Efficacy of Vapam (metam-sodium) against pink ground pearl, *Eumargarodes laingi* Jakubski (Hemiptera: Margarodidae), in sugarcane

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Summary

The liquid soil fumigant Vapam (metam-sodium) was investigated for control of pink ground pearl, *Eumargarodes laingi*, in sugarcane. Vapam drenched into pots at the equivalent of 125 L ha^{-1} killed almost all cysts of pink ground pearl. In field trials, Vapam injected into soil at 250–500 L ha^{-1} before planting consistently reduced pearl numbers in the first year after application on two soil types. Control of up to 85% was achieved in a sandy soil. In red volcanic clay (the more usual habitat), population reductions of 50–70% were achieved. Treated populations of pink ground pearl recovered within two years post-treatment in ratoon crops, so Vapam alone will not provide long-term control using current application methods. However, it may be useful in combination with resistant sugarcane varieties that maintain populations at low levels.

Introduction

Pink ground pearls, *Eumargarodes laingi* Jakubski, are pests of sugarcane in the Bundaberg district, primarily on red volcanic clays but also on some other soil types (Dominiak *et al.* 1989, Walker and Allsopp 1993). The encysted nymphs ('pearls') live in the soil and suck juice from cane roots, reducing crop yield. Control relies on cultural methods and choice of sugarcane varieties (Allsopp and McGill 1996). There is no insecticide available to reduce high populations, but some past success has been achieved with the soil fumigants ethylene dibromide (Wilson 1969) and methyl bromide (Dominiak *et al.* 1989), applied over the whole field before planting. The liquid soil fumigant Vapam (metam-sodium) can be used in fields as a pre-planting treatment for control of weeds, pathogens and pests. The active agent is methyl isothiocyanate (MIT), which is produced from Vapam on contact with soil. This paper summarizes the results of pot and field trials of Vapam as a control method for pink ground pearl.

Materials and methods

Pot experiment

The potential efficacy of Vapam against pink ground pearl was tested in 21 cm diameter plastic pots containing red volcanic clay to a depth of 12 cm. Each pot was seeded with 100 cysts of pink ground pearl, diameter >1.7 mm, which were placed in a layer 6 cm below the soil surface. Pots were then treated with one of five different amounts of Vapam, 0 , 0.43 , 0.87 , 1.73 or 3.46 mL. Treatments were drenched into each pot in 900 mL of water. The soil was then covered with 5 cm of untreated soil and sealed with another 250 mL of water. Pink ground pearls were recovered by wet-sieving after 20 d, and numbers live and dead were assessed. Ground pearls were considered alive if able to produce wax filaments after 7 d on moist filter paper in petri dishes. Treatments were replicated three times, and a correction for control mortality was applied using Abbott's formula (Abbott 1925).

Field trials: general methods

Trials were carried out near Bundaberg. Vapam was applied after fields had been cultivated for planting, by injecting the diluted chemical into soil at a depth of about 200 mm using winged tines that housed horizontal spray tubes with outlet holes about 60 mm apart. Different application rates were achieved by varying tractor speed. Application was followed by a power harrow or rotary hoe in clay soil to produce a fine surface tilth, a roller to pack the soil surface, and overhead irrigation the same day. Plot size was five cane rows (spacing 1.5 m) by 20 m in all trials.

Pink ground pearls were subsequently counted in soil samples; these comprised two volumes of soil each 1370 cm^3 collected by spade beside one cane plant in each of the central three rows of each plot and at least 3 m in from either end. Pink ground pearls were wet-sieved from soil and collected on a 0.6 mm mesh screen.

Crop yield was measured over the whole length of the central three rows of each plot. Either cane was harvested by commercial harvester and collected in a weighing bin, or millable stalks were counted and a 60-stalk sample was cut by hand and weighed from each plot. Levels of ccs (commercial cane sugar) were measured in juice extracted by a small mill from a 6-stalk sample from each plot.

Treatment means were compared by the least significant difference test when analysis of variance indicated a significant treatment effect (P = 0.05). Numbers of ground pearls were transformed as log (x + 1) to stabilize the variance before analysis.

Field trial: red volcanic clay

One field trial was established in a red volcanic clay. Two application rates of Vapam, 250 and 500 L ha^{-1} (plus untreated controls), were applied to five replicate plots. Treatments were applied in August and cane was replanted in September 1993. Pink ground pearls were then sampled in each year of 1993–1995. Yield of the plant crop of sugarcane was measured in October 1994.

Field trials: irrigation after Vapam application

Three trials were established in a single canefield with red volcanic clay in February 1994. Vapam was applied at rates of 194–360 L ha^{-1} (Table 2). Eight treated plots were paired with eight untreated plots within each trial. Trials then received either a heavy irrigation (average 86 mm), a light irrigation (29 mm), or two light irrigations (36 + 46 mm) three days apart. Numbers of pink ground pearls were subsequently counted in July 1994.

Field trials: sandy soil

Two trials were carried out in adjacent fields in a sandy soil (sand to sandy loam). Vapam was applied at 250 and 500 L ha^{-1} (plus untreated controls) to six replicate plots. Each trial was treated at a different time, one in November 1994 and the second in February 1995. Cane was planted in autumn 1995, and numbers of pink ground pearls were counted in July in each year of 1995–1997. Plant cane yield was measured in the first trial in November 1996.

Results

Pot experiment

Mortality of pink ground pearls at concentrations equivalent to 125, 250, 500 and 1000 L ha^{-1} was 99.2, 99.7, 99.7, and 98.9%, respectively, after correction for mortality of 11.6% in untreated soil.

Field trial: red volcanic clay

Vapam at 250 and 500 L ha^{-1} significantly reduced numbers of pink ground pearl in 1993 by 67 and 72%, respectively (Table 1). Numbers in the two rates could not be separated statistically. There was no significant difference between treatments in the number of pearls in 1994 or 1995 (Table 1). Neither cane nor sugar yield was affected by Vapam treatment in the plant crop (Table 1).

Field trial: irrigation after Vapam application

Vapam significantly reduced numbers of pink ground pearls in each of three trials in red volcanic clay (Table 2). The number of pink ground pearls was lower in the treated than the untreated plot in all but one of 24 paired plots over the three trials. The reduction in numbers was very similar in each trial, regardless of differences in irrigation after application (Table 2).

Field trials: sandy soil

Vapam significantly reduced the number of pink ground pearls in the first year of the plant crop in sandy soil, by up to 85%, when applied in either November or February (Table 3). Numbers differed significantly between treatments in the second year in the February trial only, and in the third year did not differ in either trial. Vapam caused a massive increase in yield of the plant crop in 1996 in the first trial, doubling cane tonnage and more than doubling production of sugar (Table 3).

Table 1. Effect of Vapam on numbers of pink ground pearls, and on plant crop yield, in a red volcanic clay.

Samples and dates	0 L ha^{-1}	250 L ha^{-1}	500 L ha^{-1}	P
Pearls/3 samples				
November 1993	544 a	177 b	151 b	<0.001
(Reduction)		(67%)	(72%)	
July 1994	222 a	115 a	137 a	0.054
December 1995	126 a	131 a	64 a	0.14
Harvest 1994				
Tonnes cane ha^{-1}	103 a	106 a	111 a	0.31
Tonnes sugar ha^{-1}	15.1 a	15.6 a	16.6 a	0.35

Means in rows followed by the same letter not significantly different by least significant difference test (P=0.05).

Table 2. Effect of Vapam on number of pink ground pearls with different amounts of irrigation after treatment.

Samples	Heavy water		Light water		Light water × 2	
	0	296 L ha^{-1}	0	194 L ha^{-1}	0	360 L ha^{-1}
Pearls/3 samples						
1994	345	153 **	269	117 **	325	135 *
(Reduction)		(56%)		(56%)		(59%)

* P<0.05, ** P<0.01.

Table 3. Effect of Vapam applied in November 1994 or February 1995 on numbers of pink ground pearls, and on plant crop yield, in a sandy soil.

Treatment month	Samples and years	0 L ha^{-1}	250 L ha^{-1}	500 L ha^{-1}	P
November	**Pearls/3 samples**				
	1995	87 a	26 b	14 b	0.037
	(Reduction)		(70%)	(84%)	
	1996	289 a	123 a	89 a	0.15
	1997	569 a	711 a	429 a	0.42
	Harvest 1996				
	Tonnes cane ha^{-1}	52 b	88 a	105 a	0.002
	Tonnes sugar ha^{-1}	7.8 b	14.4 a	17.4 a	0.002
February	**Pearls/3 samples**				
	1995	253 a	79 b	37 b	0.001
	(Reduction)		(69%)	(85%)	
	1996	405 a	169 b	143 b	<0.001
	(Reduction)		(58%)	(65%)	
	1997	749 a	700 a	675 a	0.73

Means in rows followed by the same letter not significantly different by least significant difference test (P=0.05).

Discussion

Vapam has the potential to kill a large proportion of pink ground pearls if applied evenly through the soil, as in our pot experiment. However, equivalent control was not achieved in field trials, even at high application rates. Control the year after application was very consistent, averaging 50–70% at about 250 L ha^{-1} and above 70% at 500 L ha^{-1}; the best result was 85% in a sandy soil. It is certain that application method was a limiting factor in our trials; Vapam is not an efficient soil fumigant (McKenry *et al.* 1994), and much of its effect is probably localized near the depth of injection. Penetration into clods that are frequent in red volcanic clay is also likely to be poor. Drenching of soil with Vapam in a large volume of irrigation water is the most efficient application method (Gerstl *et al.* 1977, McKenry *et al.* 1994); this is analogous to what we did in pots, but is not practical for a fallow treatment in canefields.

Altered irrigation after application of Vapam did not improve field performance. Irrigation is recommended to help seal the soil surface; very dry soil is also to be avoided (Product Information). The amount of post-treatment irrigation was not a critical factor in our trials.

Timing of Vapam application was varied in one pair of trials to target supposedly vulnerable stages in the pest's life cycle. Application in November and February was intended to coincide with the expected presence of adults and early-stage nymphs, respectively (Hitchcock 1965). However, results of application were very similar in the two trials. More recent studies show that the majority of the pink ground pearl population is present as the cyst stage throughout the year in canefields (Samson and Harris 1998), so targeting specific life stages cannot be successful.

The effect on crop yield of the control of pink ground pearl achieved in these trials is not known, because Vapam is a non-specific biocide which may control many pests and diseases (Gerstl *et al.* 1977). No increase in yield was measured at the first harvest of a trial in red volcanic clay. This contrasted with a large yield increase at the first harvest of a trial on sandy soil, where there was a lower initial population of ground pearls. The yield increase on sandy soil was probably due partly to control of other harmful organisms, particularly nematodes which were confirmed present in large numbers in 1997.

Although significant reductions in pearl numbers were measured within a year of application, these reductions were not sustained for a whole crop cycle. Differences between treatments could not be detected statistically after one or two years. This is unlikely to have been due to pink ground pearls migrating into treated plots, as their dispersal ability is very limited. Adults are flightless, and spread of the pest is mainly in soil on farm machinery and in run-off water (Dominiak *et al.* 1989). Cultivation of fields may have dragged some soil containing pearls along the cane rows, but this would not have produced much movement. The true cause is not known; possibly Vapam inhibited some unknown biological control

of pink ground pearl, or the rate of population increase may decline at higher densities as a result of intraspecific competition. In the two trials on sandy soil, the rapid increase of pearl numbers in treated plots may have been caused by the greatly improved crop growth in those plots (see above).

In conclusion, Vapam can reduce numbers of pink ground pearls; however, it will certainly not eliminate them and populations may recover within a few years. Vapam alone is not an effective control of pink ground pearl, but could be part of a management program including resistant varieties to maintain populations at low levels.

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