Contract report for the
Horticultural Development Council

Chemical disinfectants for treatment of sand contaminated with *Phytophthora* 1995

(PC 107)

Final Report (July 1995)

Project Number:	PC107
Title:	Comparison of chemical disinfectants for treatment of a glasshouse sand bed contaminated with *Phytophthora*
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Location of project:	Commercial nursery, East Anglia
Date project commenced:	August 1994
Date project completed:	July 1995
Key words:	disinfectant phytophthora sand bed

CONTENTS

APPLICATION

The objective of the project was to provide information on the efficacy of chemical disinfectants in reducing the inoculum of *Phytophthora* in a sand bed. Eight disinfectant treatments were identified which reduced phytophthora root rot and increased the number of marketable plants when dieffenbachia were placed on treated sand. Disinfectant treatments were less effective when infected root debris was present in the sand.

SUMMARY OF RESULTS

The objective of the work was to compare the efficacy of selected chemical treatments in disinfecting sand contaminated with *Phytophthora nicotianae*. Disinfectants were evaluated *in vivo* by standing newly potted dieffenbachia plants on sand naturally contaminated with the fungus and assessing the incidence of plants developing root rot. A more severe test was done by adding dieffenbachia root debris infested with *P. nicotianae* to the sand before applying disinfectants. No fungicides were applied for control of *Phytophthora*. A one day interval was allowed between treating sand and placing young plants on it. None of the plants developed phytotoxic symptoms. Although none of the treatments prevented phytophthora root rot completely, eight treatments (Clearsol, formalin, Glu-Cid, Jet 5, Opticide H, Panacide M, Ter-Spezial and sodium hypochlorite) reduced the mean number of plants developing the disease compared with the incidence in plants placed on untreated sand. Formalin, Glu-Cid and Opticide H were particularly effective and no plants died following treatment of naturally contaminated sand with these products. The effectiveness of disinfectants was considerably less when root debris infested with *Phytophthora* was added to the sand before treatment. Loss of treatment efficacy on addition of root debris was least with formalin and Glu-Cid.

ACTION POINTS FOR GROWERS

1. For the most effective results when disinfecting a sand bed, remove waste peat, plant roots and any other organic debris before applying the treatment.

2. On nurseries where phytophthora root rot has occurred in crops stood on sand beds, consider treating the sand with formalin, Glu-Cid, Opticide H or Ter Spezial before standing another susceptible crop (e.g. dieffenbachia, gerbera, saintpaulia, fuchsia) on the beds. Note that some products (particularly formalin) should only be applied when the house is empty of plants because of the risk of fumes from the disinfectant causing crop damage. If in doubt, check for possible vapour damage to crop before use.

3. Formalin and Glu-Cid showed no fall in treatment efficacy, as assessed by number of marketable plants, when root debris was added to sand, and should be considered for use where a high level of organic contamination is present.

4. Disinfectants in most areas of use are exempt from the 1986 Control of Pesticides Regulations. Formalin is an exception and is classed as a commodity chemical (SOLA 0159/91) within the Control of Pesticides Regulations, with specific restrictions on fields of use and maximum concentrations and instructions on operator safety. Also, the Control of Pesticide Regulations do apply to any disinfectant if it is applied to a crop or the growing medium.

INTRODUCTION

Although there is a large body of published information on disinfectant efficacy against micro-organisms causing human or animal diseases, information on the effectiveness of different chemical disinfectants for use in commercial horticulture is relatively scarce. Moreover, the majority of economically important plant diseases are caused by fungi, whilst in medicine and veterinary science it is bacteria and viruses that are of the greatest concern. It is therefore difficult to extrapolate from work on disinfectants against human and animal diseases to their potential for use against plant diseases.

The work described here is one of a series of a series of experiments designed to investigate the effectiveness of a selected range of chemical disinfectants against economically important plant pathogens. Disinfectants were evaluated against fungi from taxonomically different groups and in a range of commercial situations. Disinfectants were evaluated *in vivo*, on different surfaces commonly treated with disinfectant and using a natural inoculum level of the pathogen.

This project is concerned with treatment of a sand bed for control of *Phytophthora.* The project was undertaken following investigation of a disease problem on a nursery where newly potted dieffenbachia plants stood on a sand bed had developed root rot and died. A *Phytophthora* species, identified as *P. nicotianae*, was found associated with rotting roots of yellowing and dying plants on the bed. Symptoms were generally not observed until plants had stood on the beds for 6-8 weeks, at which time roots were beginning to extend into the sand, indicating that infection probably arose from the beds. The commercial objective of the work was to identify disinfectant products which will disinfect sand contaminated with *Phytophthora* and thereby allow growers to eliminate the standing area as a possible source of this disease.

A related project was recently completed:

Evaluation of disinfectants for treatment of plastic plug trays contaminated with *Thielaviopsis basicola* (PC 38c)

MATERIALS AND METHODS

Plants

Newly potted plants of dieffenbachia *cv.* Compacta were placed on sand one day after the sand had been treated with disinfectant. No fungicides were incorporated into the compost or subsequently applied to plants as drenches. Plants were watered by overhead irrigation.

Treatments

	Product	Active ingredient	Rate product used (ml/litre water)	Rate applied (l/m^2)
1.	Water		-	-
2.	Clearsol	40% tar acids	10	5
3.	Cryptonol	14% hydroxyquinolene sulphate	3	5
4.	Formalin	38% formaldehyde	150	5
5.	Glu-Cid	20% glutaraldehyde	20	5
6.	Iodel FD	2% iodine	8	5
7.	Jet 5	hydrogen peroxide/PAA	11	0.5
8.	Opticide-H 200	20% glutaraldehyde + 20% QAC	20	5
9.	Panacide M	30% dichlorophen	17	5
10.	Panacide M	30% dichlorophen	17	1
11.	Ter-Spezial	quaternary ammonium compound (QAC)	10	5
12.	Sodium hypochlorite	10-14% available chlorine	100	5
13.	Virkon	organic acids and salts	10	5
14.	Aliette	80% fosetyl-aluminium	1	5

The rates of use chosen for testing were as specified on product labels, wherever a specific recommendation for treatment of sand existed. In other cases, the minimum dilution (maximum concentration) stated on the label was used. Several of the labels recommended an application volume of 5 litres/m^2, and this was adopted for all treatments unless the label specifically stated a different application volume. Panacide M was evaluated at two application rates (5 litre/m^2 and 1 litre/m^2).

Treatments were applied to naturally infested sand and also to sand to which 10 grammes of dieffenbachia rotting root pieces had been added to the top 1 cm layer (54 cm^3).

Experimental design

The experiment was a factorial experiment with two factors (inoculum level and disinfectant treatment) at two and 14 levels respectively. Treatments were arranged in four randomised blocks with 10 plants/plot; there was double replication of the untreated control.

Assessments

The incidence of dead plants was assessed at intervals. The cause of plant death was determined by laboratory tests. A full disease and plant quality assessment was done when healthy plants were ready for marketing. Each plant was assessed for:

-root extent (% root ball covered in root)
-root rot typical of *Phytophthora* on a 0-5 index (0-nil, 5-severe)
-plant quality index (0-dead, 5-excellent plant)

Crop diary

August 11	Disinfectants applied to sand
August 12	Plants stood on sand
September 15	First disease assessments; phytophthora root rot confirmed
September 26	Plants spaced
September 29	Second disease assessment
October 27	Third disease assessment
November 30	Final disease assessment

RESULTS

Phytotoxicity

No phytotoxicity symptoms were observed in any of the plants stood on sand treated with disinfectants.

Phytophthora root rot

Symptoms of root rot were first observed in early September four weeks after plants were placed on sand. *Phytophthora nicotianae* was confirmed as the cause of root rotting and plant death. At the first assessment on 15 September, 17 of the 300 plants in the trial had died from root rot. Dead plants were most common on untreated sand, but also occurred on some of the areas of sand treated with disinfectant.

The number of dead plants on untreated sand increased steadily with time, the increase being the more rapid on sand with added inoculum (Fig 1).

Effect of disinfectant treatment on plant death

At the final assessment on 30 November, when 35% of the plants stood on untreated sand without added inoculum had died, none of the plants on sand treated with formalin, Glu-Cid and Opticide H had died. Treatment of sand with Clearsol, Panacide M (both rates), Ter Spezial and sodium hypochlorite also resulted in a large reduction in plant death (Fig. 2). Full results are shown in Table 1.

On sand with added inoculum, formalin and Glu-Cid were particularly effective, reducing the incidence of dead plants from 50 % (untreated sand) to 3% (Fig. 3).

Effect of disinfectant treatment on marketable plants

On sand with a natural inoculum of *P. nicotianae*, the number of marketable plants was increased markedly by Clearsol, formalin, Glu-Cid, Jet 5, Opticide H, Panacide M (at both rates), Ter Spezial and sodium hypochlorite (Fig. 4 and Table 2). On sand with added inoculum, the number of marketable plants was increased markedly by formalin, Glu-Cid, Opticide H and Ter Spezial (Fig. 5). Plant quality was greatest following treatment of sand with formalin, Glu-Cid and Opticide H (Table 2).

Effect of disinfectant treatment on root rot and extent

Treatments reducing plant death and increasing the number of marketable plants also reduced root rot and increased root extent (Figs 6 & 7). Full results are shown in Table 3.

Effect of inoculum level

At all assessments, the mean number of dead plants was greater on sand with added inoculum than on sand without it (Fig. 1 and Table 1).

Fig 1. Disease development.

Dieffenbachia stood on infested sand

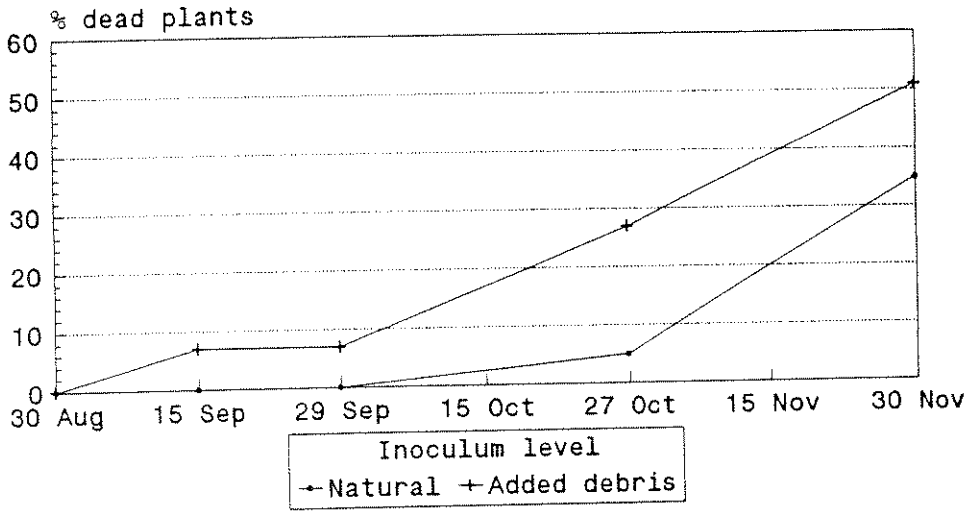

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Fig 2. Number of dead plants - 30 Nov

Natural inoculum level in sand

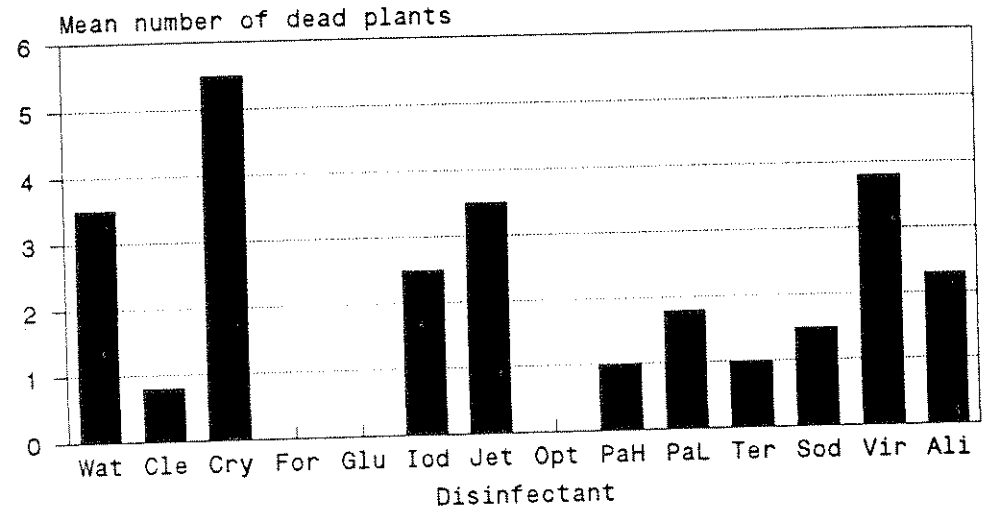

Fig 3. Number of dead plants - 30 Nov

Added root debris in sand

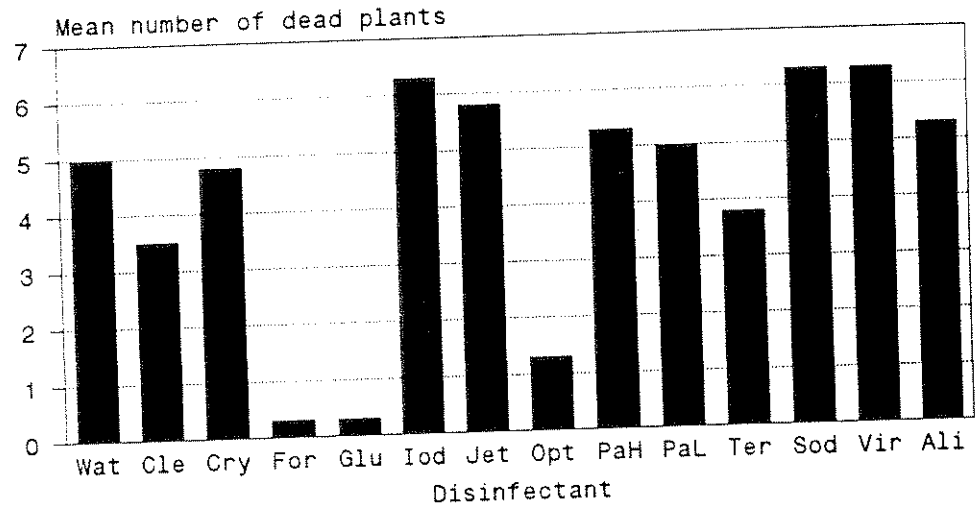

Fig. 4 Effect of disinfectants on no. of marketable plants - natural inoculum

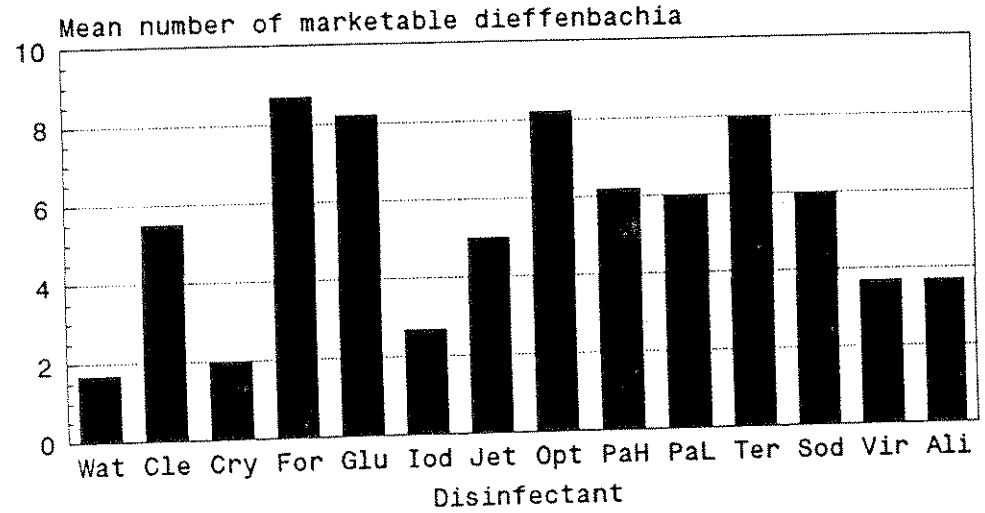

Fig. 5 Effect of disinfectants on no. of marketable plants - added root debris

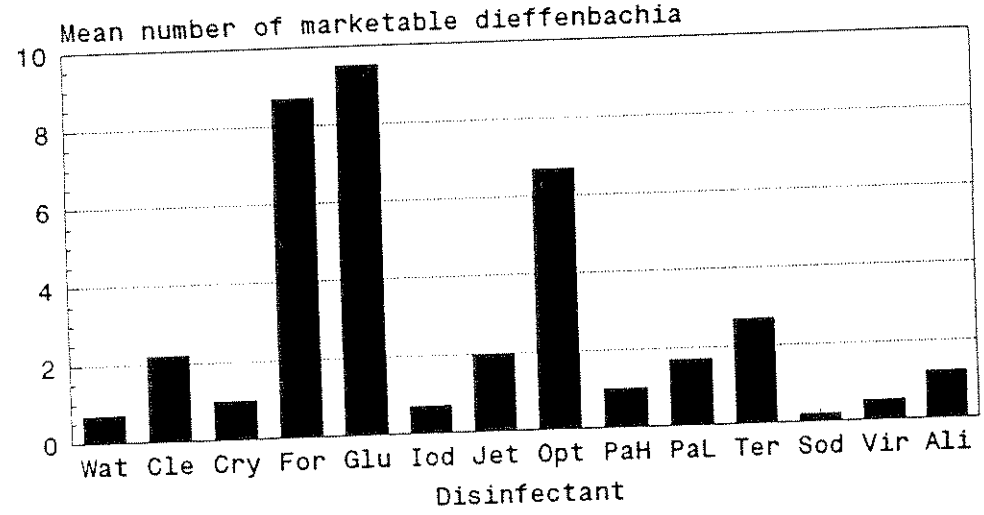

Fig 6. Effect of disinfection on root rot

Natural inoculum level in sand

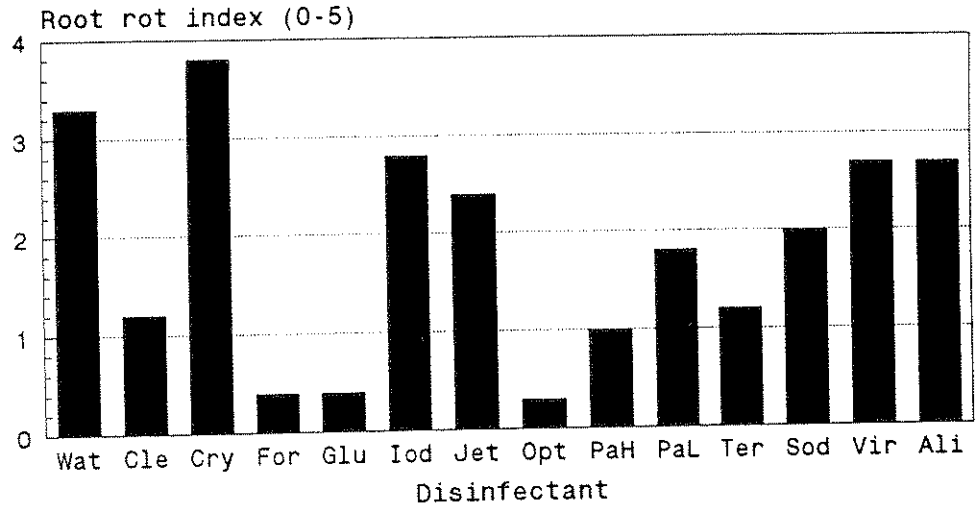

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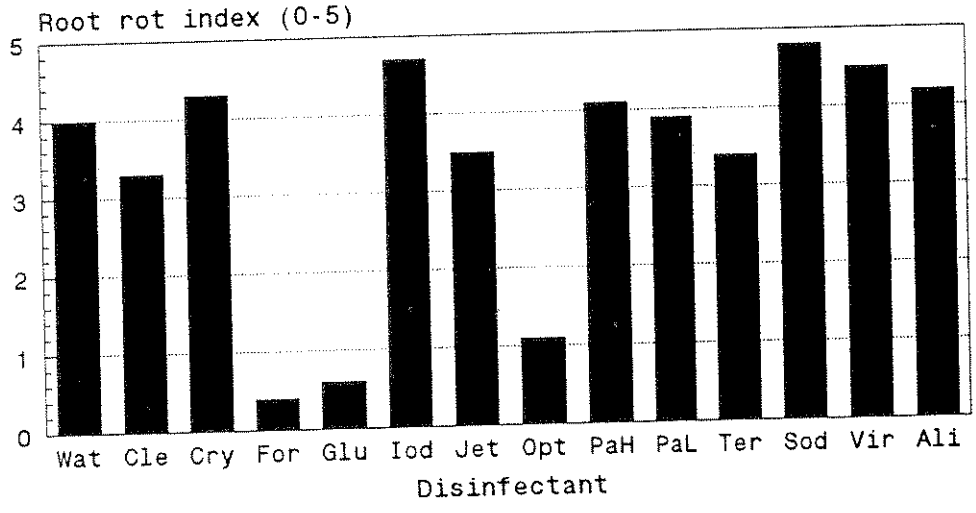
Fig 7. Effect of disinfection on root rot

Added root debris in sand



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DISCUSSION

Eight disinfectants reduced the incidence of phytophthora root and increased the number of marketable plants when applied to contaminated sand one day before standing plants on the sand. These represented five types of disinfectant: aldehyde, hydrogen peroxide + peracetic acid, hypochlorite, phenolics and a quaternary ammonium compound. The three products containing an aldehyde (formalin, Glu-Cid and Opticide H) were particularly effective.

In the same experiment, hydroxyquinolene sulphate (Cryptonol), an iodophor (Iodel FD) an organic acid + salts (Virkon) and the fungicide fosetyl aluminium (Aliette) appeared to have only a slight effect at the rates tested.

In previous experiments investigating chemical disinfectants for control of *Phytophthora* species, effective chemicals were: formaldehyde, glutaraldehyde, an organic acid, peracetic acid, a phenolic and a quaternary ammonium compound; products less effective or ineffective were chloramine, a phenolic and a QAC (Loschenkohl *et al.*, 1990; Noske & Shearer, 1985; Pilgaard, 1990; Vanachter *et al.*, 1991). The results from this project confirm the efficacy of formaldehyde, glutaraldehyde, peracetic acid, a phenolic and a QAC. Differing results obtained with different phenolics and QAC's may be due to differences in active ingredient, formulation, rates of use, temperature and duration of treatment, level of organic contamination or nature of the target pathogen.

Panacide M was evaluated at two rates of application. Reducing application from 5 litres/m^2 to 1 litre/m^2 appeared slightly to reduce the performance of treatment although these differences were not statistically significant. Further work is needed to determine if rates of application of other products could also be reduced with no loss of efficacy.

In the absence of any fungicide treatment to plants or compost, a single application of formalin to the standing area increased the number of marketable plants from 17% to 87% (natural inoculum level in sand) and from 7% to 87% (added inoculum level in sand). Several other products resulted in similar large increases in numbers of marketable plants. These results emphasise the importance of applying a disinfectant to the pot standing area as a method of preventing root disease. It is likely that, in the absence of applying a disinfectant, one or more applications of fungicide to plants would be needed to achieve a similar degree of disease control.

Further work is needed to determine if a repeat application of disinfectant between crops, or a combination of disinfection of standing area and application of appropriate fungicide to plants, would result in 100% marketable plants.

The mean number of dead plants occurring on sand with added root debris was consistently greater than on sand without it. Moreover, treatment of sand with three disinfectants (formalin, Glu-Cid and Opticide H) at the lower inoculum level resulted in a reduction of the number of dead plants to zero, whereas on sand with added inoculum these treatments were less effective. These results indicate that removal of peat and root debris before using a disinfectant will enhance the benefit achieved.

The rank order of the four treatments most effective in increasing the number of marketable plants (formalin, Glu-Cid, Opticide H, and Ter Spezial) was the same on naturally

contaminated sand and on sand with added root debris (Figs 8 and 9). Formalin and Glu-Cid showed no decline in efficacy when peat and root debris was added to sand, whereas seven other treatments effective on naturally contaminated sand (more than 50 % of plants marketable) showed a decline in efficacy of 15 to 50 % when evaluated at the higher inoculum level. Decline in efficacy was particularly marked with sodium hypochlorite, Panacide M and Ter Spezial (Fig 10). These results indicate that formalin and Glu-Cid are likely to be the most effective products when treating sand which is heavily contaminated with *Phytophthora* or is heavily soiled with organic debris.

Fig 8. Ranking of product efficacy

Natural inoculum level

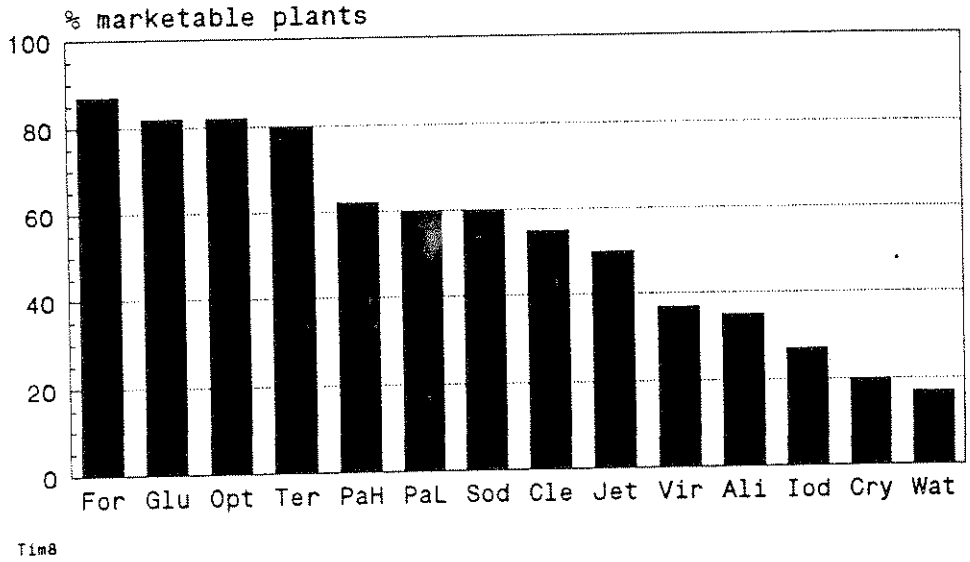


Fig 9. Ranking of product efficacy

Added root debris

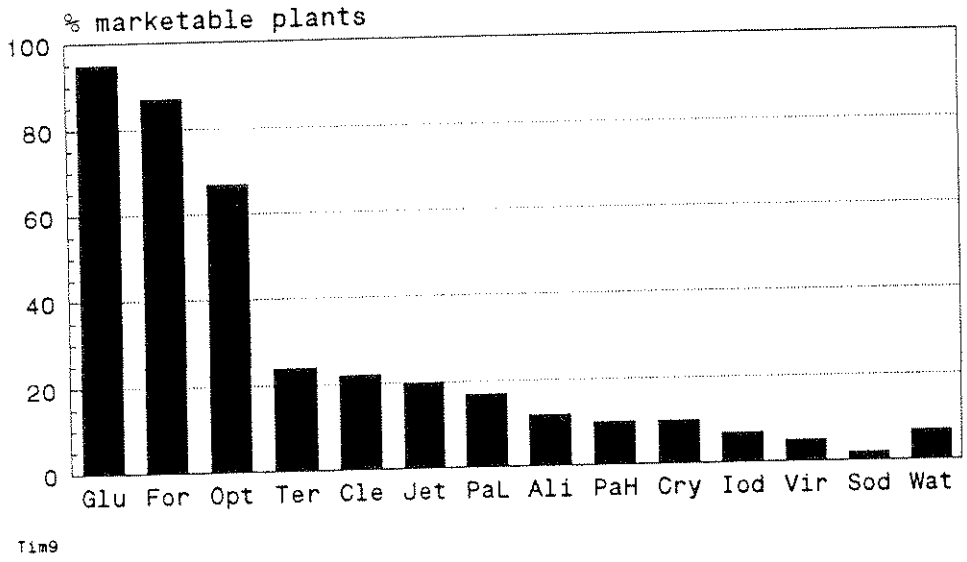
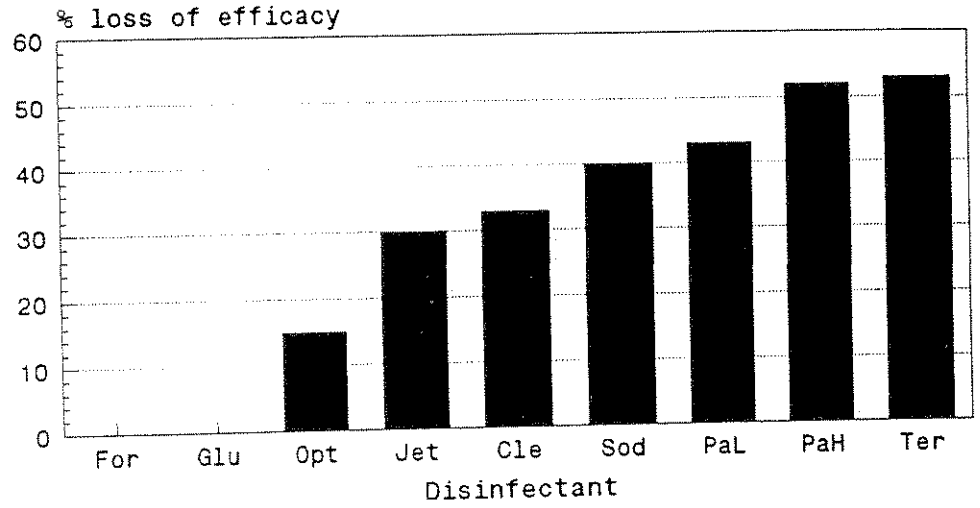


Fig 10. Loss of efficacy with addition of root debris

Number of marketable plants



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CONCLUSIONS

1. Dieffenbachia plants stood on sand naturally contaminated with *Phytophthora nicotianae* developed root rotting and died. The first plants died after 4 weeks.

2. More plants developed root rot and died when placed on sand with peat and root debris incorporated in the surface layer.

3. No phytotoxic symptoms were observed as a result of standing plants on sand one day after treating it with disinfectants .

4. In the absence of any fungicide treatment, a single application of chemical disinfectant before standing plants on contaminated sand markedly reduced plant death and increased numbers of marketable plants.

5. Eight disinfectants (Clearsol, formalin, Glu-Cid, Jet 5, Opticide H, Panacide M, Ter Spezial and sodium hypochlorite) significantly increased numbers of marketable plants. These represented five types of disinfectant (aldehydes, hydrogen peroxide, hypochlorite, phenolics and a quaternary ammonium compound).

6. Treatment of sand with Clearsol, formalin, Glu-Cid, Opticide H, Panacide M or Ter Spezial, at the rates used, resulted in greater reductions in plant death than treatment of sand with Aliette.

7. Three aldehyde containing products (formalin, Glu-Cid and Opticide H) were particularly effective and reduced the number of dead plants to zero on naturally infested sand. Ter Spezial and two phenolic products (Clearsol and Panacide M) were the most effective non-aldehyde containing products on naturally infested sand.

8. Disinfectants were less effective when applied to sand with peat and root debris, taken from affected dieffenbachia plants, incorporated in the surface layer.

9. Loss of treatment efficacy when added root debris was present was least with formalin and Glu-Cid and greatest with sodium hypochlorite, Panacide M and Ter Spezial.

10. At a concentration of 17 ml/litre, application of Panacide M appeared only slightly less effective in reducing plant death and increasing number of marketable plants when applied at 1 litre/m^2 as at 5 litres/m^2.

ACKNOWLEDGEMENTS

We are grateful to Dr J Duncan of the Scottish Crop Research Institute for confirming identification of the *Phytophthora* species isolated from affected plants as *P. nicotianae.*

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Table 1. Effect of sand disinfection and inoculum level on death of dieffenbachia from *Phytophthora* root rot.

	Mean number of dead plants (of 10)			
	15 Sept	**29 Sept**	**27 Oct**	**30 Nov**
Disinfectant				
Water	0.4	0.4	1.6	4.3
Clearsol	0.2	0.5	0.7	2.1
Cryptonol	0.2	0.7	2.2	5.1
Formalin	0.1	0.1	0.1	0.1
Glu-Cid	0.0	0.0	0.2	0.1
Iodel FD	0.5	1.5	2.7	4.4
Jet 5	0.0	0.6	2.0	4.6
Opticide H	0.0	0.0	0.1	0.6
Panacide (5 litres/ha)	0.0	1.0	1.6	3.1
Panacide (1 litre/ha)	0.1	1.0	1.6	3.4
Ter Spezial	0.0	0.1	0.7	2.4
Sodium hypochlorite	0.1	0.5	1.5	3.9
Virkon	0.2	1.0	2.6	5.0
Aliette	0.2	1.2	2.1	3.8
Significance	NS	*	*	***
SED	0.24	0.5	0.91	1.19
Inoculum level				
Natural inoculum	0.0	0.2	0.7	2.0
Added inoculum	0.3	1.0	2.2	4.2
Significance	**	***	***	***
SED	0.09	0.49	0.34	0.45

* significant at P<0.05
** significant at P<0.01
*** significant at P<0.001

Table 1 (Continued)

	Mean number of dead plants (of 10)			
	15 Sept	29 Sept	27 Oct	30 Nov
Natural sand				
Water	0.0	0.0	0.5	3.5
Clearsol	0.0	0.0	0.2	0.8
Cryptonol	0.0	0.5	1.7	5.5
Formalin	0.0	0.0	0.0	0.0
Glu-Cid	0.0	0.0	0.2	0.0
Iodel FD	0.5	1.0	1.7	2.5
Jet 5	0.0	0.5	1.2	3.5
Opticide H	0.0	0.0	0.0	0.0
Panacide (5 litres/ha)	0.0	0.0	0.2	1.0
Panacide (1 litres/ha)	0.0	0.0	0.5	1.8
Ter Spezial	0.0	0.0	0.2	1.0
Sodium hypochlorite	0.0	0.5	0.5	1.5
Virkon	0.0	0.5	1.5	3.8
Aliette	0.0	0.2	0.5	2.3
Inoculated sand				
Water	0.7	0.7	2.7	5.1
Clearsol	0.5	1.0	1.2	3.5
Cryptonol	0.5	1.0	2.7	4.8
Formalin	0.2	0.2	0.2	0.3
Glu-Cid	0.0	0.0	0.2	0.3
Iodel FD	0.5	2.0	3.7	6.3
Jet 5	0.0	0.7	2.7	5.8
Opticide H	0.0	0.0	0.2	1.3
Panacide (5 litres/ha)	0.0	2.0	3.0	5.3
Panacide (1 litre/ha)	0.2	2.0	2.7	5.0
Ter Spezial	0.0	0.2	1.2	3.8
Sodium hypochlorite	0.2	0.5	2.5	6.3
Virkon	0.5	1.5	3.7	6.3
Aliette	0.5	2.2	3.7	5.3
Significance	NS	NS	NS	NS
SED	0.34	0.71	1.28	1.68

NS - not significant

Table 2. Effect of sand disinfection and inoculum level on plant quality and number of marketable plants - 30 November 1994.

Treatment	Plant quality index (0 - 5)	Mean number marketable plants (0 - 10)
Disinfectant		
Water	1.4	1.2
Clearsol	2.7	3.9
Cryptonol	1.3	1.5
Formalin	4.2	8.7
Glu-Cid	4.4	8.9
Iodel FD	1.5	1.7
Jet 5	1.9	3.5
Opticide H	4.0	7.5
Panacide (5 litres/ha)	2.5	3.6
Panacide (1 litre/ha)	2.4	3.6
Ter Spezial	3.0	5.4
Sodium hypochlorite	2.0	3.1
Virkon	1.5	2.1
Aliette	1.9	2.4
Significance	***	***
SED	0.41	0.93
Inoculum level		
Natural inoculum	3.1	5.4
Added inoculum	1.9	2.8
Significance	***	***
SED	0.16	1.35

*** significant at $P<0.001$

Table 2. (Continued)

Treatment	Plant quality index (0 - 5)	Mean number marketable plants (0 - 10)
Natural sand		
Water	1.72	1.7
Clearsol	3.47	5.5
Cryptonol	1.40	2.0
Formalin	4.30	8.7
Glu-Cid	4.32	8.2
Iodel FD	2.17	2.7
Jet 5	2.45	5.0
Opticide H	4.37	8.2
Panacide (5 litres/ha)	3.65	6.2
Panacide (1 litre/ha)	3.20	6.0
Ter Spezial	3.87	8.0
Sodium hypochlorite	3.42	6.0
Virkon	2.15	3.7
Aliette	2.47	3.5
Inoculated sand		
Water	1.15	0.7
Clearsol	1.90	2.2
Cryptonol	1.22	1.0
Formalin	4.15	8.7
Glu-Cid	4.37	9.5
Iodel FD	0.90	0.7
Jet 5	1.40	2.0
Opticide H	3.65	6.7
Panacide (5 litres/ha)	1.42	1.0
Panacide (1 litre/ha)	1.55	1.7
Ter Spezial	2.02	2.7
Sodium hypochlorite	0.65	0.2
Virkon	0.90	0.5
Aliette	1.32	1.2
Significance	*	**
SED	0.583	1.31

* significant at $P<0.05$
** significant at $P<0.01$

Table 3. Effect of sand disinfection and inoculum level on *Phytophthora* root rot and root extent in dieffenbachia plants.

Treatment	Root rot (0 - 5)	Root extent (0 - 100)
Disinfectant		
Water	3.7	9.66
Clearsol	2.3	13.50
Cryptonol	4.1	9.15
Formalin	0.4	22.84
Glu-Cid	0.5	24.36
Iodel FD	3.8	9.45
Jet 5	3.0	11.95
Opticide H	0.7	21.97
Panacide (5 litres/ha)	2.6	15.19
Panacide (1 litre/ha)	2.8	12.27
Ter Spezial	2.3	17.29
Sodium hypochlorite	3.4	12.04
Virkon	3.6	6.24
Aliette	3.5	10.73
Significance	***	***
SED	0.39	1.877
Inoculum level		
Natural inoculum	1.9	16.76
Added inoculum	3.4	11.33
Significance	***	***
SED	0.15	0.709

*** significant at $P<0.001$

Table 3. (Continued)

Treatment	Root rot (0-5)	Root extent (0-100)
Natural sand		
Water	3.3	11.70
Clearsol	1.2	17.42
Cryptonol	3.8	9.37
Formalin	0.4	23.52
Glu-Cid	0.4	25.07
Iodel FD	2.8	12.50
Jet 5	2.4	13.45
Opticide	0.3	25.30
Panacide (5 litres/ha)	1.0	21.25
Panacide (1 litre/ha)	1.8	15.92
Ter Spezial	1.2	20.72
Sodium hypochlorite	2.0	17.07
Virkon	2.7	7.05
Aliette	2.7	14.32
Inoculated sand		
Water	4.0	7.62
Clearsol	3.3	9.57
Cryptonol	4.3	8.92
Formalin	0.4	22.15
Glu-Cid	0.6	23.65
Iodel FD	4.7	6.40
Jet 5	3.5	10.45
Opticide H	1.1	18.65
Panacide (5 litres/ha)	4.1	9.12
Panacide (1 litre/ha)	3.9	8.62
Ter Spezial	3.4	13.85
Sodium hypochlorite	4.8	7.00
Virkon	4.5	5.42
Aliette	4.2	7.12
Significance	***	*
SED	0.55	2.654

* significant at P<0.05
** significant at P<0.001

Contract between ADAS (hereinafter called the "Contractor) and the Horticultural Development Council (hereinafter called the "Council") for a research/development project.

1. TITLE OF PROJECT

Contract No: PC107

COMPARISON OF CHEMICAL DISINFECTANTS FOR TREATMENT OF A GLASSHOUSE SAND BED CONTAMINATED WITH *PHYTOPHTHORA*

2. BACKGROUND AND COMMERCIAL OBJECTIVE

Dieffenbachia plants grown on a sand bed on a nursery in Lincolnshire developed a root rot caused by *Phytophthora* sp. The pathogen was found associated with rotting roots of yellowing and dying plants on the bed. Symptoms were not observed until plants had been stood on beds for 6 - 8 weeks and roots were extending into the sand beds, indicating that infection was originating from the sand. The problem was a persistent one and losses of more than 20% of plants were occurring in some batches. HDC Review CP4 on disinfection and chemical disinfectants recommended evaluation of products against selected important pathogens, including *Phytophthora* using naturally contaminated surfaces or standing areas. The site provides an ideal opportunity to undertake such an evaluation.

3. POTENTIAL FINANCIAL BENEFIT TO THE INDUSTRY

Financial benefit to the industry will accrue for the following reasons:

1. A reduction in poor growth and plant death due to *Phytophthora* root rot.

2. Reduced risk of *Phytophthora* root rot and hence a reduced need to apply preventative fungicide treatments to control the disease.

3. Reduced reliance on fungicides and consequently a reduced risk of fungicide resistance developing.

4. SCIENTIFIC/TECHNICAL TARGET OF THE WORK

To compare the efficacy of selected chemical disinfectants in disinfecting sand contaminated with *Phytophthora* sp. The work would be undertaken as a replicated trial, with efficacy evaluated by observation of root rot in *Dieffenbachia* plants placed on treated sand.

5. CLOSELY RELATED WORK - COMPLETED OR IN PROGRESS

HDC Review CP4 - completed in 1992.
No experiments evaluating disinfectants for treatment of sand to control *Phytophthora* are known to the proposer.

6. DESCRIPTION OF THE WORK

A trial of randomised block design with four-fold replication. *Phytophthora* inoculum

will be at two levels (natural and artificially contaminated sand) in plant pots (10 pots/treatment). Treatments would include the following applied at label recommended rates:

1. Untreated (water drench)
2. Cryptonol
3. Formalin
4. Glu-Cid
5. Jet 5
6. Panacide M (high rate)
7. Panacide M (low rate)
8. Clearsol
9. Iodel
10. Opticide-H 200
11. Ter-Spezial
12. Sodium hypochlorite
13. Virkon
14. Aliette

After treatment, young *Dieffenbachia* plants untreated with fungicide would be placed on the pots of treated sand. Plants would be examined at appropriate times for evidence of root rotting. Cause of root rotting would be determined on a sample of plants. Plant growth would be examined for evidence of chemical phytotoxicity.

7. COMMENCEMENT DATE, DURATION AND REPORTING

Start date 01.08.94; duration 1 year. Results would be reported by a written report to be completed by July 1995. Results would also be presented at a suitable HDC/ADAS/HRI Conference.

8. STAFF RESPONSIBILITIES

Project Leader:	Dr T M O'Neill	ADAS Cambridge
Key staff:	D Pye.	ADAS Cambridge

9. LOCATION

Commercial nursery, Lincolnshire and ADAS Cambridge

Contract No: PC107
Date: 21.9.94

TERMS AND CONDITIONS

The Council's standard terms and conditions of contract shall apply.

Signed for the Contractor(s)

Signature.....M.C.Healt.....

Position.....ACCOUNT.....MANAGER.

Date.....1.10.94.....

Signed for the Contractor(s)

Signature.....

Position.....

Date.....

Signed for the Council

Signature.....E.J.Kennedy.....

Position.....P.P CHIEF EXECUTIVE

Date.....21-9-94.....