Comparative efficacy of trunk treatments for control of Fuller's rose weevil, *Asynonychus cervinus* (Boheman) (Coleoptera: Curculionidae), on citrus

R.D. Magarey, K. Clarke, D.G. Madge and G.A. Buchanan, Sunraysia Horticultural Centre, Department of Agriculture, P.O. Box 905, Mildura, Victoria 3502, Australia.

Summary

A sticky polybutene barrier and three pyrethroid insecticides; lambdacyhalothrin, deltamethrin and bioresmethrin were tested as trunk bands in bioassays and field trials for control of Fuller's rose weevil (FRW), *Asynonychus cervinus* (Boheman) on citrus. The weevil lays its eggs underneath the calyx and is a quarantine pest for exports to Japan. The polybutene band was the most effective treatment in the bioassays and provided 100% exclusion of weevils. In the field trials on skirted Navel orange trees, lambdacyhalothrin was the most effective treatment. All treatments except for bioresmethrin significantly reduced the number of adults in citrus canopies, in relation to the control. However, only lambdacyhalothrin significantly reduced the number of FRW eggs underneath fruit calices. The polybutene band was less effective in the field trial. Prunings and weeds provided alternative pathways into the canopy for all treatments.

Introduction

Until 1987, Fuller's rose weevil (FRW) (also known as Fuller rose beetle *Asynonychus godmani* Crotch in the United States) was considered a minor pest of citrus. Larvae feeding on roots caused no economic damage and it was rarely necessary to apply a treatment for control of adults feeding on foliage. FRW lays its eggs in crevices, such as underneath the calyx of fruit, and therefore exported fruit may contain viable eggs of Fuller's rose weevil. The recent development of citrus exports to Japan has been impeded by the presence of eggs on fruit. Whenever viable egg masses are found by quarantine authorities, shipments are fumigated with methyl bromide which may result in peel damage and shorten shelf life, especially with lemons (Anon 1988). The expense of fumigation reduces profit margins which further reduces the viability of Japanese exports.

Reduction of FRW populations in the grove should reduce the proportion of infested fruit and minimize the requirement for fumigation. Foliar application of insecticides has largely been unsuccessful due to the problem of timing applications. Weevils prefer to feed on young leaves, therefore if a growth flush appears after insecticide application, the treatment is likely to be ineffective (Morse 1989).

A promising approach for control of the flightless FRW in the field is tree skirting, in combination with some form of trunk treatment. Sticky polybutene trunk bands are effective physical barriers but their application is labour intensive and they lose their effectiveness when covered with dust and other debris (Haney and Morse 1988). The presence of the band also may result in sunburn injury, fungal rots or other phytotoxic effects. Chemical barriers are much easier to apply but persistence is a major problem. Many of the common insecticides registered on citrus have been tested as trunk bands and of these, azinphos-methyl and carbaryl are the most successful, but neither has produced consistent results (Morse 1989).

Synthetic pyrethroids hold considerable potential for control of FRW. These compounds exhibit many desirable qualities including rain fastness, stability in sunlight and high toxicity to weevils (Guillebeau *et al.* 1989). Some of the compounds are also highly persistent, for instance Pajares and Lanier (1989) found that the pyrethroids cypermethrin and esfenverelate provided excellent control of elm bark beetles on treated twigs for 18 weeks after treatment.

In this study the synthetic pyrethroids lambdacyhalothrin, deltamethrin, and bioresmethrin were assessed for efficacy in controlling FRW in laboratory bioassays and field trials, and compared with polybutene bands. These three pyrethroids were selected from a range of pyrethroids and other insecticides tested during preliminary trials. This paper reports Victorian results from a coordinated program on control of FRW in southeast Australia.

Materials and methods

Laboratory bioassay

Simulated citrus trunks were prepared by cutting citrus limbs to a standard length of 400 mm and an average diameter of 70 mm. Seven treatments were applied to bands 100 mm wide on separate limbs. The treatments comprised three synthetic pyrethroid insecticides, each at two rates, viz: lambdacyhalothrin[a] (0.3% and 0.6% a.i.), deltamethrin[b] (0.03% and 0.06% a.i.) and bioresmethrin[c] (0.06% and 0.12% a.i.) and a polybutene[d] sticky band which was applied with a scraper. The insecticides were applied to run-off, approximately 50 ml per limb. The polybutene band was approximately 100 mm wide and 5 mm thick. Controls were left untreated. After the sprayed limbs had dried, groups of ten FRW which had been collected were allowed to crawl up each of the treated limbs and the control. They were then removed to ventilated storage jars containing untreated orange tree leaves which were renewed regularly. The surviving weevils were counted after 24 hours and then at 7, 14, 21 and 28 days. The treated limbs were stored in an upright position under an iron roof, to simulate the effects of dust and temperature on the treatments, but without any direct sun, precipitation or irrigation which could cause premature deterioration of the chemicals.

The treatments were replicated four times. Each replicate was assayed for beetle mortality by allowing fresh groups of weevils to crawl up the limbs at 0, 7, 14 and 28 days after the initial application, and survival assessed as above.

Field trial

A grove of Navel oranges (cv Lane's Late) located at Colignan, Victoria and heavily infested with FRW was chosen for the trial. This grove was planted as a double hedgerow (rows 1.4 m apart and double rows 5.4 m apart) and watered by drip irrigation. To prevent foliage from coming into contact with the ground, trees were skirted and weeds touching the canopies were removed. The trial contained eight replicates arranged in an 8 × 8 latin square design with plots of nine trees. Since canopies in the hedgerow touched weevils could crawl from one tree to another. To overcome this the four outer trees in the plot were used as buffers. Except for a higher rate of deltamethrin the same seven trunk treatments as used in the bioassay were applied at approximately 300 mm above the ground. Each tree was sprayed with 250 ml insecticide using a handline sprayer with four nozzles on a U shaped wand designed to encircle the trunk.

Three applications of insecticides were made; on 27 March, 8 May and 19 June 1990. The polybutene material was applied with a trowel on 27 March.

The population density of adults in citrus canopies was assessed by beating ten limbs per plot (two limbs on each of five trees) five times with a rubber mallet and counting the number of weevils collected in a 0.28 m^2 tray. After counting the tray was inverted to allow return of the weevils to the tree. The numbers of live egg masses

Footnote

[a] Karate EC insecticide. 50 g L^{-1} lambdacy-halothrin. ICI Australia, P.O. Box 4311, Melbourne, 3001.

[b] Cislin SC insecticide 10 g L^{-1} deltamethrin. Wellcome Australia, P.O. Box 12, Concord, NSW, 2137.

[c] BRM SC insecticide 50 g L^{-1} bioresmethrin. Wellcome Australia, P.O. Box 12, Concord, NSW, 2137.

[d] Tac-gel Formula 3 polybutene. Rentokil Pty Ltd, 554 Pacific Highway, Chatswood, NSW, 2067

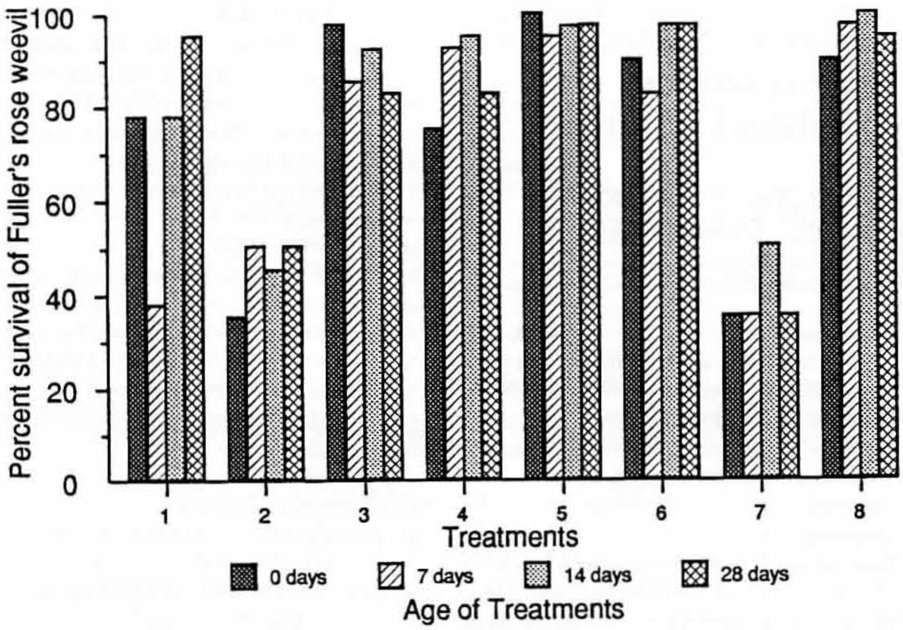

Figure 1. The effectiveness of various limb treatments on survival of FRW adults at 0, 7, 14 or 28 days after application of the treatments in laboratory trials. Survival shown is after beetles were held for 21 days. Treatments were; 1 – lambdacyhalothrin 0.3% a.i., 2 – lambdacyhalothrin 0.6% a.i., 3 – deltamethrin 0.03% a.i., 4 – deltamethrin 0.06% a.i., 5 – bioresmethrin 0.06% a.i., 6 – bioresmethrin 0.12% a.i., 7 – polybutene, 8 – control.

underneath calices was determined by microscopic examination of ten fruits per plot. Numbers of adults and live egg masses were assessed on the following dates: 1 May, 5 June, and the 16 and 17 July 1990. Data were analysed by regression analysis based on a Poisson distribution. Treatments were compared by uncertainty intervals; disjoint intervals indicating significant differences at the $P = 0.05$ level (Andrews *et al.* 1980).

Results

Laboratory bioassay

The limbs held underneath the iron roof became covered in dust during the course of the experiment. Results for the bioassay were summarized as the survival rate at 21 days after exposure to the treatments (Figure 1). The polybutene band and lambdacyhalothrin (0.6% a.i.) were the most effective and consistent treatments with an average mortality rate of 61% and 55% respectively by Day 21. No weevils succeeded in crossing the polybutene barrier and most dropped to the ground after even the smallest contact with the material. Significant contact with the material usually proved lethal. Lambdacyhalothrin (0.3% a.i.) and deltamethrin (0.06% a.i.) were the next most effective treatments causing 28% and 14% mortality respectively. There is no explanation for the seven day drop in survivorship due to the former treatment. Deltamethrin (0.03% a.i.) and bioresmethrin (0.06 and 0.12% a.i.) had virtually no effect on weevil mortality. For the effective treatments, there was no trend towards decreasing efficacy with time.

Field Trial

Numbers of adults in citrus canopies. The numbers of weevils in the citrus canopies fell from a mean of 24.8 prior to treatment and also significantly during the course of the experiment (Table 2). There was also a highly significant ($P < 0.001$) treatment effect, but no significant treatment by time interaction. As a result an estimated treatment mean provides an adequate statistical summary of the data (Table 2). Lambdacyhalothrin at 0.03% and 0.06% a.i. were the most effective treatments and reduced weevil populations by 91% and 93% respectively compared to the control (Table 2). Polybutene bands decreased weevil numbers by 75%, whilst deltamethrin at 0.6% and 0.12% a.i. were the next most effective treatments, both reducing the weevil population by 70% compared to the control. Weevil numbers in both of the bioresmethrin treatments were not significantly different from the control. There was a highly significant ($p < 0.001$) row and column (across the rows) effect. This indicates the experimental design had accounted for some of the extraneous pre-treatment variation and improved the sensitivity of treatment comparisons.

Viable egg masses. There was a highly significant ($P < 0.001$) reduction in the number of viable egg masses over the three measurement periods (Table 3). The treatment factor was also significant at $P < 0.001$, but there was no interaction between treatment and time. Only lambdacyhalothrin at 0.3% and 0.06% a.i. significantly reduced the numbers of viable egg masses laid underneath the calices (Table 4), with the reduction being 70% and 75% respectively, although the two rates were not significantly different. Rows ($P < 0.05$) and columns ($P < 0.01$) were also statistically significant.

Discussion

FRW populations in orange tree canopies in Sunraysia peak during April/May and decline to very low levels during November (Madge *et al.* 1991). The number of adults emerging from the soil and climbing trunks is likely to be greatest from January to May. In order to reduce weevil populations it is necessary to apply trunk treatments prior to and during this period. Trunk treatments when combined with tree skirting have the potential to reduce weevil populations significantly.

Lambdacyhalothrin was the best treatment, reducing weevil populations by over 90% compared to the control in the field trial. Polybutene bands were very effective in the bioassays, but were not as effective as lambdacyhalothrin in the field trial. In the bioassays weevils tend to crawl over one another transferring polybutene between weevils (Morse, personal communication). In the field the weevils can detect the band before becoming trapped. This enables them to search for alternative paths into the canopy. James (1991) also found polybutene trunkbands to be effective treatments. Watershoots, prunings and weeds must be continually removed otherwise they act as bridges into the canopy. The potential of banding treatments for control of FRW is reduced by the problems associated with expense of application and possible phytotoxicity.

Table 1. Regression analysis of number of FRW adults in citrus canopies.

Source	df	deviance	mean deviance	mean deviance ratio
Rows	7	134.9	19.3	7.50***
Columns	7	97.6	13.9	5.42***
Time	2	96.4	48.2	18.75***
Treatment	7	479.0	68.4	25.62***
Treatment × Time	14	50.1	3.6	1.39 ns
Residual	154	395.8	2.6	–
Total	191	1253.8	6.6	–

ns not significant *** significant at P=0.001.

The reduction in the number of viable egg masses was not as great as the reduction in adult numbers in the canopy. There are two likely explanations. The first is that a large proportion of eggs were laid by adults which had crawled into the canopy prior to trunk treatment. Another possible reason is that the crevice underneath the calyx is a preferred ovipositional site, and thus there may not be a linear correlation between the number of egg masses beneath the calyx and adult population density.

Lambdacyhalothrin was the most effective treatment and further work should be carried out to examine its effectiveness for control of FRW. In particular, it is likely that a lower rate may provide effective control since 0.6% a.i. was only marginally more effective than 0.3% a.i.. One factor that is likely to reduce the efficacy of pyrethroid insecticides is rainfall, especially within two days of application (Guillebeau *et al.* 1989). In this trial 4–6 mm of rain fell within 48 hours of applying both the first and the second spray. This may have contributed to the ineffectiveness of deltamethrin and bioresmethrin, but it also demonstrates that lambdacyhalothrin is rainfast.

Due to the seasonal decline in weevil numbers it was not possible to determine the persistence of lambdacyhalothrin in the field trial, but based on the bioassay it is at least four weeks. Field data on lambdacyhalothrin's persistence, when combined with work to determine optimal rates for use, should lead to its registration as a trunk treatment for reducing populations of FRW in the grove and assist growers and packers overcome the export quarantine problem.

Table 2. Effect of seven insecticidal treatments on the number of FRW adults in citrus canopies. Number of weevils collected in a 0.28 m² tray, at three sampling dates (1st May, 5th June and 16th July).

Treatment	Rate (%a.i.)	Mean Weevil Counts[A]			Estimate[B] Φ	0.05 Uncertainty Interval[C]	
		May	June	July		Lower	Upper
lambdacyhalothrin	0.30	1.00	0.88	0.13	0.67	0.31	1.37
lambdacyhalothrin	0.60	0.88	0.50	0.14	0.50	0.22	1.13
deltamethrin	0.06	4.00	2.50	0.25	2.25	1.39	4.19
deltamethrin	0.12	4.50	1.62	0.75	2.29	1.36	4.09
bioresmethrin	0.06	13.78	8.33	6.11	9.41	5.93	15.70
bioresmethrin	0.12	5.86	4.14	2.14	4.05	2.04	5.98
polybutene	–	3.25	0.88	0.13	1.42	0.87	2.85
Control	–	9.00	6.87	7.00	7.62	4.34	11.61
Mean	–	5.41	3.28	2.14	–	–	–

A – Arithmetic treatment means. B – Log regression estimate.
C – Disjoint intervals indicating significant differences at P = 0.05.
Interval = $\Phi \pm (t/\sqrt{2}) \times SE(\Phi)$

Table 3. Regression analysis for the number of viable egg masses of FRW beneath calices of oranges.

Source	df	deviance	mean deviance	mean deviance ratio
Rows	7	20.3	2.9	1.63*
Columns	7	38.8	5.5	3.13**
Time	2	50.8	25.4	14.35***
Treatment	7	68.2	9.7	5.51***
Treatment×Time	14	23.6	1.7	0.95ns
Residual	154	272.4	1.8	
Total	191	474.0	2.5	

ns not significant * significant at P=0.05.
** significant at P=0.01. *** significant at P=0.001.

Table 4. Effect of seven insecticidal treatments on the number of viable egg masses of FRW underneath fruit calices. Number of egg masses per ten fruit, at three sampling dates (1st May, 5th June and 16th July).

Treatment	Rate (% a.i.)	Mean Weevil Counts[A]			Estimate[B] Φ	0.05 Uncertainty Interval[C]	
		May	June	July		Lower	Upper
lambdacyhalothrin	0.30	1.75	0.75	1.25	1.23	0.73	2.06
lambdacyhalothrin	0.60	1.87	0.75	0.38	1.01	0.59	1.75
deltamethrin	0.06	3.87-	1.00	1.50	2.15	1.34	3.44
deltamethrin	0.12	2.88	1.75	1.13	1.92	1.20	3.08
bioresmethrin	0.06	4.37	1.62	2.37	2.80	1.81	4.33
bioresmethrin	0.12	2.75	2.37	2.50	2.49	1.58	3.92
polybutene	–	5.00	1.87	1.12	2.72	1.75	4.24
Control	–	5.00	4.00	3.37	4.07	2.70	6.15
Mean	–	3.44	1.77	1.70	–	–	–

A – Arithmetic treatment means. B – Log regression estimate.
C – Disjoint intervals indicating significant differences at P = 0.05.
Interval = $\Phi \pm (t/\sqrt{2}) \times SE(\Phi)$

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