Disinfestation of potted foliage plants for export

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Summary

Experiments were conducted on the disinfestation of some Australian native and ornamental plants grown for export. Results showed that at temperatures required for acclimatization of plants prior to storage in shipping containers (15–18°C), methidathion 1.25 ml/l + dienochlor 0.4 g/l was effective against *T. urticae* and *P. longispinus*, although the results suggested that improved control could be achieved at higher temperatures (20–25°C). The inclusion of iprodione 1 g/l as the standard fungicidal treatment did not affect the level of control. Aldicarb 0.2 g/100-mm pot + dienochlor 0.4 g/l was also found to be effective against *T. urticae* but gave variable results against *P. longispinus*.

Neither methidathion + dienochlor + iprodione, nor aldicarb + dienochlor + iprodione caused any phytotoxic effect on *Aglaonema commutatum, Araucaria heterophylla, Casuarina torulosa, Chamaedorea elegans, Howea forsterana, Laccospadix australasicus, Melaleuca armillaris, Nerium oleander, Schefflera actinophylla* and *Syngonium podophyllum* when compared against water + non-ionic wetting agent (Nonidet) controls.

Introduction

High production costs, particularly the cost of heating glasshouses in Europe and North America, have led nurserymen in these regions to place increasing emphasis on the importation of ornamental plants (Anon. 1985*a*).

Conveyance of such plants over long distances often requires prolonged storage in unfavourable conditions leading to transport problems rarely encountered with plants grown near the point of sale (Conover and Poole 1983). In Australia, Brunsdon *et al.* (1984) recently studied problems associated with the transport of potted foliage plants in shipping containers. Their study included experiments on preshipment disinfestation treatments. Strict hygiene is essential for exported plants with some countries requiring phytosanitary certification under the International Plant Protection Convention (Anon. 1985*b*).

This paper reports a study conducted to investigate the efficacy of selected disinfestation treatments against long-tailed mealybug, *Pseudococcus longispinus* (Targioni-Tozetti) and two-spotted mite, *Tetranychus urticae* Koch, two pests of ornamental plants likely to cause control difficulties. The phytotoxic effects of three pesticide treatments were also tested on 10 plant types typical of the kinds of plants likely to be exported. Both experiments were conducted under conditions determined from previous plant physiology experiments (Brunsdon *et al.* 1984) with the phytotoxicity experiment conducted over 40 days to simulate a completed trip.

Materials and methods

Disinfestation

Experiment 1: Pest control of *T. urticae* and *P. longispinus* under a single temperature regime (15–18°C).

Forty adult female mites and 20 mealybugs (10 large and 10 small stages) were transferred individually by a camel hair brush on to each of 40 plants of *Chamaedorea elegans* Martius (1–2 plants each 10 cm high and 2–3 opened leaves per plant, per 100-mm pot), *Laccospadix australasicus* Wendl and Drude (single plant 30 cm high per 100-mm pot) and *Schefflera actinophylla* Endlicher (single plant 30 cm high per 100-mm pot).

Plants were kept in a temperature-controlled glasshouse at 15–18°C and 50% shade. Irrigation was supplied as required by bench-top sprinklers.

Commercial formulations of aldicarb (TEMIK 10G, 10% granule) 0.1 g and 0.2 g per 100-mm pot, dienochlor (not registered in Australia but used extensively overseas as PENTAC 50WP (50% w.p.)) 0.4 g l^{-1} and methidathion (SUPRACIDE, 40% e.c.) 1.25 ml l^{-1} were tested either individually or in combination (Table 2). Iprodione (ROVRAL 50% w.p.) 1 g l^{-1} was added to some treatments to test the pesticidal activity of a mixture containing this fungicide. Pesticide treatments were applied on a single occasion and were replicated five times on single plants. Spray treatments containing a non-ionic wetting agent (Nonidet 0.2 ml l^{-1}) were applied with a hand sprayer to incipient run-off. The granular systemic insecticide treatment was sprinkled on to the surface of the potting mix and watered in. Irrigation was withheld for 2 days following application of treatments to ensure that aldicarb was not leached out of the pots prior to uptake and assessment was made after 14 days by destructively sampling plants and counting live organisms by means of a binocular microscope.

Experiment 2: Pest control of *T. urticae* under two temperature regimes, 15–18°C and 20–25°C.

Chamaedorea elegans plants were infested with mites (1 plant 50 cm high per 150-mm pot) using the method described in Experiment 1. During this time all plants were supplied with liquid fertilizer on three occasions to increase the level of nitrogen, thereby encouraging mite feeding and reproductive activity. The plants were held in a warm glasshouse (20–25°C).

Methidathion 1.25 ml l^{-1} plus dienochlor 0.4 g l^{-1}; aldicarb 0.1 g per 100-mm pot plus dienochlor 0.4 g l^{-1} and aldicarb 0.2 g per 100-mm pot plus dienochlor 0.4 g l^{-1} were compared in Experiment 2. Iprodione 1 g l^{-1} was included with all treatments.

Spray treatments containing a non-ionic wetting agent were applied with a hand sprayer to the stage of incipient run-off on three occasions 4–6 days apart. Granular treatments were sprinkled over the surface of the pot on two occasions, 10 days apart, and watered in; assessments were made after 14 days.

Following treatment, half the plants were held in a shaded glasshouse at 15–18°C and the remainder in a second shaded glasshouse at 20–25°C.

Phytotoxicity

Methidathion + dienochlor + iprodione and aldicarb 0.2 g + dienochlor + iprodione, the

Table 1 Native and ornamental plants used in the phytotoxicity trial

Botanical name	Family	Common name
Aglaonema commutatum Schott 'Pseudobracteatum'	Araceae	Chinese evergreen
Araucaria heterophylla (Salisb.) Franco	Araucariaceae	Norfolk Island pine
Casuarina torulosa Aiton	Casuarinaceae	Forest sheoak
Chamaedorea elegans Martius	Palmaceae	Parlour palm
Howea forsterana Beccari	Palmaceae	Kentia palm
Laccospadix australasicus Wendl & Drude	Palmaceae	Atherton palm
Melaleuca armillaris Smith	Myrtaceae	Bracelet honey myrtle
Nerium oleander Linnaeus	Apocynaceae	Oleander
Schefflera actinophylla Endlicher	Araliaceae	Umbrella tree
Syngonium podophyllum Schott	Araceae	'White butterfly'

two most effective disinfestation treatments, were tested for phytotoxic effect on 10 Australian native and introduced plant species (Table 1) with each variety replicated five times. Prior to the commencement of the experiment all plants were held at 15–18°C and 50% shade in a glasshouse for 2 weeks to acclimatize them to temperate conditions. All pots were watered to field capacity before treatments were applied. Spray treatments containing a non-ionic wetting agent were applied by hand sprayer to incipient run-off. Aldicarb was sprinkled on to the surface of the potting mix and watered in. Following treatments, all pots were immediately placed in a darkened constant-temperature room set at 10°C and 90% R.H. Plants were retained under these conditions for 40 days and ethylene produced by the plants was removed by 2 × 1 kg ethylene absorption cylinders (Ethysorb).

Plants were assessed for health and vigour using the following quality scores: 0, dead plant; 1, plant barely alive; 2, low quality plant; 3, low quality medium strong plant; 4, medium quality medium strong plant; 5, medium quality reasonably strong plant; 6, medium quality well-grown strong plant; 7, good quality well-grown strong plant; 8, very good quality well-grown strong plant; 9, excellent quality well-grown strong plant; and 10, outstanding quality well-grown strong plant.

Results

Disinfestation

Experiment 1. Methidathion 1.25 ml l^{-1} + dienochlor 0.4 g l^{-1} gave the best control of both pest species on each of the host plants tested ($P<0.05$). None of the results were classified as ineffective. The inclusion of the fungicide iprodione 1 g l^{-1} did not affect the efficacy of this treatment ($P>0.05$). Both aldicarb treatments gave some failed results as shown by response category 2, while aldicarb + dienochlor demonstrated efficacy in most tests, although it was generally less effective than methidathion + dienochlor.

Analysis. Data from Experiment 1 were analysed by categorizing the counts into the response groupings defined below.

Response group	*T. urticae*	*P. longispinus*
0 : worked	0 adults 0 nymphs + eggs	0 total mealybugs
1 : partially worked	1–5 adults 1–20 nymphs + eggs	1–5 total mealybugs
2 : not worked	>5 adults >20 nymphs + eggs (Counted to 40 for confirmation)	>5 total mealy bugs

Categorical frequencies were analysed by fitting a generalized linear model with POISSON errors and log link function, viz.

$$C_{ijk} = \mu + s_i + \tau_j + r_k + (s\tau)_{ij} + (sr)_{ik} + (\tau r)_{jk} + (s\tau r),$$

where C_{ijk} is the count, μ is the overall mean, s_i is the species effect (plant), τ_j is the treatment effect and r_k is the response.

Pest population data categorized into the response groupings are given in Table 2.

The reduction in deviance after dropping the species × treatment × response term from the model for both *T. urticae* and *P. longispinus* was not significant ($P>0.05$), while the treatment × response terms was highly significant ($P<0.05$). Within this latter term, contrasts were tested in the 0 response category for *T. urticae* and overall response categories for *P. longispinus*. The control *v.* rest contrast gave a significant reduction in deviance ($P<0.05$) as did the contrast of methidathion with all other treatments ($P<0.05$). The addition of iprodione to methidathion plus dienochlor did not give significant reduction in deviance ($P>0.05$).

Experiment 2. Numbers of live mite stages are given in Table 3. The treatment results were obviously different from those of the

Table 2 Effectiveness of pesticide against *T. urticae* and *P. longispinus* on various plants

Treatment	*T. urticae*						*P. longispinus*		
	Adults			Nymphs and eggs					
	0	1	2	0	1	2	0	1	2
	C. elegans								
Aldicarb 0.1 g	2	3	0	3	0	2	3	2	0
Aldicarb 0.2 g	3	1	1	0	2	3	3	0	2
Dienochlor	1	4	0	1	4	0	0	3	2
Aldicarb + Dienochlor + Iprodione	5	0	0	0	4	1	0	5	0
Methidathion + Dienochlor	5	0	0	1	4	0	5	0	0
Methidathion + Dienochlor + Iprodione	5	0	0	1	4	0	4	0	1
Control	0	2	3	0	0	5	0	1	4
	S. actinophylla								
Aldicarb 0.1 g	4	0	1	3	1	1	1	3	1
Aldicarb 0.2 g	5	0	0	5	0	0	1	4	0
Dienochlor	3	2	0	1	4	0	0	1	4
Aldicarb + Dienochlor	5	0	0	1	4	0	1	4	0
Aldicarb + Dienochlor + Iprodione	5	0	0	2	3	0	4	1	0
Methidathion + Dienochlor	5	0	0	2	3	0	4	1	0
Methidathion + Dienochlor + Iprodione	4	1	0	0	5	0	3	2	0
Control	1	3	1	0	3	2	0	2	3
	L. australasicus								
Aldicarb 0.1 g	4	1	0	1	2	2	2	2	1
Aldicarb 0.2 g	5	0	0	1	3	1	0	5	0
Dienochlor	5	0	0	4	1	0	1	2	2
Aldicarb + Dienochlor	5	0	0	1	2	2	1	4	0
Aldicarb + Dienochlor + Iprodione	5	0	0	5	0	0	0	3	2
Methidathion + Dienochlor	5	0	0	5	0	0	2	3	0
Methidathion + Dienochlor + Iprodione	5	0	0	2	3	0	3	2	0
Control	2	2	1	2	0	3	1	2	2

Table 3 Efficacy of pesticide treatments against *T. urticae* tested under two temperature regimes

Treatment	15–18°C		20–25°C	
	Adults	Nymphs	Adults	Nymphs
Methidathion 1.25 ml l^{-1} + Dienochlor 0.4 g l^{-1}	0	0.2 ± 0.18[A]	0	0
Aldicarb 0.1 g + Dienochlor 0.4 g l^{-1} + Iprodione 1 g l^{-1}	0	0.6 ± 0.54	0	0
Aldicarb 0.2 g + Dienochlor 0.4 g l^{-1} + Iprodione 1 g l^{-1}	0	0.2 ± 0.18	0	0
Control	3.5 ± 0.5	31.6 ± 6.90	3.8 ± 3.0	15.6 ± 13.1

[A]Mean ± s.e.

Table 4 Phytotoxicity of pesticide treatments to native and ornamental plant species using a scale of 1–10 to measure quality and vigour

Plant types	Treatments		
	Methidathion 1.25 ml l^{-1} + dienochlor 0.4 g l^{-1} + iprodione 1 g l^{-1}	**Aldicarb 0.2 g/100-mm pot + dienochlor 0.4 g l^{-1} + iprodione 1 g l^{-1}**	**Water + non-ionic wetting agent[A] 0.2 ml l^{-1}**
Aglaonema commutatum	6.80 ± 0.80[B]	7.00 ± 0.77	6.40 ± 0.40
Araucaria heterophylla	8.00 ± 0.45	8.80 ± 0.20	7.80 ± 0.73
Casuarina torulosa	6.80 ± 0.49	7.00 ± 0.55	6.20 ± 0.73
Chamaedorea elegans	7.40 ± 0.51	8.40 ± 0.24	7.00 ± 0.32
Howea forsterana	8.60 ± 0.24	8.20 ± 0.58	8.20 ± 0.37
Laccospadix australasicus	8.40 ± 0.60	7.80 ± 0.20	8.20 ± 0.37
Melaleuca armillaris	8.00	8.20 ± 0.20	8.00
Nerium oleander	8.00 ± 0.63	8.40 ± 0.60	9.00
Schefflera actinophylla	6.60 ± 1.12	8.50 ± 0.24	8.80 ± 0.20
Syngonium podophyllum	8.20 ± 0.20	7.60 ± 0.93	8.20 ± 0.37

[A] Nonidet(R)
[B] Mean ± s.e.

control populations, while there were no differences between treatments in adult and nymphal stages at both temperature regimes. Accordingly, an analysis was not conducted.

While effective control was achieved in both temperature regimes, complete control was achieved only in the higher temperature regime.

Phytotoxicity

Mean data are given in Table 4.

Aglaonema was affected by the storage conditions and remained alive for only 1 week after they were removed from the coolroom. In addition, *Syngonium* lost some leaves during the first week, but later fully recovered. *Schefflera* appeared to be damaged by the methidathion + dienochlor + iprodione treatment with mean plant health reduced to medium to good quality. The low values for *Casuarina* may also have been due to the storage conditions but this was not clear due to the variation in foliage coloration. Vigour was not affected in any of the plant species.

The plants used in this trial comprised a range of botanically dissimilar types and these results suggest that these pesticide treatments could be used on most plant species without causing visual damage.

Discussion

These experiments assessed treatments for controlling *T. urticae* and *P. longispinus* on flowering ornamental and woody plants. These pests are more difficult to control than aphids and caterpillars which were not included in this study as they would be controlled effectively by the treatments in question.

The basic aim of this study was to determine a disinfestation treatment that would permit the export of plants. In general terms, an acceptable treatment needs to meet the phytosanitary requirements of the importing country. Although most countries are signatories to the International Plant Protection Convention, disinfestation requirements vary from place to place (Anon. 1987). Some countries, however, e.g. Israel and Japan, prohibit imports of material containing any injurious pests and an acceptable treatment must therefore meet this criterion.

Methidathion (0.05% a.i.) + dienochlor (0.02% a.i.) provided acceptable control ($P < 0.05$) under the set conditions of these experiments. Inclusion of iprodione to protect plants against fungal diseases (Bertus, personal communication) did not affect the efficacy of this treatment ($P > 0.05$) against either pest. Dienochlor gave some control of *T. urticae* but did not meet the standard required for the export of ornamental plants to some countries. Similar results have been obtained previously on *Dracaena, Schefflera, Hedera* and *Dieffenbachia* (Lindquist 1980*b*), *Dracaena* and *Chamaedorea* (Oetting and Morishita 1979), and *Impatiens* (Oetting 1980*b*).

Aldicarb was studied because of the different approach to control afforded by the granular formulation and for its broad spectrum activity. However, the results suggested that this pesticide could not be relied upon to disinfest plants despite the relatively high rates used. Lindquist (1980*a*) achieved poor control of *Planococcus citri* infesting *Coleus* with two applications of aldicarb in 3 weeks. Oetting (1980*a*) obtained good control with aldicarb applied against *P. citri* infesting *Coleus* at 112 kg ha^{-1}.

Although methidathion and dienochlor are recommended separately against *P. longispinus* and *T. urticae* respectively, this study was considered essential to determine their efficacy when applied in combination under cool (15–18°C) glasshouse conditions used during the period of acclimatization required between the ambient nursery conditions and containerization for export (Brunsdon *et al.* 1984).

The results of these experiments suggest that while good control of *T. urticae* can be achieved by a combination of methidathion + dienochlor applied under cool conditions, complete control was achieved only when treatments were applied in the warmer temperature regime. It is recommended that disinfestation treatment be applied to plants immediately prior to their placement in the acclimatization conditions.

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