Contract Report for the
Horticultural Development Council

Chemical disinfectants for treatment of capillary matting contaminated with *Fusarium oxysporum*-1995 (HNS 63)

Final Report (February 1996)

Project Number:	PC 107
Title:	Comparison of chemical disinfectants for treatment of capillary matting stood on sand contaminated with *Fusarium oxysporum* f. sp. *dianthi*
Project leader:	Dr T M O`Neill ADAS Horticulture Brooklands Avenue Cambridge CB2 2BL
Location of project:	Commercial nursery, Cambs
Date project commenced:	April 1995
Date project completed:	February 1996
Key words:	dianthus wilt disinfectant *Fusarium oxysporum* phytotoxicity

CONTENTS

APPLICATION

The objective of the project was to provide information on the efficacy of chemical disinfectants in reducing the inoculum of *Fusarium oxysporum* f. sp. *dianthi* in capillary matting. At the rates used, Iodel and Opticide were the most effective of eleven disinfectants. Drenching plants with Bavistin DF also gave good control of fusarium wilt in hybrid pinks placed on contaminated matting. The majority of hybrid pinks stood on matting treated with sodium hypochlorite died.

SUMMARY OF RESULTS

The objective of the project was to provide information on the efficacy of 11 chemical disinfectants in disinfecting capillary matting contaminated with *Fusarium oxysporum* f. sp. *dianthi*. The efficacy of a single Bavistin drench applied to plants immediately after placing them on the matting was also examined. The disinfectants were evaluated *in vivo* by standing newly potted hybrid pinks on matting naturally contaminated with the fungus and assessing the incidence of plants developing wilt. A more severe test was done by adding roots and peat debris from wilt affected plants to the surface before applying disinfectants. No fungicides were applied for control of *Fusarium* where disinfectants were being evaluated. A three day interval was allowed between applying disinfectants and placing young plants on the treated areas. Plants placed on matting treated with sodium hypochlorite slowly developed leaf yellowing and stunted growth. Four weeks after application all plants were affected and eventually most of them died. Plants stood on matting treated with Glu-Cid showed reduced growth. The incidence of fusarium wilt and plant death was relatively low, even in plots with added inoculum. Nevertheless, 10 weeks after placing plants on contaminated matting, the incidence of dead and wilting plants was reduced from 10.2 % (plants stood on untreated matting) to less than 5 % by eight disinfectants; the lowest incidence (1.1 %) was recorded where matting was treated with Iodel or Opticide, or where plants were drenched with Bavistin.

ACTION POINTS FOR GROWERS

1. If potted *Dianthus* plants are being placed on used capillary matting and there is a risk of fusarium wilt (e.g. the previous crop was also *Dianthus*), consider treating the matting with one of the eight disinfectants found to reduce fusarium wilt and plant death (Formalin, Glu-Cid, Iodel, Jet 5, Opticide, Panacide M, Ter Spezial or Virkon).

2. None of the disinfectants gave complete control of fusarium wilt and it is unlikely that disinfection by itself will be sufficient to prevent the disease occurring, especially on nurseries where the pathogen is a persistent problem. Experimental work in Holland on disinfection of contaminated water by heat treatment also indicates that fusarium species can be difficult to eliminate, compared with other fungal pathogens.

3. Drenching the growing medium with an MBC fungicide (e.g. Bavistin DF) will reduce the risk of fusarium wilt.

4. In an earlier HDC-funded study, investigating control of fusarium wilt in cyclamen (Projects PC50 and 50a), incorporation of a well-matured or composted bark into the growing medium gave partial control of cyclamen wilt. It is possible that incorporation of bark into the growing medium will help in control of fusarium wilt in *Dianthus* species.

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 use against plant diseases.

The work described here is one of a series of experiments designed to investigate the effectiveness of a selected range of chemical disinfectants against economically important plant pathogens. Disinfectants are being evaluated against fungi from taxonomically different groups and in a range of commercial situations. As far as possible disinfectants are being 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 capillary matting on a sand bed for control of *Fusarium*. Related projects are:

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

Evaluation of disinfectants for treatment of a sand bed contaminated with *Phytophthora nicotianae* (PC 107)

MATERIALS AND METHODS

Plants

Two crops of newly potted hybrid pinks cv. Doris were grown in an unheated polythene tunnel on capillary matting over sand. The first crop was grown from 6 June to 21 August and the second from 24 August to 2 November. The first crop were placed on new capillary matting and inoculated with a spore suspension of *Fusarium oxysporum* f. sp. *dianthi*. After 9 weeks, plants were removed, inoculum in the form of roots and peat (10 g/m^2) from wilt-affected plants was added to half of each plot, and disinfection treatments were then applied. Three days after treatment with disinfectant, newly potted plants of hybrid pinks, cv. Devon Cream were placed on the treated areas. No fungicides were incorporated into the compost or subsequently applied to plants as drenches (except for treatment 13). Plants were watered by overhead irrigation.

Treatments

	Product	Active ingredient	Rate product used (ml/litre water)	Rate applied (l/m^2)
1.	Water		-	5
2.	Chloros	sodium hypochlorite	100	5
3.	Cryptonol	14% hydroxyquinolene sulphate	3	5
4.	Formalin	38% formaldehyde	20	5
5.	Glu-Cid	20% glutaraldehyde	50	5
6.	Iodel FD	2% iodine	8	5
7.	Jet 5	hydrogen peroxide/PAA	11	0.5
8.	Jeyes Fluid	chlorinated phenol	7	5
9.	Opticide-H 200	20% glutaraldehyde + 20% QAC	20	5
10.	Panacide M	30% dichlorophen	17	5
11.	Ter-Spezial	quaternary ammonium compound (QAC)	10	5
12.	Virkon	organic acids and salts	10	5
13.	Bavistin DF	carbendazim	1.5 g	5
14.	Healthy control		-	-

The rates of use chosen for testing were as specified on product labels, wherever a specific recommendation for treatment of capillary matting existed. In other cases, the maximum concentration allowed 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.

Treatments were applied to naturally contaminated matting and also to matting to which 10 g/m^2 of dianthus rotting root pieces had been scattered over the surface.

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 16 plants/plot in the first crop and 22 plants/plot in the second crop. Data were analysed by analysis of variance.

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 in flower and ready for marketing. Each plant was assessed for:

-plant death
-wilting
-yellowing of lower leaves
-collapse in plant centre (brown centre)
-unmarketable (any of the above symptoms)
-plant vigour (1-very poor plant, 5-excellent plant)

Crop diary

6 June	-first crop (cv. Doris) placed on matting
20 June	-inoculated with *F. oxysporum* f. sp. *dianthi*
21 August	-first crop removed; root debris added
21 August	-disinfectants applied
24 August	-second crop (cv. Devon Cream) placed on matting
24 August	-Bavistin DF drench applied (treatment 13)
24 September	-first symptoms of Chloros phytotoxicity
2 November	-final disease and quality assessment

Varietal susceptibility

The susceptibility of each of eight varieties (Crimson Joy, Dawlish Joy, Devon Blush, Devon Joy, Doris, Joy, Monica Wyatt and Rose Devon Pearl) to fusarium wilt was investigated by placing plants (six of each variety) on capillary matting contaminated with *Fusarium oxysporum* f. sp. *dianthi*.

RESULTS

Disease control

The incidence of fusarium wilt was relatively low both in the first crop (cv. Doris), used to generate a naturally contaminated surface, and in the second crop (cv. Devon Cream), used to test the efficacy of disinfection treatments. Nevertheless, some interesting differences between treatments were observed. Eight disinfectants reduced the incidence of dead and wilting plants from 10.2 % to less than 5 % (Fig. 1). The best disinfectants for fusarium control appear to be Iodel and Opticide, although these were not significantly more effective than other treatments (Table 1). Cryptonol and Jeyes Fluid, at the rates used, were less effective. A post-planting drench of Bavistin also gave good control of fusarium.

No differences in the incidence of fusarium wilt were recorded between plants placed on naturally contaminated matting and those placed on matting with root debris taken from wilt affected plants.

There were no significant differences in the numbers of plants with yellowing of lower leaves, brown centres or the number of unmarketable plants (Table 2)

Effect of disinfectants on plant growth

Chloros (sodium hypochlorite) was phytotoxic, probably by root uptake, and plants developed yellow leaves which withered and died. Eventually, most plants stood on Chloros treated matting died. Plants stood on matting treated with Glu-Cid were significantly smaller than plants on untreated matting at the final assessment.

Varietal susceptibility to fusarium wilt

Of the six varieties placed on untreated contaminated matting, the greatest incidence of wilting and plant death occurred in cv. Crimson Joy (3/6), followed by Rose Devon Pearl (1), Dawlish Joy (1) and Doris (1). There was no wilting or plant death in cv. Devon Joy, Devon Blush, Joy or Monica Wyatt. These results should be interpreted with caution because of the small number of plants tested.

Fig 1. Effect of disinfectants on fusarium wilt of hybrid pinks-Cambs 1995

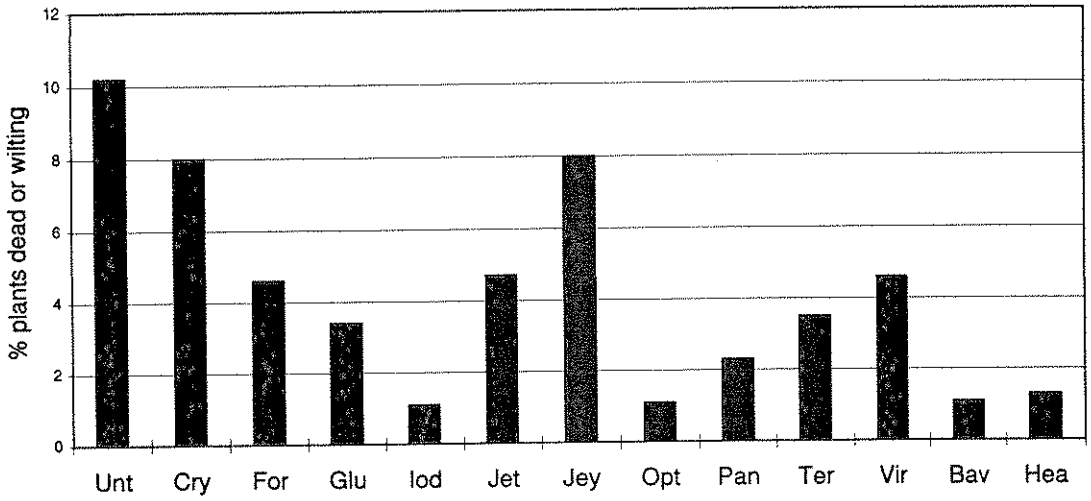

Table 1. Effect of disinfecting the standing area on fusarium wilt of hybrid pinks (cv. Devon Cream)-1 November 1995

Treatment	% dead	% wilting	% dead or wilting	Mean vigour (1-5)
1. Untreated	2.3 (3.2)	7.9 (11.2)	10.2 (13.0)	3.9 (11.2)
2. Chloros	73.9 (66.5)	- -	98.9 (87.8)	1.0 (5.7)
3. Cryptonol	6.8 (10.7)	1.1 (2.2)	8.0 (11.7)	4.1 (11.7)
4. Formalin	1.1 (2.2)	3.4 (5.4)	4.6 (7.5)	4.0 (11.5)
5. Glu-Cid	1.1 (2.2)	2.3 (4.4)	3.4 (5.4)	2.7 (9.5)
6. Iodel	0 (0.0)	1.1 (2.2)	1.1 (2.2)	4.4 (12.0)
7. Jet 5	1.1 (2.2)	3.5 (5.5)	4.7 (7.7)	3.5 10.7)
8. Jeyes Fluid	3.4 (6.6)	4.6 (6.1)	8.0 (10.0)	3.5 (10.7)
9. Opticide	1.1 (2.2)	0 (0.0)	1.1 (2.2)	3.8 (11.1)
10. Panacide M	1.1 (2.2)	1.1 (2.2)	2.3 (4.4)	3.5 (10.7)
11. Ter Spezial	3.5 (5.5)	0 (0.00	3.5 (5.4)	4.1 (11.7)
12. Virkon	0 (0.0)	4.6 (7.5)	4.6 (7.5)	3.8 (11.1)
13. Bavistin*	0 (0.0)	1.1 (2.2)	1.1 (2.2)	4.1 (11.7)
14. Healthy control[+]	0 (0.0)	1.3 (2.3)	1.3 (2.3)	3.8 (11.1)
Significance	- ***	- NS	- ***	- ***
SED (df 39)	8.48 (7.13)	3.15 (7.22)	3.79 (5.28)	0.42 (0.71)

Angular transformed values are shown in parenthesis.

*drench treatment to plants
[+] placed on uncontaminated sand

NS-not significant
***-significant at P<0.001

Table 2. Effect of disinfecting the standing area on fusarium wilt of hybrid pinks (cv. Devon Cream)-1 November 1995

Treatment	% yellowing	% brown centre	% unmarketable
1. Untreated	20.5	3.4	34.1
2. Chloros	-	-	-
3. Cryptonol	17.0	4.6	29.5
4. Formalin	21.6	4.6	30.7
5. Glu-Cid	26.1	9.1	38.6
6. Iodel	25.0	1.1	27.3
7. Jet 5	30.3	2.4	37.4
8. Jeyes Fluid	34.1	5.7	47.7
9. Opticide	10.2	17.1	36.4
10. Panacide M	22.7	12.5	37.5
11. Ter Spezial	25.9	3.5	33.0
12. Virkon	27.3	6.8	38.6
13. Bavistin*	21.6	1.1	23.9
14. Healthy control^{+}	20.0	9.3	30.6
Significance	NS	NS	NS
SED (df 39)	10.51	5.56	0.79

*drench treatment to plants
$^{+}$ placed on uncontaminated sand

NS-not significant

DISCUSSION

The experiment reported here confirmed that eight disinfectants, at the rates tested, were partially effective against fusarium wilt; two products (Cryptonol and Jeyes Fluid) were ineffective at the rates tested. Effective products were from 7 different disinfectant types. Iodel and Opticide appeared slightly more effective than other treatments.

In previous work evaluating chemical disinfectants (Pilgaard, 1990; Vanachter *et al.*, 1991; Linfield, 1991) activity against *Fusarium* species has been reported for the following types of disinfectant:

Type of disinfectant	Example
quaternary ammonium compounds (QACs)	Ter Spezial
organic acid	Virkon
formaldehyde	formalin
glutaraldehyde,	Glu-Cid
hydrogen peroxide/peracetic acid	Jet 5
phenolic	Panacide M

All the types of disinfectants listed above were also effective in the work described here. Hydrogen peroxide incorporated into wax has also been shown to control post-harvest decay of Galia melons caused by *Fusarium solani* (Aharoni *et al.*, 1994).

Sodium hypochlorite was severely toxic to growth of hybrid pinks, presumably by root uptake as no symptoms occurred within the first three weeks of placing plants on treated matting. *Dianthus* species are known to be particularly sensitive to bromide residues, and it is recommended that they should not be planted in soil with concentrations greater than 5 mg/l. It is possible that they are also particularly sensitive to hypochlorite. In an earlier (ADAS) experiment involving zonal pelargoniums, treatment of capillary matting on metal benches with sodium hypochlorite resulted in vein blackening of plants placed on the treated matting.

CONCLUSIONS

1. Hybrid pinks, cvs. Doris and Devon Cream, placed on capillary matting contaminated with *Fusarium oxysporum* f. sp. *dianthi* developed fusarium wilt. After eight weeks a few of these plants had died.

2. The incidence of wilting and dead plants was reduced by all disinfectants, at the rates tested, except for Cryptonol and Jeyes Fluid. Iodel and Opticide appeared slightly more effective than other treatments.

3. Chloros was phytotoxic and most plants placed on treated matting had died after nine weeks. Glu-Cid reduced plant vigour.

4. Drenching plants with Bavistin immediately after placing them on contaminated matting reduced the incidence of fusarium wilt and plant death.

REFERENCES

Aharoni,Y; Copel, A & Fallik, E (1994). The use of hydrogen peroxide to control post-harvest decay on Galia melons. *Annals of Applied Biology* **125**, 189-193.

Linfield, C A (1991). A comparative study of the effects of five chemicals on the survival of chlamydospores of *Fusarium oxysporum* f. sp. *narcissi*. *Journal of Phytopathology* **131**, 297-304.

Pilgaard, A (1990). Disinfection of glasshouses. *Gartner Tidende* **49**, 1323.

Vanachter, A; Vangheel, M; Assche C van & Wambeke E van (1990). Screening of some alternative disinfectants for general sanitary use in intensive horticulture. *Mededelingen Faculteit Landbouwwetenschappen Rijksuniversiteit Gent* **56**, 979-987.

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: HNS63

COMPARISON OF CHEMICAL DISINFECTANTS FOR TREATMENT OF CAPILLARY MATTING STOOD ON SAND CONTAMINATED WITH *FUSARIUM OXYSPORUM* F.SP *DIANTHI*

2. BACKGROUND AND COMMERCIAL OBJECTIVE

Dianthus plants are very susceptible to fusarium wilt caused by *Fusarium oxysporum* f.sp. *dianthi*. Symptoms may occur within a few weeks of planting cuttings or much later in the plant life. *F. oxysporum* forms thick-walled resting spores which are relatively difficult to kill by physical (e.g. UV, heat, ozone) or chemical treatment. These spores may occur freely or in root and/or peat debris on a surface where infected plants have stood, and pose a risk to subsequent susceptible crops on the same area. HDC Review CP4 on disinfection and chemical disinfectants recommended evaluation of products against selected important pathogens, including *Fusarium*, using naturally contaminated surfaces or standing areas.

The **commercial objective** of this proposal is to identify chemical disinfectants which can be shown successfully to disinfect capillary matting contaminated with *Fusarium*, and thereby minimise the risk of disease when there is repeated cropping on the same area.

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 *Fusarium* wilt.

2. Reduced risk of *Fusarium* root rot and wilt 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.

4. SCIENTIFIC/TECHNICAL TARGET OF THE WORK

To compare the efficacy of selected chemical disinfectants in disinfecting capillary matting contaminated with *F.oxysporum* f.sp. *dianthi*. The work would be undertaken as a replicated trial, with efficacy evaluated by observation of root rot in dianthus plants placed on treated matting.

5. CLOSELY RELATED WORK COMPLETED OR IN PROGRESS

HDC Review CP4 - completed in 1992.
HDC Projects PC107 (disinfection of sand contaminated with *Phytophthora*, using

8. STAFF RESPONSIBILITIES

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

9. LOCATION

Commercial nursery, Cambridgeshire or ADAS Arthur Rickwood

Contract No: HNS63

TERMS AND CONDITIONS

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

Signed for the Contractor(s)

Signature....M.C. Heath.....

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

Date.....8/11/94.....

Signed for the Contractor(s)

Signature.....

Position.....

Date.....

Signed for the Council

Signature.....

Position.....CHIEF EXECUTIVE

Date.....1.11.94.....