Research report

Evaluation of 10 insecticides against pink ground pearl *Eumargarodes laingi* Jakubski (Hemiptera: Margarodidae)

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Summary

Bioassays of alpha-cypermethrin at 0.01 g L^{-1} killed adult female of *Eumargarodes laingi*. Cadusafos was active at 1 g L^{-1}, and malathion and tefluthrin were active at 10 g L^{-1}. Variable results were obtained with thiodicarb; active at 0.01 and 10 g L^{-1}, but not at 0.1 or 1 g L^{-1}. Chlorpyrifos, fipronil, methidathion, carbofuran and bifenthrin were not active at 10 g L^{-1}. A field trial of alpha-cypermethrin did not lower subsequent cyst populations significantly.

Introduction

Pink ground pearls, *Eumargarodes laingi* Jakubski, are the most damaging of the four margarodids known to feed on the roots of sugarcane in Queensland (Dominiak *et al.* 1989). The species is known from a wide range of soil-texture types in the Bundaberg and Isis areas but is particularly prevalent on the red volcanic clays and silty clays east of Bundaberg. Adult females of *E. laingi* emerge over an extended period from September through February, with the main emergence in October–December. Eggs are laid in groups near the soil surface. First instars move through the soil until they commence feeding on a root and become sessile. A test is then secreted to cover most of the body except the feeding tube, legs and antennae. The second and final nymphal instar has a long feeding tube, reduced antennae and no legs; it remains encysted until it moults to an adult. *E. laingi* has a one year life cycle and no males are known.

Insecticides have failed to control nymphs or adults of *E. laingi* (Dominiak *et al.* 1989, 1992). Present control is dependant on the use of tolerant cultivars and other cultural methods (Dominiak *et al.* 1989; Walker and Allsopp 1993). However, an effective insecticide would give growers an additional option. Here we use a bioassay technique that allows the rapid screening of potential insecticides. The most promising material was then evaluated in the field.

Materials and methods

Laboratory bioassay

Adult *E. laingi* were collected from the soil surface in sugarcane fields and were held in containers of soil at 25°C until treated later that day.

Insects were treated with four organophosphates, two carbamates, three pyrethroids and one pyrazole (Table 1). Concentrations of 0.01, 0.1, 1 and 10 g active ingredient per litre of water were prepared except fipronil, where only 1 and 10 g L^{-1} were used. Three groups of 20 insects each were tested with each concentration of insecticide.

Table 1. Products used in the laboratory bioassay.

Active ingredient	Product	Formulation
Cadusafos	Rugby	250 g L^{-1} EC
Chlorpyrifos	Lorsban	500 g L^{-1} EC
Fipronil	Reagent	200 g L^{-1} flowable
Malathion	Malathion	500 g L^{-1} EC
Methidathion	Supracide	400 g L^{-1} EC
Carbofuran	Diafuran	350 g L^{-1} flowable
Thiodicarb	Larvin	375 g L^{-1} flowable
Alpha-cypermethrin	Fastac	250 g L^{-1} EC
Bifenthrin	Talstar	100 g L^{-1} EC
Tefluthrin	Force	50 g L^{-1} EC

Prior to testing, adults of *E. laingi* were tapped onto moist filter paper in a Petri dish. An 'Air Brush' air brush gun was then used to apply the insecticide solutions. The gun handle was held in a laboratory stand with the spray directed downwards. The gun was started giving a constant spray delivery with the spray tip 15 cm above the Petri dish path. The Petri dish was moved horizontally across into the spray path and held there for one second. The Petri dish was then covered with a lid and held at 30°C in a growth cabinet. Spraying took place over 4 days. One set of water-only controls was established each day. Live and dead insects were counted under a microscope 2 and 7 days after insecticide application. Insects were considered dead if they failed to respond when prodded.

Data were analysed by comparing in 2 × 2 contingency tables the actual treatment mortalities with the mortality for that day's control. Actual mortalities were corrected for control mortality using Abbott's formula (Abbott 1925).

Field trial

Alpha-cypermethrin identified in the bioassay as apparently having control potential. It was tested in a field trial near Bundaberg in a field of ratoon sugarcane infested with *E. laingi*. Although no direct comparisons could be drawn from the bioassay, three insecticide treatments were chosen based on the likely commercial costs of application which growers would be prepared to pay under the current industry economic climate.

Four treatments were applied: 0, 250, 500 and 1000 mL of Fastac per hectare diluted in water sprayed onto the soil surface. Treatments were applied between 10 am and 12 noon on 22 October 1991 to coincide with emergence of adult females. Each plot was four rows wide and 10 m long (60 m^2). The treatments were arranged in a randomized complete-block design; each of the three blocks comprised one plot of the water-only control and 2 plots of each alpha-cypermethrin treatment.

Resultant cyst numbers were determined on 5 September 1992 by taking five 3 kg samples from within the cane row of each plot. Each sample was washed through a 1.0 mm sieve and the cysts counted. Data were analysed by ANOVA following transformation by ln(x) to stabilize the variances.

Results

Laboratory bioassay

None of the insecticides caused significant mortality of *E. laingi* at 2 days after application.

After 7 days, the organophosphates chlorpyrifos and methidathion and the pyrazole fipronil caused no significant mortality (Table 2). Malathion was significantly active at 10 g L^{-1}, but not at lower concentrations. Cadusafos caused significant mortality only at 1 and 10 g L^{-1}.

Of the carbamates, carbofuran caused no significant mortality at any concentration. Thiodicarb was significantly active at 0.01 and 10 g L^{-1}, but caused no significant mortality at 0.1 or 1 g L^{-1}.

Table 2. Corrected mortalities (%) of adult *E. laingi* after 2 and 7 days.

Insecticide	Concentration (g L^{-1})	After 2 days (corrected)	After 7 days (corrected)
Cadusafos	0.01	8.9	0.0
	0.1	1.7	0.0
	1	10.6	72.9**
	10	0.0	51.6*
Chlorpyrifos	0.01	0.0	0.0
	0.1	0.0	0.0
	1	0.2	3.3
	10	0.0	0.0
Fipronil	1	0.0	0.0
	10	0.0	0.0
Malathion	0.01	0.0	0.0
	0.1	0.0	20.0
	1	0.0	30.0
	10	0.0	87.5**
Methidathion	0.01	0.0	0.0
	0.1	0.0	0.0
	1	0.0	0.0
	10	0.0	12.5
Carbofuran	0.01	0.0	12.9
	0.1	0.0	0.0
	1	0.0	15.0
	10	0.0	0.0
Thiodicarb	0.01	6.9	55.0*
	0.1	0.0	10.0
	1	1.8	26.3
	10	0.0	92.2**
Alpha-cypermethrin	0.01	1.6	58.2*
	0.1	1.6	65.6**
	1	0.0	55.7*
	10	0.0	65.0**
Bifenthrin	0.01	0.0	5.6
	0.1	0.0	11.9
	1	0.0	0.0
	10	0.0	0.0
Tefluthrin	0.01	0.0	7.5
	0.1	1.7	0.0
	1	0.0	0.0
	10	1.7	77.5**

* Significantly different from control at the 5% level.
** Significantly different from control at the 1% level.
Analysis was conducted on raw data before correction.

Table 3. Number of *E. Laingi* cysts found in plots in September 1992 resulting from the field trial evaluating alpha-cypermethrin.

Treatment	Mean number of cysts per 5 samples
Control	551
Alpha-cypermethrin at 62.5 g a.i. ha^{-1}	285
Alpha-cypermethrin at 125 g a.i. ha^{-1}	376
Alpha-cypermethrin at 250 g a.i. ha^{-1}	269

There was no significant difference between plots.

Of the pyrethroids, alpha-cypermethrin caused significant mortality at all concentrations tested with no significant differences between concentrations. Bifenthrin was not active at any concentration and tefluthrin significantly reduced numbers at 10 g L^{-1} only.

Field trial

There was a trend to lower cyst numbers in insecticide-treated plots (F=1.7, df=3,15, P=0.21) with no apparent difference between concentrations (mean cysts per sample (SE): 0 mL ha^{-1}, 110.1 (25.8); 250 mL ha^{-1}, 57.0 (7.8); 500 mL ha^{-1}, 75.1 (11.7); 1000 mL ha^{-1}, 53.8 (8.5)) (Table 3.).

Discussion

Of the five organophosphates, only cadusafos and malathion showed any appreciable effect against *E. laingi*. Cadusafos showed good activity at 1 g L^{-1} and was the most active organophosphate; it may be worth testing in field trials.

Malathion was effective only at 10 g L^{-1} and has had variable results in field trials. In sugarcane Arnold (1964) found that 16.8 kg product per hectare (product concentration not specified) reduced *E. laingi* populations but did not prove useful in the long term. Wilson (1966) and Dominiak *et al.* (1992) failed to control populations with up to 15 kg active ingredient per hectare. However, in turf grass soil drenches of as low as 4 kg active ingredient per hectare significantly lowered populations of *E. laingi* (Spink and Dogger 1961) and malathion was recommended for the control of ground pearls in Australian turf (Ford 1983).

Chlorpyrifos was consistently ineffective however Goodyer (personal communication) has found variable results with it against *E. laingi* in turf. In contrast, Hou *et al.* (1986) reported considerable success with chlorpyrifos against the Chinese ground pearl *Neomargarodes niger* Green.

Of the two carbamates, carbofuran was ineffective; this parallels other failures on ground pearls overseas (Anon. 1985, de Klerk 1987, Gonzalez *et al.* 1969, Hou *et al.* 1986). Thiodicarb gave variable results and should be retested.

Of the pyrethroids, bifenthrin was ineffective and tefluthrin was effective only at 10 g L^{-1}. Alpha-cypermethrin was the most active compound tested, giving about 60% mortality in the bioassay with no effect of increasing concentration. In the field trial, there was a trend to reduced cyst numbers in the insecticide-treated plots resulting in an average mortality of about 46% over the three treatments. This level of control is deemed unacceptable given the high reproductive rate of the pest. No further field trials were conducted with alpha-cypermethrin as higher use rates would have been prohibitively expensive for growers.

The poor level of control in the field may be related to the wide spread of adult emergence times compared with the residual life of the insecticide and to the non surfacing of adults emanating from cysts deep in the soil. These problems are commonly reported by margarodid researchers evaluating insecticide control measures.

It was expected that the pyrethoids would be considerably more effective than other insecticide groups at the same rates. Elliott (1989) reported that where organochlorine, organophosphate and carbamate insecticides were effective at 1 kg ha^{-1} in the field, the pyrethroids were effective at 200 g ha^{-1} with some being effective at 5 g ha^{-1}.

Jakubski (1950) first noted the presence of wax glands in *Eumargarodes* in the description of the new species. Foldi (1981) noted that the wax glands in each developmental stage play an important part in protecting the entire insect and its offspring. All pyrethroids are lipophilic compounds (Elliott 1989) further adding to the expectation that this group would preform better than other insecticide groups.

Elliott (1989) reported that pyrethroids such as alpha-cypermethrin containing the alpha-cyano functional group were three times more active than other cyclopropane pyrethroids such as bifenthrin and tefluthrin which lack this moiety. This appears to be reflected in the laboratory results. The poor performance of alpha-cypermethrin in the field trial may have been due to it becoming strongly absorbed onto the soil particles or its repellent action to the mobile stage.

Tefluthrin has a higher vapour pressure than most pyrethroids (Elliott 1989) and is regarded as being an effective soil pyrethroid. Possibly the laboratory conditions did not allow the fumigant action to be effective except at the highest rate. This pyrethroid should be further evaluated in the field.

From the present and past work (Dominiak *et al.* 1989, 1992) control of *E. laingi* with insecticides targeted at either the adult or the cyst remains commercially ineffective. Cultural controls combined with cultivars showing tolerance or antibiosis appear to offer more potential.

References

Abbott, W.S. (1925). A method for computing the effectiveness of an insecticide. *Journal of Economic Entomology* 18, 265-7.

Anon. (1985). Zimbabwe Sugar Association, Experiment Station. Report for 1984 and 1985, pp. 71-5.

Arnold, P.G. (1964). Minutes and Proceedings of the Cane Pest and Disease Control Board Conference, pp. 45-6. (Bureau of Sugar Experiment Stations, Brisbane).

de Klerk, C.A. (1987). Chemical control of *Margarodes prieskaensis* (Jakubski) (Coccoidea: Margarodidae) on grapevines. *South African Journal of Enology and Viticulture* 8, 11-15.

Dominiak, B.C., Allsopp, P.G. and Corrie, K.D. (1989). The pink ground pearl *Eumargarodes laingi* Jakubski: past, present and future. Proceedings of the Australian Society of Sugar Cane Technologists 11, 110-5.

Dominiak, B.C., McGill, N.G. and Allsopp, P.G. (1992). Pink ground pearl *Eumargarodes laingi*: recent research on insecticides and cultivar resistance. Proceedings of the Australian Society of Sugar Cane Technologists 14, 76-83.

Elliott, M. (1989). The pyrethroids: early discovery, recent advances and the future. *Pesticide Science* 27, 337-51.

Ford, P. (1983). Ground pearls and mealy bugs in turf. Proceedings of the Turfgrass Management Seminar. (Australian Turfgrass Research Institute, Sydney).

Foldi, I. (1981). Ultrastructure of the wax-gland system in subterranean scale insects (Homoptera, Coccoidea, Margarodidae). *Journal of Morphology* 168, 159-70.

Gonzalez, R.H., Kido, H., Marin, A. and Hughes, P. (1969). Biologia y ensayos preliminares de control del margarodes de la vid, *Margarodes vitis* (Philippi). *Agricultura Technica* 29, 93-122.

Hou, Z.D., Sun, Y.F., Zhang, Y., He, Z.X., Feng, Z.G., Wang, M.Q., Zhang, Q.C. and Wang, X.F. (1986). A study on the biology and control of *Neomargarodes niger* Green. *Plant Protection* 12, 2-4.

Jakubski, A. (1950). The first margarodine coccid from Australia. *Annals and Magazine of Natural History*, Series 12(3), 397-413.

Spink, W.T. and Dogger, J.R. (1961). Chemical control of the ground pearl, *Eumargarodes laingi*. *Journal of Economic Entomology* 54, 423-4.

Walker, P.W. and Allsopp, P.G. (1993). Factors influencing populations of *Eumargarodes laingi* and *Promargarodes* spp. (Hemiptera: Margarodidae) in Australian sugarcane. *Environmental Entomology* 22, 362-7.

Wilson, G. (1966). In Annual Report, Bureau of Sugar Experiment Stations, pp. 50-1. (Bureau of Sugar Experiment Stations, Brisbane).