% live parasitoids freshly sprayed	after 1 day	after 2 days
abamectin	10	83.05 b	83.75 b	88.93 a
abamectin	15	58.48 c	91.43 ab	88.93 a
abamectin	25	39.43 d	86.58 ab	89.20 a
fenbutatin oxide	40	94.55 a	96.50 a	93.13 a
methidathion	125	0.00 e	0.00 c	0.00 b
untreated		95.65 a	91.65 ab	84.38 a
LSD (P=0.05)		7.03	11.67	9.96

Means within columns followed by different letters are significantly different.

Table 5. Effect of abamectin and fenbutatin oxide on parasitism of *Aspidiotus nerii* by *Aphytis lingnanensis*.

	Rate (mL 100 L^{-1})	Mean % parasitism freshly sprayed leaves	after 1 day
abamectin	10	18.35 b	41.32 a
abamectin	15	8.34 b	43.95 a
abamectin	25	6.23 b	42.98 a
fenbutatin oxide	40	37.58 a	46.00 a
untreated		35.00 a	43.39 a
LSD (P=0.05)		12.80	13.57

Means within columns followed by different letters are significantly different.

Discussion

Mite trial

Abamectin at 10, 15 and 25 mL 100 L^{-1} (combined with 0.2% petroleum oil – 200 mL 100 L^{-1}) controlled *P. oleivora* and *T. australis* on citrus for at least 20 weeks. Fenbutatin oxide was effective against *P. oleivora* for 16 weeks and *T. australis* for 20 weeks. Mite pressure from both species was similar at the commencement of the experiment.

The method of spray application (airblast and hand sprayed) and the volumes applied (10 and 20 L per tree) did not affect the abamectin treatments but fenbutatin oxide failed sooner with the lower volume air-blast application.

When *P. oleivora* is monitored commercially, the action level currently used in eastern Australia is 5–10% of fruit infested, varying with levels of the predatory mite *E. victoriensis*. (Smith *et al.* 1997). For *T. australis* the action level is higher – about 10% (and even more closely related to predatory mite numbers). In this trial, these action levels were exceeded for *P. oleivora* when the number of mites per 5 cm^2 sampling section exceeded four or five. Mean *P. oleivora* counts for the untreated trees, exceeded this level at pretreatment and in each of the six post-treatment assessments. Average mite counts of 62 and 75 in untreated trees in the last two assessments (Table 1) resulted in 100% infestation and severe rind damage. The fenbutatin oxide 10 L airblast treatment had an average 25% of fruit badly damaged after 20 weeks.

It was not possible to readily distinguish damage by the two species in this trial but it can be inferred that most damage was caused by *P. oleivora* as *T. australis* numbers remained fairly constant on the untreated trees, averaging 4.6 per 5 cm^2 (Table 2). *P. oleivora* increased rapidly on the untreated trees after 16 weeks to an average 62 per 5 cm^2 (Table 1).

The reason for *T. australis* numbers remaining so low is not clear. *P. oleivora* is more common in coastal areas and conditions may have made it more competitive than *T. australis*. Populations of five per cm^2 equate to about 10% fruit infestation and over 20 weeks this could have resulted in some rind damage. The predatory mite *E. victoriensis* did not occur in significant numbers in this trial block.

There was no significant effect of any of the miticides on the ladybird predator *C. circumdatus*. However, freshly sprayed abamectin (especially at the two higher rates) caused significant mortality and depressed reproduction of the parasitoid *A. lingnanensis*. These effects were short-lived though, with day-old spray residues not harmful.

Morse *et al.* (1987) showed that abamectin causes less than 4% mortality of the mealybug ladybird, *Cryptolaemus montrouzieri* Mulsant and about 5% mortality of *Aphytis melinus* DeBach at spraying. No tests were conducted on fecundity in these species.

The results of this study suggest that abamectin will be a useful miticide in integrated pest management in citrus in eastern Australia causing only low levels of disruption to important natural enemies such as *A. lingnanensis*.

Acknowledgments

This research was funded by Merck, Sharp and Dohme Pty. Limited. Assistance in testing *A. lingnanensis* in these trials was given by Aimi Anselme, a student of Burnside High School, Nambour.

References

Morse, J.G., Bellows, T.S., Gaston, L.K. and Iwata, I. (1987). Residual toxicity of acaricides to three beneficial species on California citrus. *Journal of Economic Entomology* 80, 953-60.

Smith, D., Beattie, G.A.C. and Broadley, R. (eds.) (1997). Citrus pests and their natural enemies. Integrated pest management in Australia. Horticultural Research and Development Corporation, Queensland Department of Primary Industries publication Q 197030, 272 pp.