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Opogona and tropical armyworm control in kumara stores

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1 Executive summary

The objective of this research project was to test the efficacy of some new pesticides and fumigants for the control of opogona larvae and tropical armyworm (larvae and pupae) in kumara stores. Industry is interested in identifying new disinfestation methods that are less hazardous to staff who apply them and to the environment and leave little or no chemical residues.

In one trial we compared the efficacy of Permigas (the industry standard for tropical armyworm control), Armourcrop DDVP and Vapormate™ on kumara heavily infested with opogona and tropical armyworm. No treatment adequately controlled opogona larvae at the rates tested. Tropical armyworm larvae were controlled with Armourcrop DDVP.

In a second trial, heat-treating kumara without chemical treatment at 55°C for over an hour showed promise.

In an end-of-season follow-up trial on kumara much less infested with insects we tested phosphine for opogona control and re-tested Vapormate™ at a higher rate of application. The latter treatment showed most promise.

We conclude that controlling opogona larvae is difficult, particularly in old, disintegrating kumara tubers. The larvae survive amongst rotting tubers, making it difficult for treatments to penetrate the produce. Heat treatment may not be economically viable. We recommend that storage facilities are maintained at 13-14°C to minimise insect activity during storage.

2 Recommendations

- Armourcrop DDVP, Vapormate™ and phosphine should be retested on lighter infestations of opogona larvae where tubers are not disintegrating.
- The effect of heating storage sheds and bins to temperatures in the range 50-55°C for over 2 hours should be investigated.
- Good hygiene practices and temperature control will minimise opogona infestations. Storage of kumara in insect-proof sheds and at a storage temperature of 13-14°C are recommended.

3 Introduction

Kumara growers are seeking better methods to eradicate eggs, pupae and larvae of opogona *(Opogona omoscopa)*, tropical armyworm *(Spodoptera litura)*, and other insects and mites present in stored kumara as well as in soil and wood on bins being moved into storage. This project continues industry efforts to identify new disinfestation methods that are less hazardous and leave little or no chemical residues.

Earlier research by Crop & Food Research has shown Permigas to be effective for the control of tropical armyworm (TAW) but not opogona (van Epenhuijsen et al. 2002). Opogona control is more difficult because the larvae tend to be associated with mummified or completely soggy, decaying tubers. Our work with BOC Ltd has led to the introduction and registration of Permigas for TAW control (Krishna 2002). Permigas delivers the active ingredient (permethrin) as an aerosol. Forced air must be used to ensure the aerosol droplets move through the bins before they settle. Volatile materials (fumigants) are preferred because they have greater potential to penetrate bulk bins of kumara. New fumigation options are required that control both major kumara pests and provide an alternative to Permigas to help reduce the build-up of pesticide resistance. We tested Armourcrop DDVP and Vapormate™ for opogona control. Dichlorvos, the active ingredient in Armourcrop DDVP, produces vapour while ethyl formate, the active ingredient in Vapormate™, is a gas.

This report describes trials carried out in 2004 on new pesticides and fumigants for the control of opogona and TAW.

4 Methods

4.1 Insect supply

Four bulk bins containing opogona-infested kumara tubers were received from Dargaville. The opogona populations in the bins were very small. Infested tubers were redistributed through the bins periodically to build up the infestation of opogona. By April 2004 the opogona population had built up sufficiently to allow trials to commence. TAW larvae, pupae and eggs were purchased from HortResearch for the trials.

Plastic buckets with a volume of 20 L were used for the trials. We placed 650 ml of river sand and a piece of timber at the bottom of each bucket to mimic the kumara storage shed environment, i.e. a mix of soil detritus and timber at the bottom of each storage bin. A 50:50 mix of clean and opogona-infested tubers was placed in the buckets up to the 15 L level. A cover of organza was tied over the top of each bucket and left for four weeks prior to the trial commencing. However, the heavily-infested tubers started to rot over this period so the most wet and soggy tubers were removed from each bucket.

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Larvae (3rd stage, 10 per plot) and a mix of female and male pupae of TAW (5 per plot) were placed in plastic containers with metal mesh on both sides on top of the opogona-infested tubers in each bucket.

4.2 *Main disinfestation trial*

We compared three Envirosols from BOC Ltd. They were:

1. Permigas—an industry standard for TAW control that contains 4 g/kg permethrin and 1 g/kg pyrethrum in liquid CO_2,
2. Armourcrop DDVP—contains 50 g/kg dichlorvos in liquid CO_2 (also known as Insectigas),
3. Vapormate™—contains 16.7% ethyl formate in liquid CO_2.

Table 1 shows the disinfestation treatments. All treatments were carried out for 12 hours and were replicated four times. The size of each treatment chamber varied. Permigas treatments were carried out in a 27 m^3 plastic-lined chamber, Armourcrop DDVP treatments were carried out in 32 m^3 insulated shipping containers, and Vapormate™ treatments were carried out in sealed 200 L drums. Heating and thermostats were used to maintain temperatures in the range 17-19°C. To accurately distribute the Envirosol treatments (Permigas and Armourcrop DDVP) large chambers were required and replicates of these treatments were carried out on different days.

Table 1: Disinfestation treatments and date of treatment for the main trial.

Treatment number	Fumigant/Pesticide	Rate of application (g/m^3)	Treatment dates
1	Control (untreated)	–	15, 16, 21, 22 April
2	Permigas	2	15, 16, 21, 22 April
3	Armourcrop DDVP	2.5	15, 16, 21, 22 April
4	Armourcrop DDVP	3.75	15, 16, 21, 22 April
5	Vapormate™	60	15 April
6	Vapormate™	120	15 April

4.3 *Heat treatment*

Several preliminary experiments were carried out to evaluate the potential of heat treatment to disinfest kumara. We first used a Contherm incubator to test various hot air treatments. The incubator did not have sufficient heating capacity. We then used a drying oven. We compared the effect of 50°C and 55°C for periods of 30 and 60 minutes on opogona and TAW. In a follow-up experiment (when supplies of opogona were running low) a longer period of 120 minutes was tested. Each treatment was replicated four times. On a metal tray in the oven we placed:

1. small pieces of opogona-infested tuber in a 35 ml container,
2. TAW (1 cm^2 of eggs and 15-20 larvae) in a 35 ml container, and
3. approx. 1.5 kg of opogona-infested kumara tubers in a bucket.

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4.4 *Assessment of efficacy*

After treatment the 20 L buckets and containers with insects and eggs were stored for 6-7 days at 20°C until assessment. The contents of each bucket were laid out on a table and decaying tubers were carefully broken by hand into smaller pieces. Clean tubers were knocked on the table in order to activate the opogona. Over a period of 20 minutes per container or bucket all live opogona adults and larvae were recorded for the first trial. For the second trial insects were recorded for 10 minutes per bucket.

4.5 *Follow-up disinfestation trial*

Because of the poor efficacy of chemical treatments in the main experiment we used the remaining infested tubers in a second experiment to retest higher rates of Vapormate™ and to test phosphine, a commonly-used grain fumigant. We did not want to retest dichlorvos (Armourcrop DDVP) at higher rates because the rate originally used in the main experiment was already high. Table 2 lists the treatments and the dates of application. Each Vapormate™ treatment was carried out in 200 L drums for 2 hours and each phosphine treatment was carried out in 500 L drums for 24 hours. Phosphine was delivered using measured quantities of aluminium phosphide. There were four replicates per treatment, two replicates on each treatment date. All treatments were carried out at approximately 15°C.

Table 2: Disinfestation treatments and date of treatment for the follow-up trial.

Treatment number	Fumigant	Rate of application (g/m^3)	Treatment dates
1	Control (untreated)	—	31 May, 1 June
2	Vapormate™	120	31 May, 1 June
3	Vapormate™	180	31 May, 1 June
4	Phosphine	1	31 May, 1 June
5	Phosphine	2	31 May, 1 June

Plastic buckets (20 L) were again used to hold opogona for each treatment. Each bucket contained opogona and TAW-infested tubers. In addition, 20 opogona larvae were placed on top of the tubers. Larvae were ready to overwinter (as shown by the yellowish colour of their fat reserves). They were slow-moving and moribund, making it more difficult to assess whether the treatment had been effective than in the main experiment.

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5 Results

5.1 Main disinfestation trial

5.1.1 Opogona

Numbers of larvae surviving in the tubers after treatment were high and variable (Fig. 1). Individual plot counts varied from 106 to 423 larvae and were analysed using a log linear model. The analysis showed there was no significant effect of disinfestation treatment on the numbers of surviving larvae.

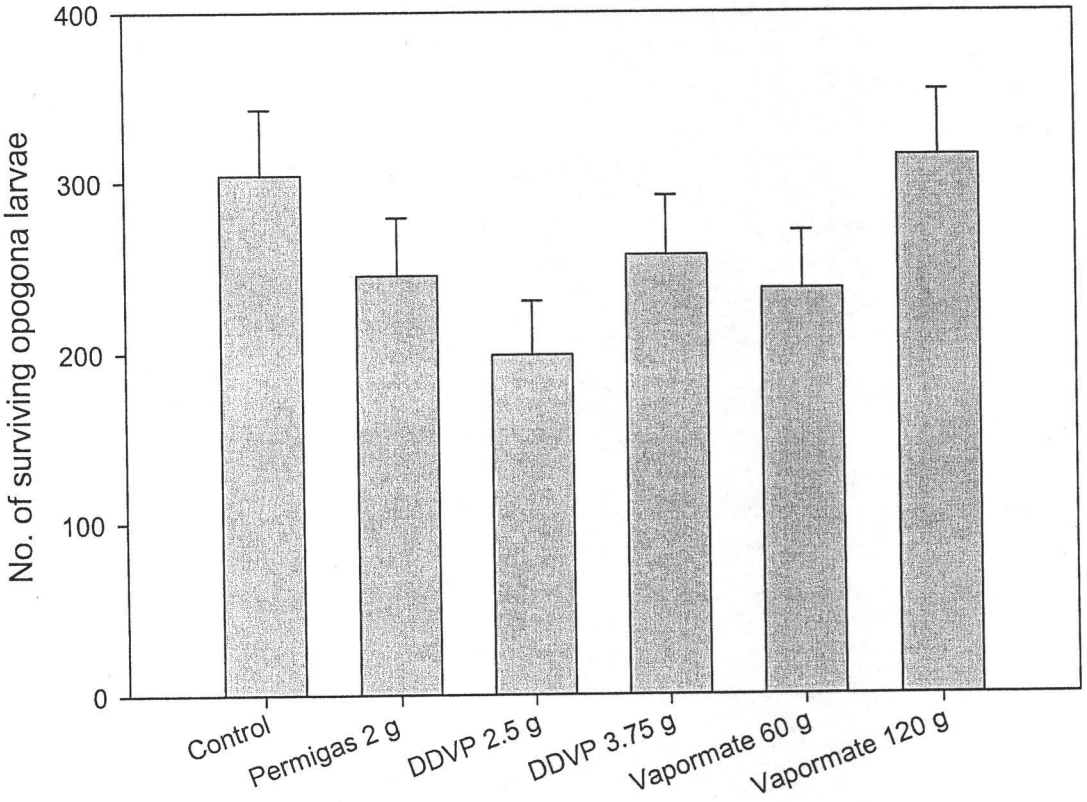

Figure 1: Effect of disinfestation treatment on survival of opogona larvae (fitted means with standard errors).

We also counted the number of surviving opogona moths (Fig. 2). Using a log linear model, the statistical analysis showed disinfestation treatment had a significant effect on numbers of opogona moths. Permigas was by far the most effective treatment for opogona moth control. This result was expected because of the effectiveness of its active ingredients (permethrin and pyrethrum) on flying insects. The higher rates of Vapormate™ and Armourcrop DDVP showed some efficacy as well.

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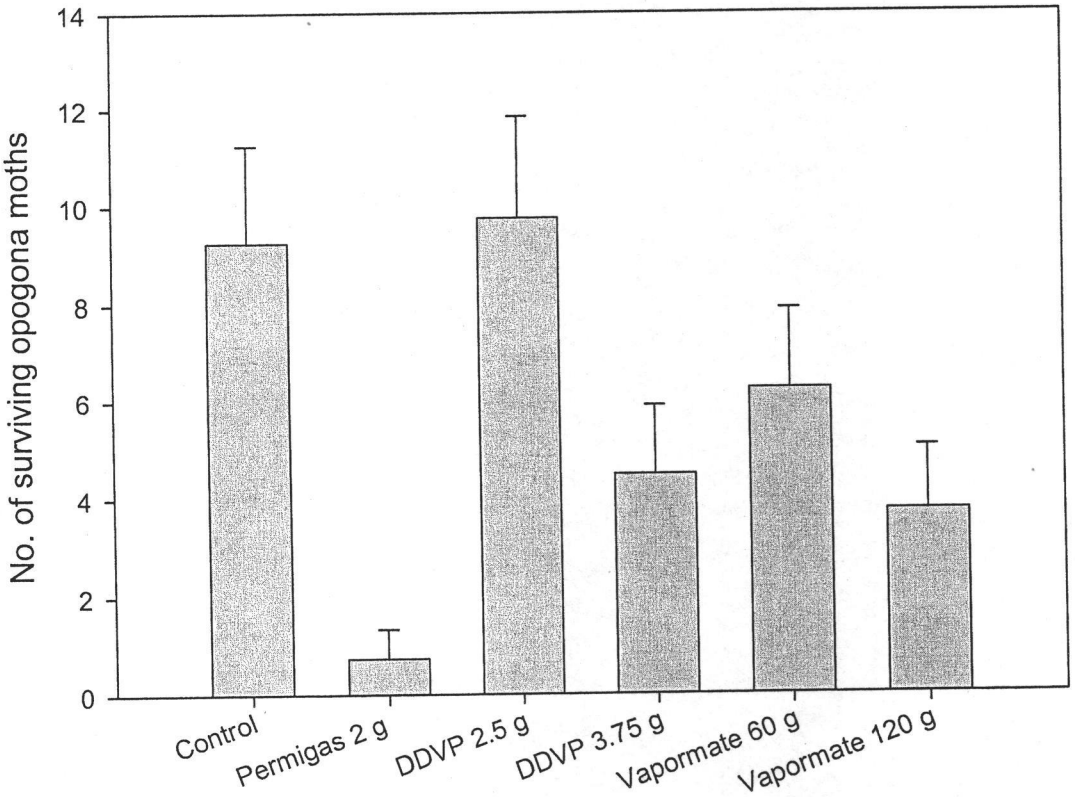

Figure 2: Effect of disinfestation treatment on survival of opogona moths (fitted means with standard errors).

5.1.2 *Tropical armyworm*

Armourcrop DDVP was the only pesticide or fumigant to control TAW larvae (Fig. 3). No statistical analysis was carried out because only two treatments (both Armourcrop DDVP) had any effect. TAW numbers were low in the buckets prior to treatment (20 per treatment) as we had delayed the experiment to build up the population of opogona. During this time the viability of TAW decreased (if TAW larvae are too cold they lose viability and if too warm they pupate). This reduced the numbers of TAW larvae available for the trial. Surviving larvae in the DDVP 2.5 g treatment remained very small after the treatments and most probably would not have survived to adulthood.

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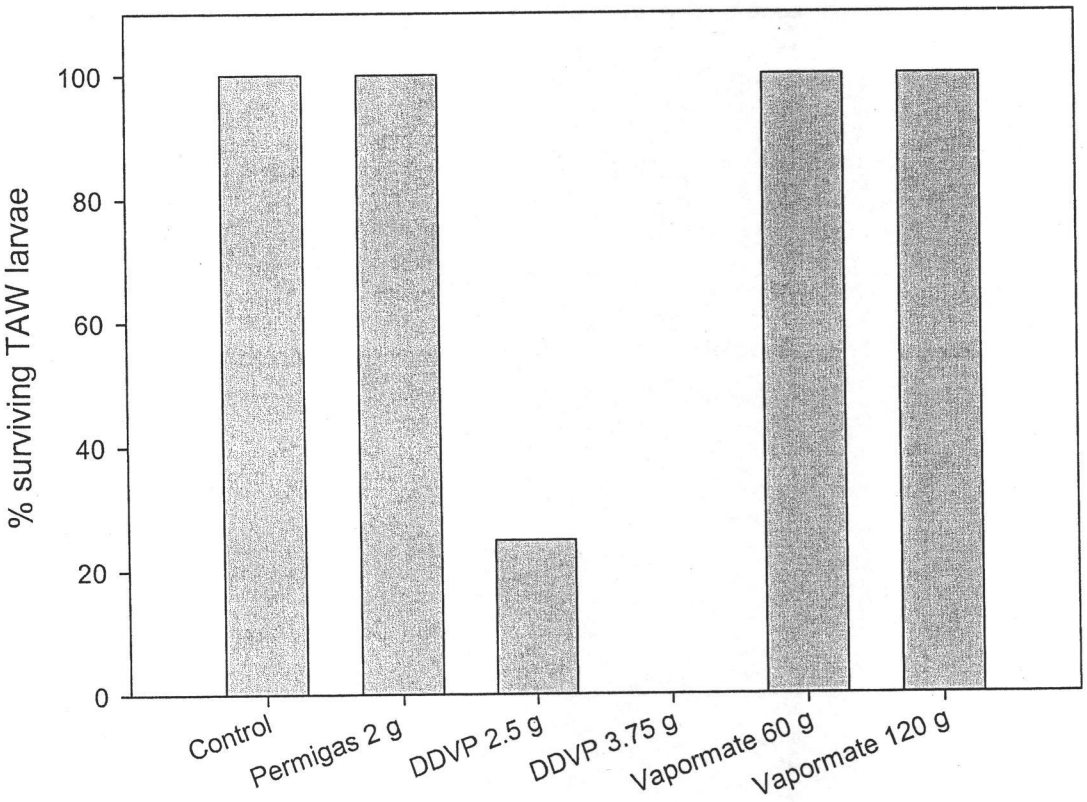

Figure 3: Effect of disinfestation treatment on survival of TAW larvae (treatment means).

Figure 4 shows TAW pupal survival rates following treatment. A statistical analysis using a log linear model showed there was no significant effect of disinfestation treatment on pupal survival.

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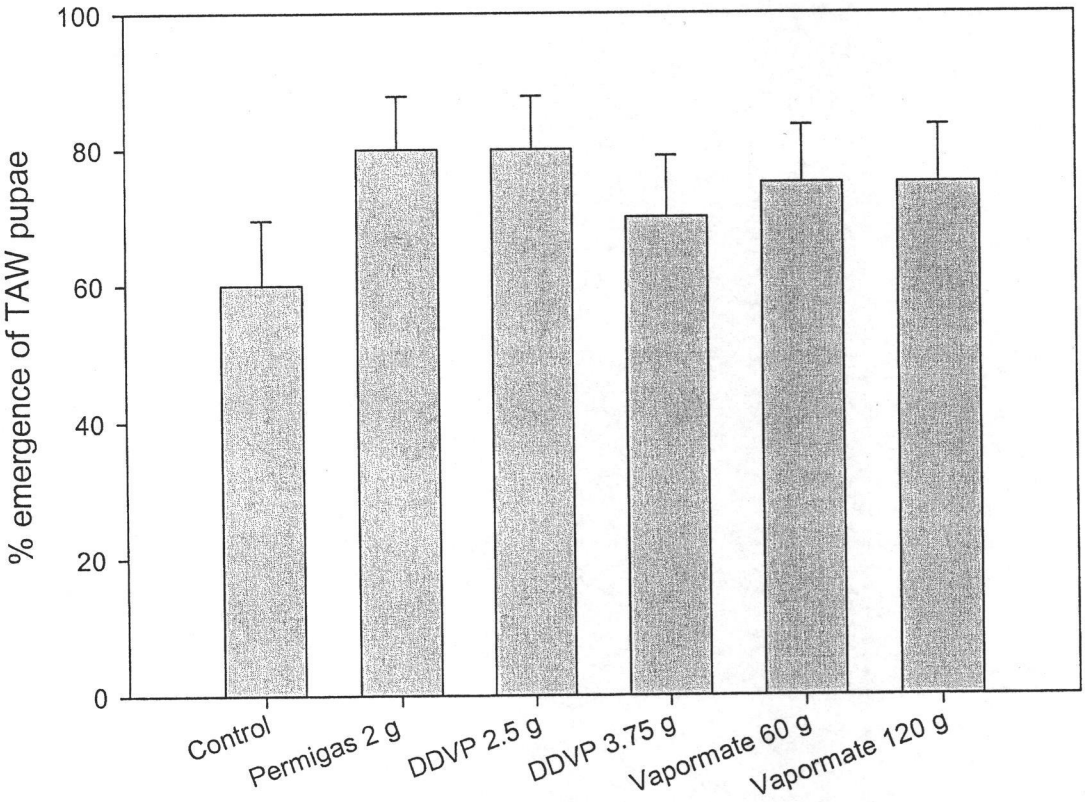

Figure 4: Effect of disinfestation treatment on survival of TAW pupae (fitted mean % moth emergence with standard errors).

5.2 Heat treatment

Heating for 30 and 60 minutes at 50°C did not control insect numbers. The infested tubers were wet and soggy and slow to warm up, providing protection for opogona and TAW larvae. Experience with other insects had indicated temperatures of 50°C and exposure for 1 hour was sufficient for control.

There were fewer infested opogona available for testing higher temperatures and longer treatment durations so results were only observational. When treated for 2 hours or more at 50°C, opogona larvae were killed. TAW were more resilient. TAW larvae and eggs (not amongst kumara) survived heat treatment of 1 hour at 55°C. A low proportion of eggs (but no larvae) survived for 2 hours at 55°C.

5.3 Follow-up disinfestation trial

Numbers of opogona larvae were low in a trial carried out 5-6 weeks after the main trial (Figure 5). We carried out a statistical analysis after logarithmic transformation of the data to determine the effect of chemical treatments on larvae survival. The analysis showed a significant effect of disinfestation treatment on the number of live opogona larvae. Table 3 summarises the

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statistical analysis. Plot to plot variability was high in all treatments, suggesting no treatment was totally effective. The higher rate of Vapormate™ was the only treatment that significantly lowered insect counts compared with the control.

Table 3: Effect of disinfestation treatment on survival of opogona larvae (statistical comparison of treatment means).

Treatment	Log10 (treatment mean)
Control (untreated)	1.4
Vapormate™, 120 g/m^3	1.3
Vapormate™, 180 g/m^3	0.7
Phosphine, 1 g/m^3	1.3
Phosphine, 2 g/m^3	1.1
LSD	0.42

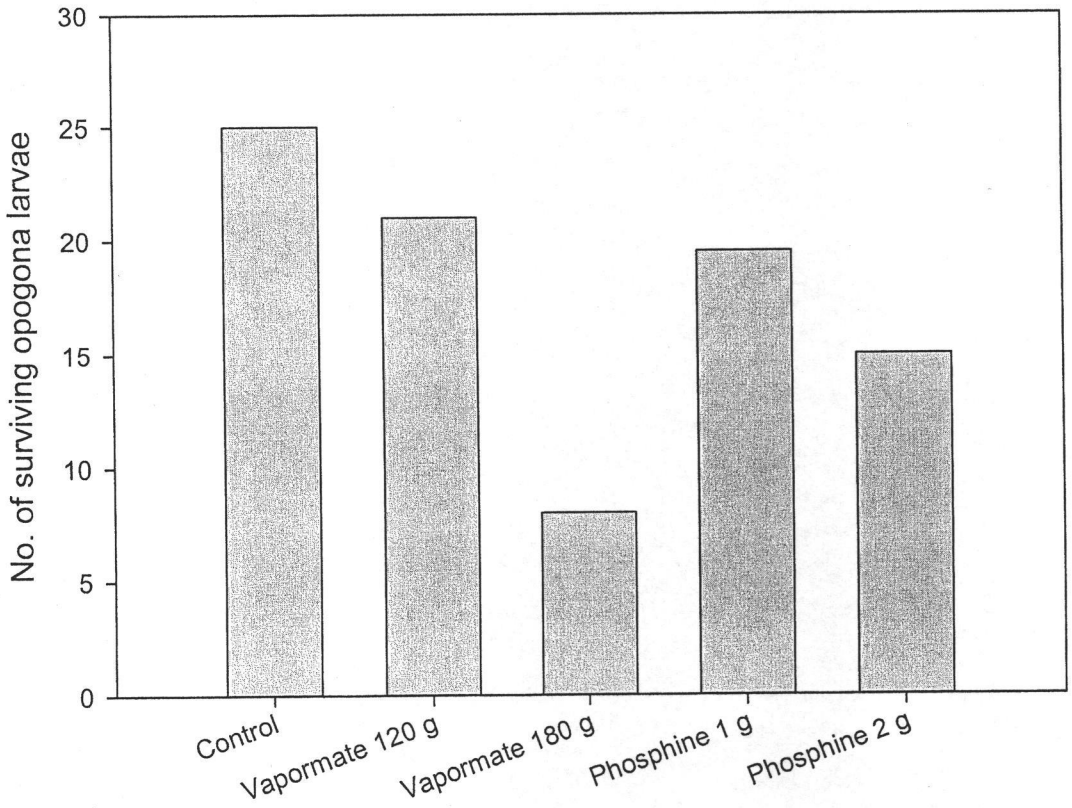

Figure 5: Effect of disinfestation treatment on survival of opogona larvae (treatment means).

Figure 6 shows counts of live 'other' insects after fumigation. These included spiders, Desjardin beetles and slaters. Counts of over 20 insects per plot

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were analysed as 30. We carried out a statistical analysis after logarithmic transformation of the data. Counts varied greatly between replicates and as a result the analysis showed no significant effect of disinfestation treatment on the number of other insects found alive.

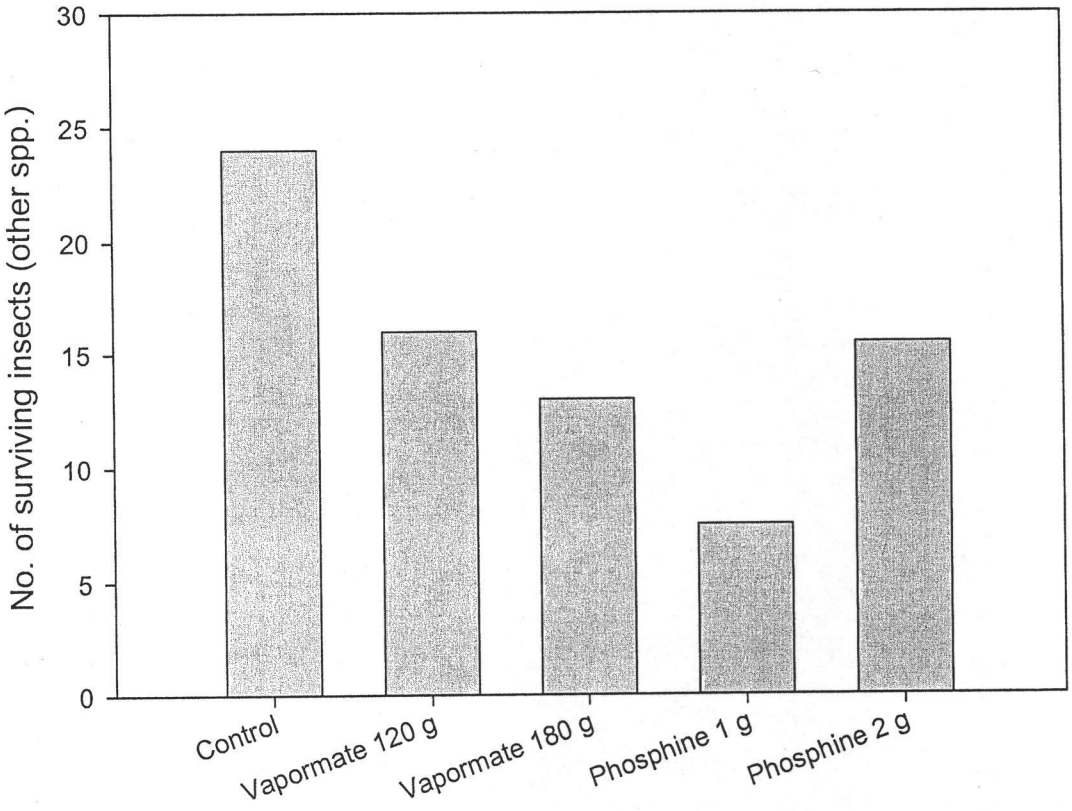

Figure 6: Effect of disinfestation treatment on survival of other insects (treatment means).

6 Discussion

The results of the experiments have been disappointing. Control of opogona is difficult, especially in badly decaying kumara. Chemical treatments may be more effective when insect infestations are lighter.

After the poor results obtained with Armourcrop DDVP in the first trial; we were reluctant to increase the rate of application in the follow-up trial as the rates were already high.

Permigas was most effective for moth control, as would be expected. However, it is an aerosol so droplets may settle before they can penetrate amongst produce compared to the fumigant (gaseous) treatments. The

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performance of Permigas for control of TAW was poor. The mesh cover on the plastic containers probably limited penetration. In earlier work (van Epenhuijsen et al. 2002) mesh covers were removed prior to fumigation and the treatment was successful for TAW control. The result highlights the need for contact with Permigas to ensure it is effective. Rapid airflow through the stacked bins and kumara is required for Permigas to be effective.

Vapormate™ showed some promise for opogona control at the higher rate tested in the follow-up trial. Vapormate™ will be registered soon in New Zealand. It is difficult to predict its uptake by the kumara industry until its price is known. As it breaks down to ethanol and formic acid there will not be concerns over residues. High rates are required compared to other fumigants and rapid sorption may be an issue when used on kumara. We had a low loading of kumara in the fumigation space, which was likely to minimise sorption (we did not measure the sorption rate). Vapormate™ could be useful for treating smaller volumes, such as a small number of infested bins.

Phosphine is a widely used toxic fumigant in Australia for grain, and in New Zealand for export timber to China and for imported flowers and foliage. To be effective phosphine needs longer contact times than methyl bromide and Vapormate™. Imported flowers require 15 hours while grain requires up to 10 days. Phosphine application requires a registered applicator.

The potential for heat treatment to be used in commercial kumara stores requires more research. It may not be possible to treat large quantities of tubers without jeopardising their quality. Another option would be to treat storage sheds and bins on their own. Just before harvest storage sheds and bins could be cleaned of debris and heat-treated to kill opogona. This would ensure the shed and storage bins were 'clean' at the start of the season. Opogona is not found on harvested tubers. Similarly, storage sheds can be protected from TAW infestation if the vents are screened and doors are well-sealed. Where available, temperature (and humidity) control through a heating and refrigeration system is extremely valuable for maintaining kumara quality and minimising insect activity. A temperature of 13-14°C is recommended for kumara storage as this is the optimum temperature for preserving kumara quality and will minimise insect activity.

7 Conclusion

Heavy infestations of opogona larvae are difficult to control, particularly if the kumara have begun to disintegrate. None of the disinfestation treatments tested (Armourcrop DDVP, Vapormate™, phosphine and Permigas) reduced opogona larvae numbers effectively at the rates and durations used. Disinfestation of sheds using heat treatment showed some promise, particularly if the procedure could be carried out on sheds and bins before harvested produce is stored in them.

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8 Reference

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9 Acknowledgements

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