Final Report (April 1993)

Project Number :	PC50a
Title :	Pot Plants - Integrated control of root disease
Project Leader :	Dr T M O'Neill, ADAS Cambridge
Location of project :	Commercial nurseries in Hertfordshire and Kent; HRI Efford.
Project Co-ordinator :	J Evans, H Evans & Sons (Europa) Ltd, Kent
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Key words :	cyclamen, poinsettia, pansy, saintpaulia, fusarium wilt, black root rot, pythium root rot, phytophthora root rot, fungicides, bark, growing medium amendments, disease suppression, biocontrol agents, inoculum level, inoculation site, watering method.

CONTENTS

APPLICATION

The objective of the project is to define integrated strategies for achieving reliable and durable control of root diseases of pot plants. Treatments include cultural techniques and appropriate use of biocontrol agents and fungicides. In the first year treatments have been identified which provide good control of cyclamen fusarium wilt, pansy black root rot and pythium root rot of poinsettia. There is opportunity for growers to apply these treatments and reduce the risk of serious losses to root disease.

SUMMARY OF RESULTS

The objective of the work was to investigate the effects of growing medium amendments, fungicides and biocontrol agents on development of four root diseases affecting cyclamen, pansy, poinsettia and saintpaulia in replicated experiments. Plants were artificially inoculated with a standard inoculum.

The first three experiments investigated control of fusarium wilt of cyclamen. Amendment of peat with 40% by volume pine bark, wood fibre, composted larch and spruce bark, composted bark and paper, composted pine bark and processed straw all significantly reduced development of fusarium wilt. The disease-suppressive effect observed with pine bark was not removed by leaching in water or autoclaving. In a comparison of different types of peat, disease progress was rapid in standard sphagnum peat and a Russian peat and relatively slow in a Finnish peat and an Irish peat. Drenching with Octave soon after potting and at monthly intervals for three months was the most effective fungicide treatment. Incorporation of crushed crab shells into the growing medium was the most effective of three biocontrol treatments. Drenching with the biocontrol product Mycostop gave a significant reduction in wilt at an early assessment but not at later assessments. Incorporation of a mycorrhizal inoculant into the growing medium appeared to reduce disease but the difference was not significant. Critical factors affecting the rate of development of fusarium wilt were found to be inoculum level, inoculation site, growing medium and method of watering. Suppression of wilt by bark amendment was most effective at low disease pressure.

The fourth experiment investigated control of phytophthora root and stem base rot of saintpaulia. The disease failed to develop despite inoculation of the growing medium. Growth of plants in peat amended with 40% perlite, processed straw and wood fibre was satisfactory. Amendment with bark significantly reduced flowering and final plant quality. Drenching plants with Aaterra, Filex and Fongarid had no adverse effect on plant growth.

The fifth experiment investigated control of black root rot of pansy, caused by *Thielaviopsis basicola*. The disease developed slowly during September and October but moderate levels of black root rot were found at the final assessment in December. Drenching plants with Bavistin gave a significant reduction in black root rot. None of the growing medium amendments, a reduced pH at potting or biocontrol agents had a significant effect on the disease.

Excellent control of pythium root rot of poinsettia was achieved by drenching with Aaterra and Fongarid. Drenching with Filex and incorporation of a mycorrhizal inoculant into the growing medium appeared to give slight control. Amendment of peat with bark, perlite, processed straw and wood fibre and drenching with a pythium biocontrol agent (Polygandron) had no effect on disease development.

ACTION POINTS FOR GROWERS

Cyclamen fusarium wilt

1. On nurseries where cyclamen wilt is a persistent problem growers should consider amendment of peat growing medium with pine bark, larch and spruce bark, woodfibre, or composted bark and paper, in order to reduce the risk of a severe problem with the disease.

2. Growers should consider combining use of a suppressive medium with a fungicide or biocontrol agent.

3. Providing sufficient air-movement to prevent botrytis can be achieved by spacing, ventilation and fans, growers should consider growing cyclamen on capillary matting rather than open benches in order to reduce the risk of rapid spread of fusarium wilt.

4. Drenching plants with Octave (four times at 0.5g/l starting immediately after potting or three times at 1 g/l starting one month after potting) gave very good control of wilt with no adverse effect on plant growth. As this fungicide is also effective against three other major disease of cyclamen (anthracnose, botrytis and brown root rot), an on-label or specific off-label approval for use of this product should be urgently pursued.

5. Growers wishing to control fusarium wilt other than by fungicide treatment should consider use of Mycostop, if it becomes available in the UK.

Black root rot of pansy

1. Drenching plants with Bavistin DF (1 g/l) three times at monthly intervals after potting gave very good control of black root rot. There was still significantly less black root rot in fungicide-treated plants 8 weeks after the final treatment. Given the frequent occurrence of black root rot in plug-raised pansies in recent years, growers should consider use of Bavistin for control of this disease.

2. Unless acidified water is used for watering it is unlikely that a low initial pH will have a marked effect on development of black root rot.

Pythium root rot of poinsettia

1. Monthly drenches of Aaterra (1 g/l) or Fongarid (1 g/l) were found to be very effective. Filex was more effective when used on plants in peat than in peat/bark.

2. Use of bark and other amendments gave no advantage.

INTRODUCTION

HDC - funded work in 1991 (Project PC50) demonstrated a significant reduction in development of cyclamen fusarium wilt when bark (Cambark Fine) or woodfibre were incorporated into the growing medium. Drenching plants with Octave at monthly intervals also reduced the disease, and the combined effect of bark and Octave appeared to reduce disease more than either treatment on its own. Application of an experimental fungicide also provided very good disease control with no adverse effect on plant growth.

The work described here was designed to investigate the reliability of disease suppression when using growing medium amendments and to extend the work to other pot plant/root disease combinations, namely, pythium root rot of poinsettia, phytophthora root rot of saintpaulia and black root rot of pansy. In addition, some potentially useful new fungicides and biocontrol agents were tested and compared with currently recommended products. The overall aim was to achieve reliable and durable control of root disease using an integrated disease control strategy. This approach to disease control maximises use of good hygiene, appropriate cultural measures and effective biocontrol agents, together with timely use of fungicides. It should reduce the need for frequent fungicide treatment and thereby reduce the risk of environmental pollution and of pathogens developing fungicide resistance.

MATERIALS AND METHODS

Variety and source of plants

These are listed in the table below. Samples of each species were examined for fungal pathogens before potting as a check on the health status of planting material; cyclamen plants were tested for tomato spotted wilt virus (TSWV).

Species	Variety	Source
Cyclamen	Sierra White with Eye	Colegrave Seeds
Pansy	Universal Beaconsfield	Colegrave Seeds
Poinsettia	Lilo	Findens
Saintpaulia	Jupiter (Cosmos series)	Royal Eveleens

Source and culture of fungi

Fungi were obtained by isolation from diseased plants (below) onto potato dextrose agar (PDA) amended with streptomycin. Cultures were grown on PDA or V8-juice agar with plates incubated at 20°C under UV light.

Fungus	Source	Culture
Fusarium oxysporum f.sp. *cyclaminis*	Cycalmen (Herts)	PDA
Thielaviopsis basicola	Pansy (ADAS Wolverhampton)	V8-juice agar
Pythium sp. (Group G)	Poinsettia (PC 91/1412)	PDA
Phytophthora cryptogea	Gerbera (M McPherson)	PDA
Phytophthora nicotianae	Saintpaulia (Kent)	PDA

Source and grade of growing media and amendments

Growing media were prepared in a rotary mixer at HRI Efford and samples were taken for chemical analysis and determination of air-filled porosity (AFP) after mixing. The vesicular-arbuscular mycorrhizal inoculant (VAM) was added immediately before potting. Sources and grades of materials are listed below.

Medium/ amendment	Source	Grade	Rate of use by volume (%)
Peat	Irish sphagnum	Standard	60
Irish peat	Bord na Mona	Special (suppressive)	100
Finnish peat	Finnfibre	Vapo	100
Russian Peat	D L Coutts	Novobalt	100
Pine bark	Cambark	Fine	40
Wood fibre	J McLauchlan Horticulture	Fine	40
Larch/Spruce bark	Sinclair	Composted	40
Pine bark	Melcourt	Composted	40
Bark and paper	Sinclair	Composted	40
Straw (processed)	Bridgemere	Fi-Pro	40
Perlite	Silva Perle	Standard	40
Chitin	Sigma Chemicals	Powder of crushed crab shells	1
VAM inoculant	AGC	Mix of 3 strains	5

Fertiliser addition at mixing consisted of

	kg/m^3	
Calcium nitrate	1.15	(low pH treatments only)
Ammonium nitrate	0.4	(Nil for low pH treatment)
Potassium nitrate	0.75	
Single superphosphate	1.2	
Dolomite lime	2.5	(2.0 Kg/m^3 for low pH treatment)
Frit WM255	0.4	

An additional 1 kg/m^3 ground chalk was added to all-peat composts. Additional ammonium nitrate was added to wood fibre, bark/paper, composted pine bark and Fi-pro straw (0.2 kg/m^3) and to Cambark bark (0.4 kg/m^3).

Where required, bark was autoclaved twice for 15 minutes at 15 psi, and leached by soaking in water three times for 24 hours, using two volumes of water to one volume of bark.

Fungicides and biocontrol agents

Product	Rate used (g/l)	Active ingredient (%)
Aaterra	1	etridiazole
Bavistin DF	1	carbendazim
Experimental	1 & 0.5	-
Filex	1.5 ml	propamocarb HCl
Fongarid 25	1	furalaxyl
Octave	1 & 0.5	prochloraz Mn
Mycostop[a]	0.05	*Streptomyces* sp.
Polygandron[b]	0.5	*Pythium oligandron*

[a] Obtained from Kemira Oy, Finland
[b] Obtained from Dr D Vesely, Czechoslovakia

Products were applied as drenches poured onto the compost surface at 50ml/plant (pansy) or 100ml/plant (cyclamen and poinsettia). Water drenches were applied to the control plants not receiving a fungicide treatment.

Location of work

Fungal culturing and preparation of inoculum and infector plants were carried out at ADAS Cambridge. Experiments were carried out at MKM Nurseries, Bell Bar, Hatfield, Herts. at Europa Nurseries, Hadlow, Kent and at HRI Efford (E block). The experiments at each location were:

Exp.	Crop	Disease	Site	Factors investigated
1.	Cyclamen	Fusarium wilt	Herts	Growing media
2.	Cyclamen	Fusarium wilt	HRI Efford	Media, watering and inoculation.
3.	Cyclamen	Fusarium wilt	Herts	Fungicides and biocontrol agents (BCA)
4.	Saintpaulia	Phytophthora root rot	HRI Efford	Media, fungicides and BCAs
5.	Pansy	Black root rot	Kent	Media, fungicides and BCAs
6.	Poinsettia	Pythium root rot	Kent	Media, fungicides and BCAs

Crop culture

Details of crop culture were:

	Exp. 1 Cyclamen	Exp. 2 Cyclamen	Exp. 3 Cyclamen	Exp. 4 Saintpaulia	Exp. 5 Pansy	Exp. 6 Poinsettia
Pot size	12C	12C	12C	9 cm	9 cm	13 cm
Bench type	Wire mesh	Wire mesh and solid	Wire mesh	Solid	Outside	Solid
Watering	Hand	Hand and cap matting	Hand	Capillary matting	Mypex matting	Capillary matting
Shading	Yes	Yes	Yes	Yes (double)	Nil	Nil
Fungicides	Rovral	Rovral	Rovral	Nil	Nil	Nil
Insecticides	Yes	Nil	Yes	Nil	Nil	Nil
Natural enemies	Nil	Yes	Nil	Nemasys	Nil	Encarsia

Inoculation of plants

Sporing cultures of *F.oxysporum* and *T.basicola* were flooded with sterile water and the culture surface scraped with a sterile needle. The resultant spore suspensions were filtered through muslin into a McCartney bottle and the concentration of spores determined by use of a haemocytometer.

The spore concentrations were adjusted as necessary by dilution with sterile water. The greatest dilutions were checked under the haemocytometer to ensure that the required number of spores were present. Spores suspensions were applied to plants by pouring them onto the growing medium surface around the pot edge (cyclamen) or over the young plant (pansy). The suspensions were agitated frequently to maintain an even suspension. Cyclamen were inoculated with 100 ml of 10^3/ml spore suspension (standard concentration) or 10/ml (low concentration, used in experiment 2). Pansies were inoculated with 50 ml of a 10^3/ml spore suspension.

Saintpaulia compost was infested with *P.cryptogea* as an 8mm diameter mycelial plug near the pot base. Poinsettia compost was infested by mixing cultures of *Pythium* sp. with peat and incorporating a basal layer (1cm depth) of infested compost. Saintpaulia and poinsettia compost was kept wet for two periods of 3 days in the first 14 to encourage fungal development.

Disease assessment

Plants were assessed weekly (Exp. 2), fortnightly (Exps. 1, 3 and 4) or monthly (Exps. 5 and 6) and those that were severely wilting, dying or dead were removed and examined for fungal pathogens. Root extent and root rotting were determined at the final assessment of all trials.

Mycorrhiza

Samples of roots from plants grown in media amended with VAM were examined microscopically by AGC MicroBio Ltd to determine if mycorrhizal associations had established.

Quality assessments

Plant quality was assessed in 10 uninoculated plants in each treatment. All plants were examined and scored for size, shape and marketability. Details of assessment categories are given below the relevant tables in the results section.

Experiment design

Experiments consisted of randomised blocks with fourfold replication. Treatment 1 (control) was duplicated in each block in experiments 1, 3 and 5. There were factorial sets of treatments in experiments 2, 4, 5 and 6. A plot consisted of 20 plants (cyclamen experiments 1 and 3); 18 plants (pansy), 16 plants (saintpaulia) and 10 plants (cyclamen experiment 2 and poinsettia).

Statistical analysis

An analysis of variance was carried out on each data set. Angular transformation was carried out to convert % data to a normal distribution. Duncans multiple range test was used to compare means.

Crop diary

Dates of potting, inoculation, treatment with fungicides and biocontrol agents, first confirmation of disease and assessments are summarised in the table.

		Exp. 1 Cyclamen	Exp. 2 Cyclamen	Exp. 3 Cyclamen	Exp. 4 Saintpaulia	Exp. 5 Pansy	Exp. 6 Poinsettia
Potted		12 June	15 June	12 June	29 July	30 July	6 Aug
Inoculated		30 June	18 June	30 June	29 July	13 Aug	6 Aug
Fungicides/BCAs	1.	-	-	17 June	29 July (B) 6 Aug (F)	30 July	13 Aug
	2.	-	-	15 July	25 Aug (B)	6 Aug	10 Sept
	3.	-	-	12 Aug	1 Sep (F)	8 Oct	8 Oct
	4.	-	-	9 Sep	21 Sept (B)		
	5.	-	-		28 Sep (F)		
Disease first confirmed		29 July	27 July	29 July	-	10 Sep	20 Aug
Main assessments		Every 14 days	Weekly	Every 14 days	19 Aug 8 Sept	26 Aug	16 Nov
Final assessment		13 Jan	11 Dec	7 Jan	29 Sep	10 Dec	17 Dec

B - biocontrol agent
F - fungicide

EXPERIMENTAL

EXPERIMENT 1: EFFECT OF GROWING MEDIUM AMENDMENTS ON CYCLAMEN FUSARIUM WILT

Objective

To investigate the mechanism of disease suppression observed with bark and wood fibre amendments and the effect of type of bark on the level of suppression, and the effect of type of peat on disease development.

Treatments

1. Peat (pH 5.5)
2. Peat/Bark (pine, Cambark Fine)
3. Peat/autoclaved bark
4. Peat/leached bark (extracted with water)
5. Peat/wood fibre (fine grade)
6. Possible suppressive peat (Irish ex Bord na Mona)
7. " " " (Vapo ex Finnfibre)
8. " " " (Novobalt ex D. L. Coutts)
9. Peat/composted larch and spruce bark (ex Sinclair)
10. Peat/composted bark and paper (ex Sincliar)
11. Peat/composted pine bark (ex Melcourt)
12. Peat/Fi-Pro straw (ex Bridgemere)

Results

Crop nutrition

Initial nutrient levels of the composts immediately after mixing were satisfactory. Surprisingly, the air-filled porosity (AFP) of peat was not increased by addition of 40% bark, perlite, woodfibre or straw (Table 1).

Some plants, especially in media with paper, straw or woodfibre amendment, showed yellowing or pale green leaves in early August. Analysis of media revealed low levels of NO_3-N (Table 2) despite liquid feeding. A liquid feed was applied twice differentially to even levels.

Table 1. Initial air-filled porosity of media

	Medium	AFP*
1.	Peat	12.2
2.	Peat/Bark	9.5
3.	Peat/Perlite	9.8
4.	Peat/Woodfibre	12.9
5.	Peat/Fi-Pro straw	10.2

* Mean result of 3 determinations

Plant Quality

The effect of growing media on growth of non-inoculated plants 6 weeks after potting is shown Table 3. All amendments appeared to improve early plant growth with woodfibre and composted pine bark particularly effective.

Amendment with pine bark appeared to delay slightly flower production and amendment with Fi-Pro straw appeared to improve flower production compared to the standard peat treatment. Other amendments had no obvious effect on flowering.

The effect of treatments on final plant quality is shown in Table 4. Results should be interpreted with caution as there were relatively few surviving plants in some treatments.

Disease

Neither fungal pathogens nor TSWV were found in young plants examined before potting. Fusarium wilt was first confirmed on 29 July four weeks after inoculation and the incidence of affected plants increased steadily thereafter (Figs 1-2). Fusarium wilt occurred first in the standard peat treatment and did not occur until 5 weeks later in the woodfibre, Finnish peat and composted bark and paper treatments. The number of plants affected by wilt increased rapidly in the standard peat and Russian peat and relatively slowly in the woodfibre, Fi-pro straw, Finnish peat, composted bark and paper, composted pine bark and larch/spruce bark treatments. At assessment on 9 September, 21 October and 2 December (Table 5) the incidence of plants affected by fusarium wilt was significantly reduced by all treatments except the Russian peat. Amendment with woodfibre was the most effective treatment. At the final assessment on 7 January, 90% of plants in the standard peat had died due to fusarium wilt, compared to 20% in the woodfibre treatment. Further results of disease assessments are shown in Appendix 1.

The leachate from pine bark was incorporated in PDA plates and the plates inoculated with *F.oxysporum* f.sp. *cyclaminis*. No inhibition of mycelial growth was observed.

Botrytis leaf and corm rotting also occurred in the trial, predominately on plants affected by fusarium wilt. Botrytis sporulation appear to be most profuse on plants in composted pine bark and least on plants in woodfibre.

Table 2. Nutrient levels of growing media (Experiment 1) 20 Aug 1992.

Growing medium	pH	Conduct µS (index)	P mg/l (index)	K mg/l (index)	Mg mg/l (index)	NO_3-N mg/l (index)	NH_4-N mg/l (index)
1. Peat	5.5	345 (2)	48 (6)	65 (2)	95 (7)	86 (4)	5.0 (0)
2. Bark	5.4	331 (2)	37 (5)	62 (2)	76 (6)	93 (4)	8.0 (0)
3. Irish peat	5.7	233 (1)	32 (5)	23 (0)	65 (6)	24 (1)	1.0 (0)
4. Finnish peat	5.7	239 (1)	24 (4)	53 (2)	50 (5)	30 (2)	6.0 (0)
5. Russian peat	5.5	216 (1)	15 (3)	45 (1)	35 (4)	39 (2)	9.0 (0)
6. Larch + spruce	6.0	308 (2)	36 (5)	80 (2)	63 (6)	66 (3)	0.0 (0)
7. Bark + paper	6.2	221 (1)	25 (4)	47 (1)	41 (5)	8 (0)	0.0 (0)
8. Compo pine bark	5.4	268 (1)	37 (5)	46 (1)	68 (6)	25 (1)	8.0 (0)
9. Fipro straw	5.9	255 (1)	46 (6)	45 (1)	54 (6)	12 (0)	5.0 (0)

Table 3. Effect of growing media on plant growth

Treatment	Mean quality score (1-5)
Peat	2.8
Peat/Bark	3.3
Peak/Woodfibre	3.6
Peat/larch and spruce bark	3.0
Peat/composted bark and paper	2.9
Peat/composted pine bark	3.3
Peat/Fi-Pro straw	3.1
Peat + Mycostop	3.0
Peat + VAM	3.0

Mean results for 8 uninoculated plants, 6 weeks after potting

Key for quality assessment

1 - Sparse leaf growth
2 - Poor leaf canopy
3 - Reasonable leaf canopy
4 - Well developed leaf canopy
5 - Well developed and even leaf canopy

Table 4 Effect of growing medium amendments on quality of surviving cyclamen - 7 January 1993

Treatment	Quality index (1-5)	Root extent (0-5)	Root rot (0-5)	No. plants assessed
1. Peat	4.0	3.3	1.3	3
2. Peat/bark	3.3	3.4	1.1	5
3. Peat/autoclaved bark	3.4	3.8	1.3	30
4. Peat/leached bark	3.6	4.3	1.3	14
5. Peat/wood fibre	2.7	4.8	1.6	58
6. Irish peat	3.8	4.4	1.3	12
7. Finnish peat	2.6	4.9	2.5	39
8. Russian peat	2.0	3.0	3.0	1
9. Peat/larch + spruce	3.0	4.3	1.5	21
10. Peat/bark + paper	3.0	4.6	1.7	40
11. Peat/composted pine bark	3.2	3.9	1.3	45
12. Peat/Fi-Pro Straw	2.8	4.4	1.5	40

Quality index:

1 - Sparse growth of leaves and flowers
2 - Poor growth of leaves and flowers
3 - Reasonable canopy of leaves and number of flowers
4 - Well developed leaf canopy and good number of flowers
5 - Well developed and even leaf canopy; good number of flowers/buds

Root extent:

0 - No roots visible
1 - Very poor root growth
2 - Poor root growth
3 - Moderate root growth
4 - Good root growth (part of root ball)
5 - Good root growth (all root ball)

Root rot:

0 - No rot visible
1 - Very slight rot
2 - Slight rot
3 - Moderate rot
4 - Severe rot (part of exposed root)
5 - Severe rot (all of exposed root)

Fig 1. Effect of bark amendments on cyclamen fusarium wilt

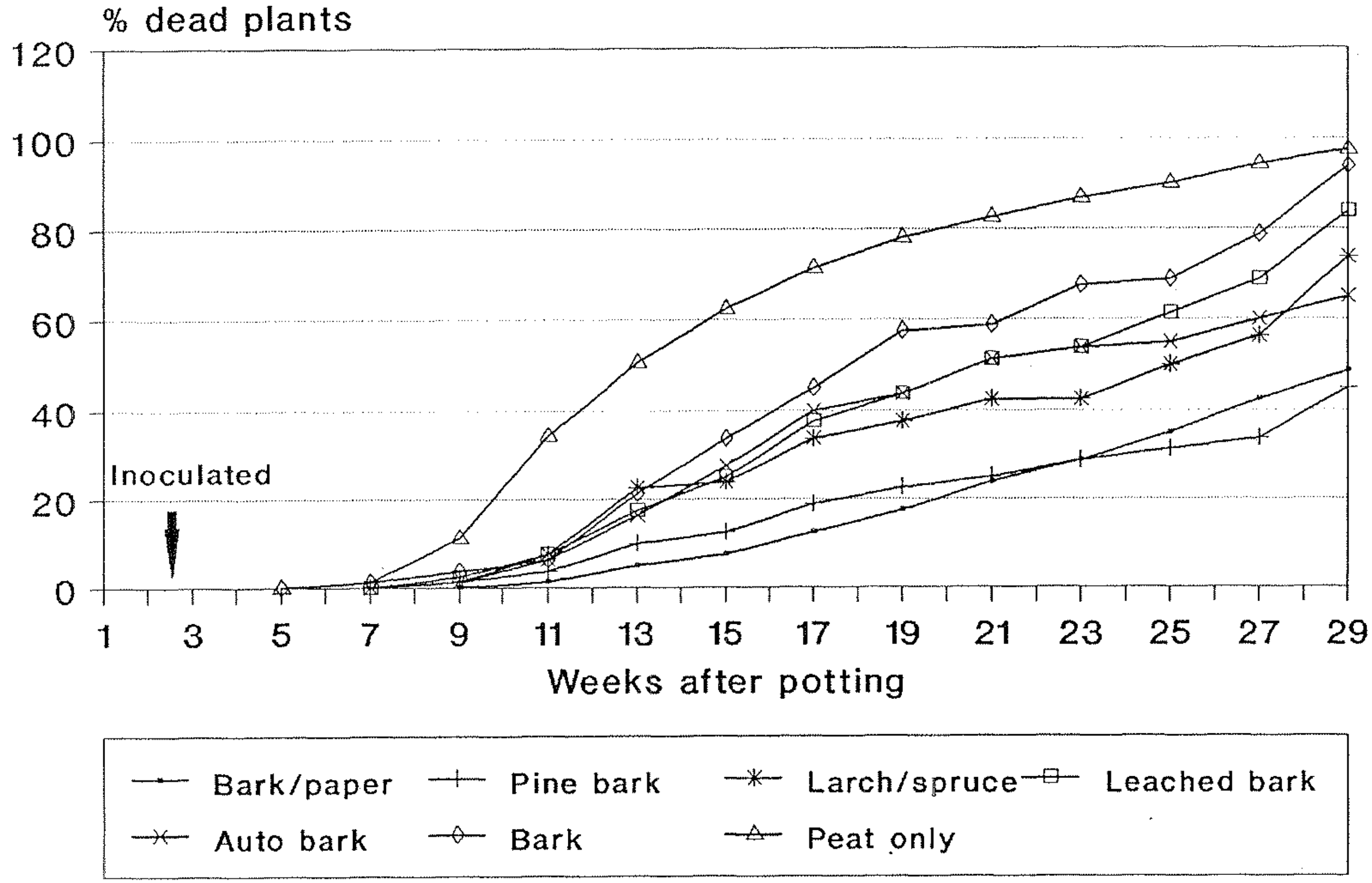

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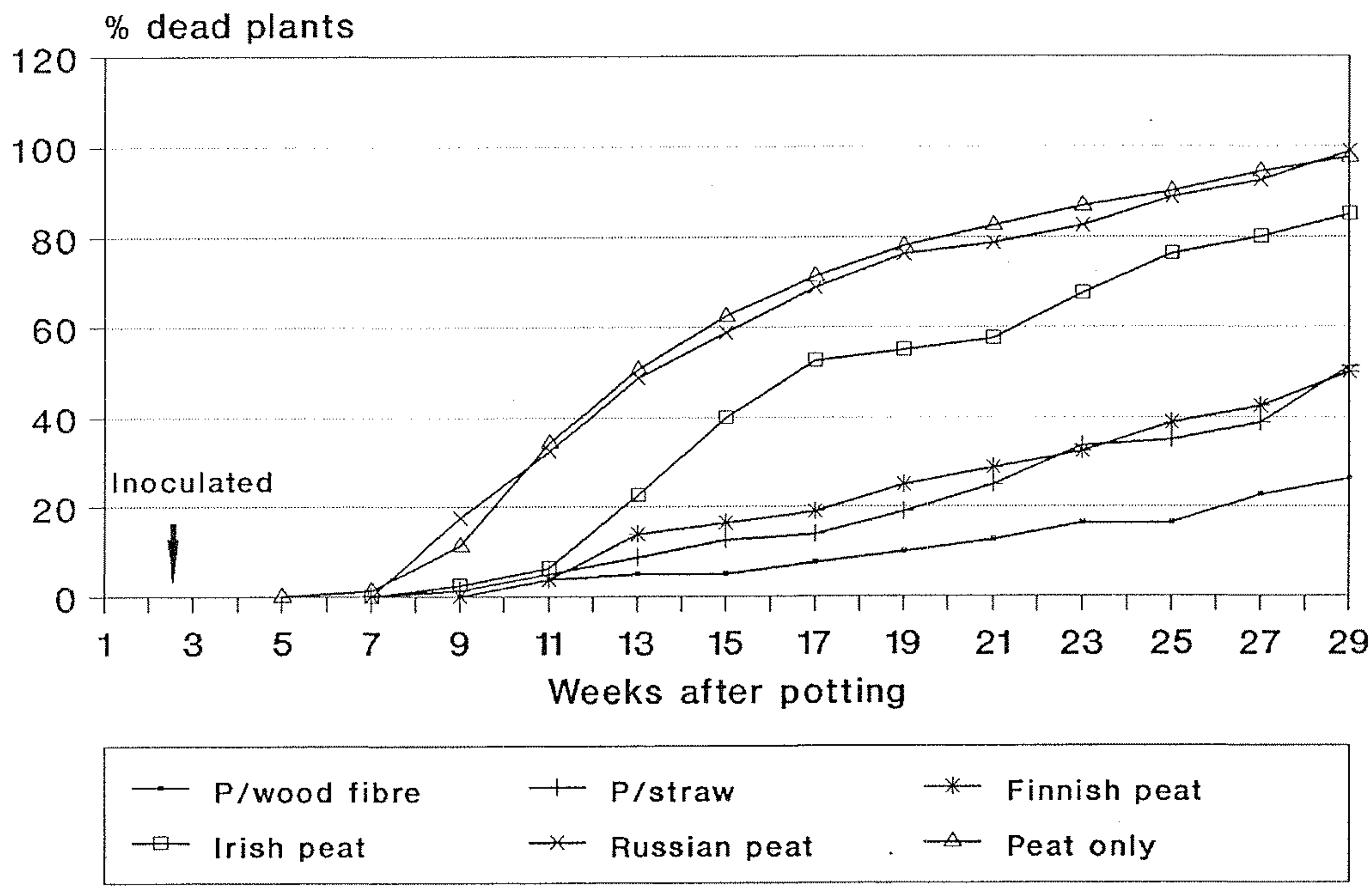
Fig 2. Effect of woodfibre, straw, & peat on cyclamen fusarium wilt



MKMAmen2

Table 5. Effect of growing medium on cumulative incidence of cyclamen fusarium wilt - 1992.

Treatment	% dead plants 9 September		21 October	
1 Peat (control)	50.6	(45.4)c	78.1	(62.6)f
2 Peat/Bark	21.2	(27.3)b	57.5	(49.4)e
3 Peat/autoclaved bark	16.2	(23.6)b	43.7	(41.4)de
4 Peat/leached bark	17.5	(24.0)b	43.7	(41.3)de
5 Peat/wood fibre	5.0	(9.2)a	10.0	(16.0)a
6 Irish peat	22.5	(27.6)b	55.0	(48.0)e
7 Finnish peat	13.7	(21.6)ab	25.0	(29.8)bc
8 Russian peat	48.7	(44.5)c	76.2	(62.1)f
9 Peat/larch + spruce	22.5	(27.9)b	37.5	(36.9)cd
10 Peat/bark + paper	5.0	(11.1)a	17.5	(24.5)ab
11 Peat/composted pine bark	10.0	(17.9)ab	22.5	(28.3)ab
12 Peat/Fi-Pro straw	8.7	(17.1)ab	18.7	(25.4)ab
SED between treatments	7.96	(5.75)	7.40	(5.07).
control vs treatment	6.89	(4.98)	6.40	(4.39)
F prob	-	<0.001	-	<0.001

	2 December		7 January	
1 Peat (control)	90.0	(73.4)h	97.5	(85.4)f
2 Peat/Bark	68.7	(56.3)fg	93.7	(77.8)f
3 Peat/autoclaved bark	55.0	(48.0)def	65.0	(53.8)cd
4 Peat/leached bark	61.2	(51.6)efg	83.7	(66.4)e
5 Peat/wood fibre	16.2	(23.8)a	26.2	(30.8)a
6 Irish peat	76.2	(61.3)g	85.0	(67.8)e
7 Finnish peat	38.7	(38.5)acd	50.0	(45.0)bc
8 Russian peat	88.7	(73.1)h	98.7	(86.8)f
9 Peat/larch + spruce	50.0	(44.9)cde	73.7	(60.8)de
10 Peat/bark + paper	35.0	(36.1)bc	48.7	(44.3)bc
11 Peat/composted pine bark	31.2	(33.8)b	45.0	(42.1)b
12 Peat/Fi-Pro straw	35.0	(36.0)bc	51.2	(45.7)bc
SED between treatment	6.54	(4.99)	5.42	(4.96)
control vs treatment	5.66	(4.32)	4.69	(4.30)
F prob	-	<0.001	-	<0.001

Angular transformed values are shown in parenthesis.

Figures in the same column not sharing a common letter are significantly different at P = 0.05.

Discussion

All of the bark amendments significantly reduced the development of fusarium wilt at one or more assessments, with composted pine bark and composted bark and paper more effective than other bark amendments. Disease suppression given by matured more pine bark (Cambark Fine) was similar to that observed in 1991 (PC50). The greater degree of suppression given by composted barks indicates that the type and preparation of a bark can influence its suppressive effect. Hoitink & Fahy (1986) reported a greater degree of disease suppression with older barks.

Neither leaching pine bark in water nor autoclaving it removed the suppressive effect on cyclamen fusarium wilt. The first result suggests that disease suppression is not due to a water soluble inhibitor and the second result suggests that disease suppression is not biological in origin or due to the presence of a heat-labile chemical inhibitor. This second result is in contrast to that obtained by Chef *et al.* (1983) where suppression of fusarium wilt of chrysanthemum and flax by mature hardwood bark compost was negated by heating. The mechanism of disease suppression of cyclamen fusarium wilt by bark thus remains unknown. Possibly the disease suppression may be related to nitrogen immobilisation by bark, for although extra nitrogen was added to all media with added bark (except composted larch/spruce), woodfibre or processed straw, analysis of them 10 weeks after potting revealed very low levels of nitrate compared to the control peat medium. However, in Experiment 2 nitrogen levels were not low in bark-amended media and suppression of fusarium wilt was still observed. Suppression of fusarium wilt of radish in a container medium amended with composted hardwood bark was affected by form of nitrogen but not by nitrogen concentration (Trillas-Gray, 1986). High levels of calcium nitrate reduced disease severity while ammonium nitrogen had no significant effect. Fusarium yellows of celery was more severe with ammonium nitrate than with nitrate nitrogen, irrespective of accompanying ions (Schneider, 1985). Further work is needed to investigate the mechanism of fusarium wilt suppression by bark, woodfibre and straw.

There was a marked difference in the rate of fusarium wilt development in four different types of peat. Irish sphagnum peat and a Russian peat were very conducive while a special Irish peat was moderately suppressive and a Finnish peat was very suppressive. The four peats all had a similar starting pH (5.2-5.4) at potting so it seems unlikely the pH is responsible for the effect. However, when media were analysed on 20 August the pH of the two suppressive peats was slightly greater (5.7) than that of the two conducive peats (5.5). Scher & Baker (1980) reported that carnation fusarium wilt was worse at lower pH values in a sandy loam soil. Tahvonen (1982) isolated a number of *Streptomyces* spp. from light-coloured peats, while darker peats from deeper layer yielded fewer *Streptomyces* spp. Both the light-coloured peat in mixes and the isolated *Streptomyces* spp. suppressed fusarium wilt of carnation. Possibly the Finnish peat used in our experiment contained a greater number of *Streptomyces* spp than the other peats.

EXPERIMENT 2: FACTORS AFFECTING DEVELOPMENT OF CYCLAMEN FUSARIUM WILT

Objective

To investigate the effect of inoculum level, inoculation site and method of watering on the degree of disease suppression by bark.

Treatments

	Medium	Inoculum level	Inoculation site	Watering
1.	Peat	Low	Compost surface	Standard (capillary matting)
2.	Peat/bark	Low	Compost surface	Standard (capillary matting)
3.	Peat	Standard	Compost surface	Standard (capillary matting)
4.	Peat/bark	Standard	Compost surface	Standard (capillary matting)
5.	Peat	Low	Pot base	Standard (capillary matting)
6.	Peat/bark	Low	Pot base	Standard (capillary matting)
7.	Peat	Standard	Pot base	Standard (capillary matting)
8.	Peat/bark	Standard	Pot base	Standard (capillary matting)
9.	Peat	Low	Compost Surface	By hand (on wire mesh bench)
10.	Peat/bark	Low	Compost Surface	By hand (on wire mesh bench)
11.	Peat	Standard	Compost Surface	By hand (on wire mesh bench)
12.	Peat/bark	Standard	Compost Surface	By hand (on wire mesh bench)
13.	Peat	Low	Pot base	By hand (on wire mesh bench)
14.	Peat/bark	Low	Pot base	By hand (on wire mesh bench)
15.	Peat	Standard	Pot base	By hand (on wire mesh bench)
16.	Peat/bark	Standard	Pot base	By hand (on wire mesh bench)

Results

Nutrition

Nutrition levels were determined six weeks after potting and found to be satisfactory (see below). Liquid feed was applied with each watering thereafter.

Treatment	pH	Cond µS (index)	P mg/l (index)	K mg/l (index)	Mg mg/l (index)	NO_3 mg/l (index)	NH_4 mg/l (index)
Peat	5.4	403 (3)	55 (6)	171 (3)	90 (7)	192 (5)	36 (1)

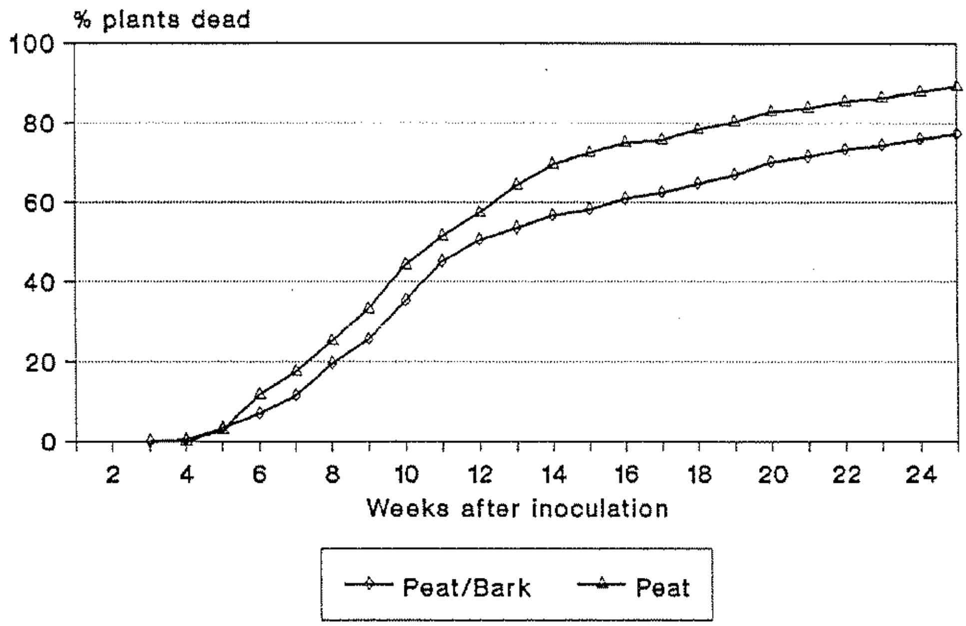
Disease

Fusarium wilt was first confirmed on 27 July, 5 weeks after inoculation. The disease increased most rapidly in the peat medium; with a standard inoculum; when inoculated from above, and when hand watered (Figs 3 and 4). Further results for individual treatments are given in Appendix 2A.

The effects of inoculum level, inoculation site and watering method on the level of disease suppression by bark are shown in Figs 5-7. Further results are given in Appendix 2B. At an assessment 14 weeks after inoculation, there was significant reduction in plant death with bark amendment under all inoculation and watering conditions. The suppression of fusarium wilt by bark was greatest at low inoculum levels (Fig 5).

Fig 3. Effect of growing medium and inoculum level on cyclamen fusarium wilt

Growing medium



Inoculum level

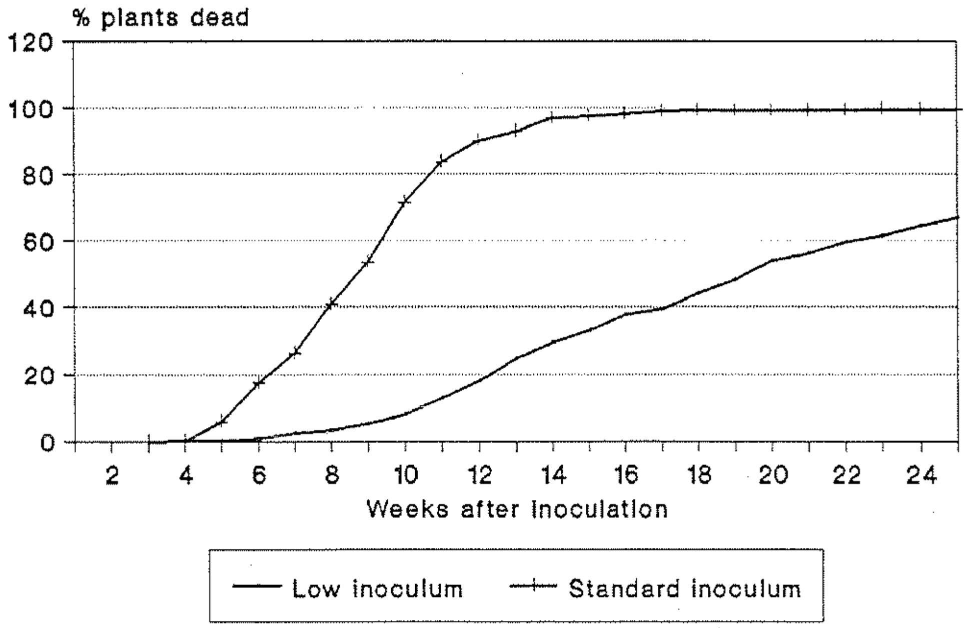
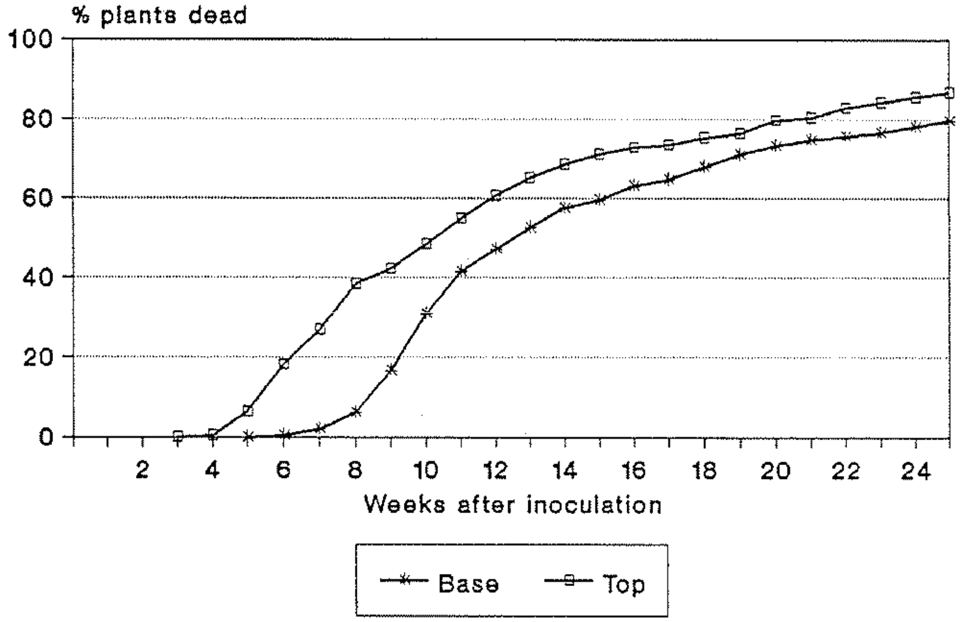


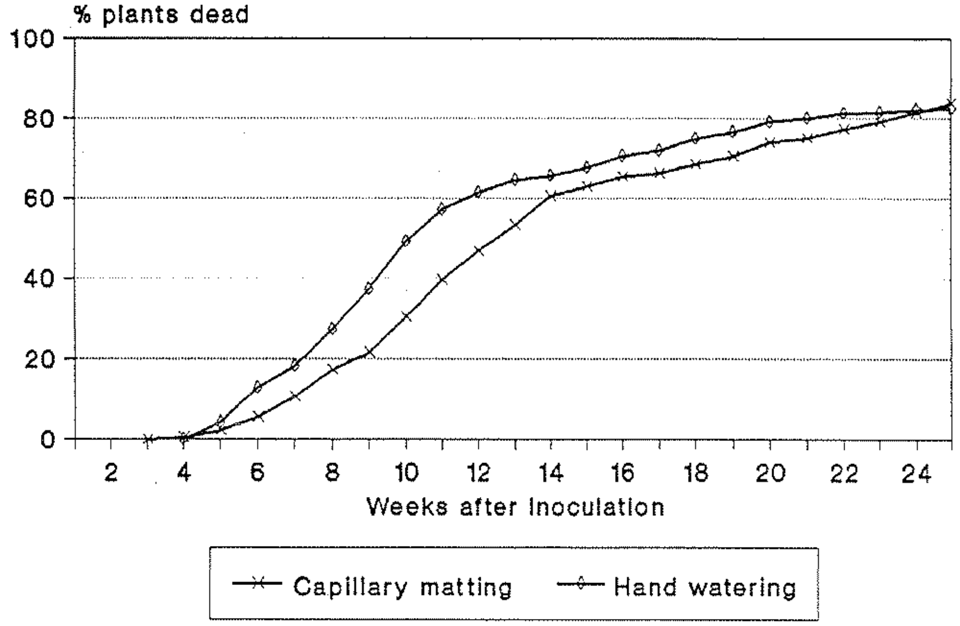
Fig 4. Effect of inoculation site and watering method on fusarium wilt

Inoculation site



Eff7

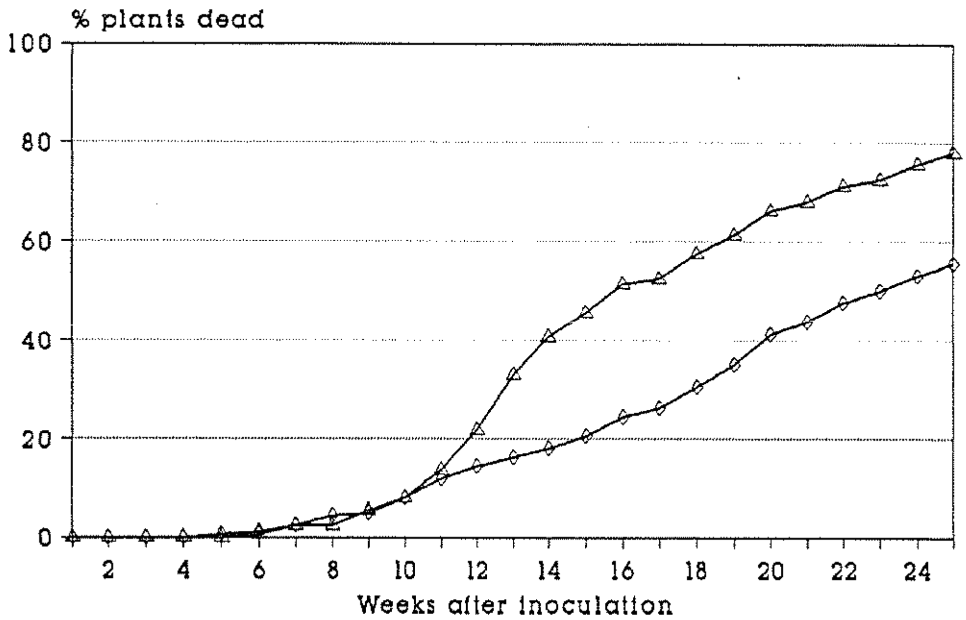
Watering method



Eff6

Fig 5. Effect of inoculum level on suppression of fusarium wilt by bark

Low inoculum



Standard inoculum

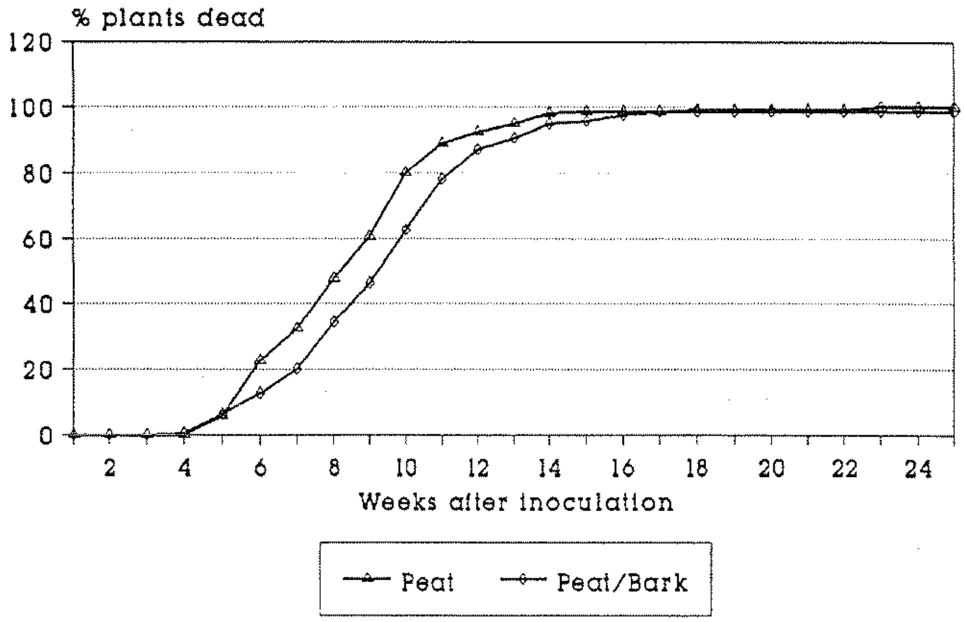
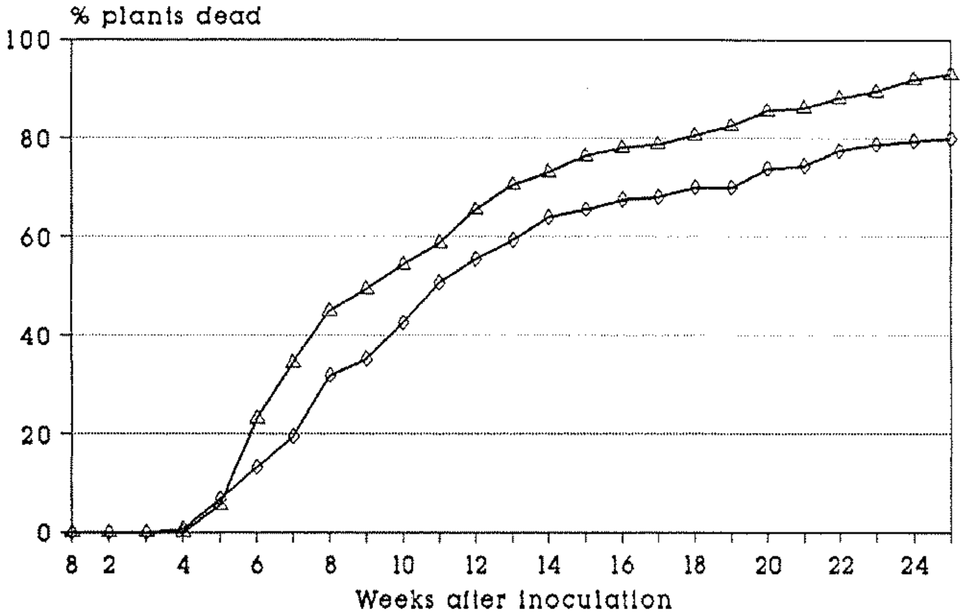


Fig 6. Effect of inoculation site on suppression of fusarium wilt by bark

Surface inoculation



Basal inoculation

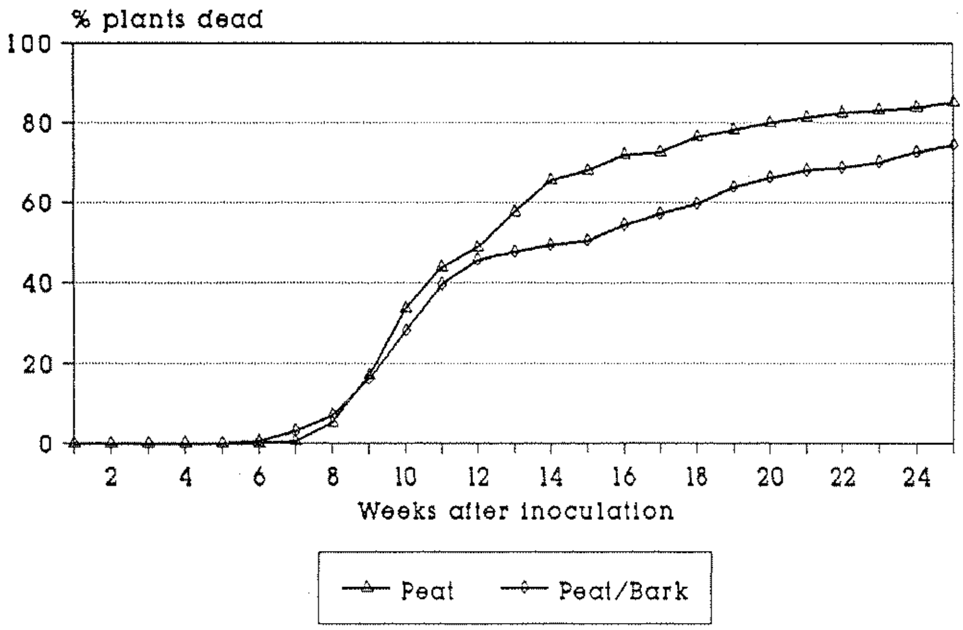
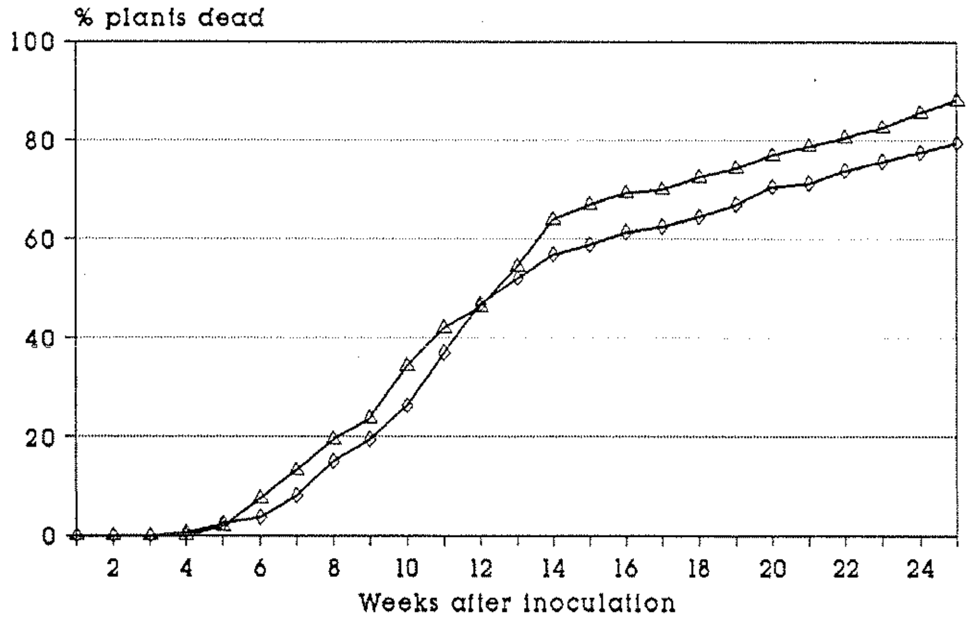
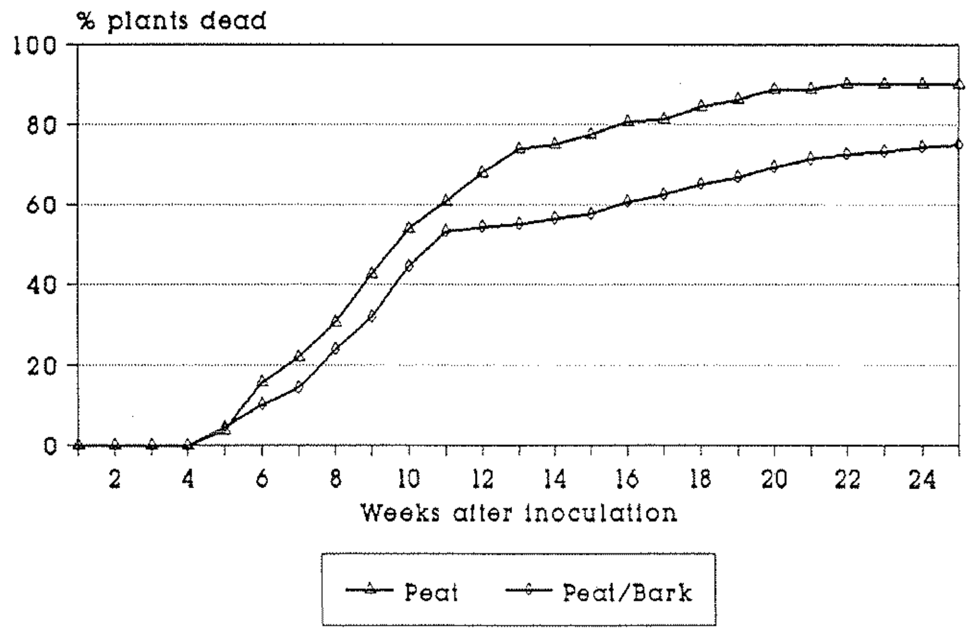


Fig 7. Effect of watering method on suppression of fusarium wilt by bark

Capillary matting



Hand watered



Discussion

The effect of inoculum level on development of fusarium wilt was in agreement with earlier studies (MAFF Project PC 23/023). Application of 10^5 spores/plant resulted in rapid symptom development 7-11 weeks after inoculation; with 10^3 spores/plant it was 13 weeks before there was rapid symptom development. The delay to symptom expression when using a low inoculum suggests that a minimum inoculum potential is necessary before *F.oxysporum* f sp. *cyclaminis* is able to infect and colonise the vascular system of cyclamen plants. It is possible that plants growing in compost contaminated with *F.oxysporum* f.sp. *cyclaminis* at a very low level may not develop symptoms of wilt.

Plants inoculated from the top by drenching with a suspension of spores and plants inoculated from the bottom by standing in a saucer of spore-suspension both developed symptoms of wilt. Rapid symptom development occurred 7-11 weeks after inoculation when drenched from above, and 9-13 weeks after inoculation when inoculated from below. These results suggest that the delay to symptom expression is likely to be greater when the pathogen spreads between pot bases than when spores are blown or splashed from plant to plant.

Rattink (1990) found that introduction of *F.oxysporum* f.sp. *cyclaminis* into the nutrient solution of an ebb and flow system resulted in dispersal of spores into the potting soil, but did not result in a noticeable occurrence of fusarium wilt in the cyclamen crop. Inoculation from the pot base and dilution of inoculum (in a large volume of nutrient solution and by settlement) are both factors which would reduce the speed of symptom development; possibly fusarium wilt would have developed if plants had been grown for a more extended period.

Plants stood on an open bench and watered by hand developed symptoms of fusarium wilt more rapidly than plants stood on capillary matting and not watered from above. Plants hand-watered are alternately in wet and dry compost while those on capillary matting have a more even moisture content. Moisture content may affect the ability of *F.oxysporum* f.sp. *cyclaminis* to infect roots. Another possible explanation is that plants on capillary matting may develop a better root system than plants hand watered and consequently are able to withstand some root loss to fusarium, at least initially. Hand-watering may also increase the risk that spores are splash-spread in water droplets onto the corm, or main roots around the corm, sites where infection is more liable to result in rapid plant wilting than infection of minor roots at the pot base.

EXPERIMENT 3: FUNGICIDES AND BIOCONTROL AGENTS FOR CONTROL OF CYCLAMEN FUSARIUM WILT

Objective

To investigate the effect of fungicides, biocontrol agents and growing medium amendments on development of fusarium wilt.

Treatments

1. Peat (pH 5.5)
2. Peat/Bark (60:40)
3. Peat/Chitin (1%)
4. Peat + Bavistin DF (1g/l) monthly (maximum of 4)
5. Peat + Octave (0.5g) monthly (maximum of 4)
6. Peat + Bavistin DF (1g/l) then Octave (1g/l) after 1, 2 and 3 months (total of 4 drenches)
7. Peat + Experimental fungicide (1 g/l) applied twice (after potting and 1 month later)
8. Peat + Experimental fungicide (0.5g/l) applied twice (after potting and 1 month later)
9. Peat + Mycostop monthly (maximum of 4) (1g/20l and 100ml/plant)
10. Peat + mycorrhizal inoculant (ex AGC) at 5% V/V incorporation

First fungicide and biocontrol treatments were applied five days after potting.

Disease

Neither fungal pathogens nor TSWV were found in young plants examined before potting.

Fusarium wilt was first confirmed on 29 July, four weeks after inoculation, and the incidence of affected plants increased steadily thereafter (Figs. 8-9). The number of plants affected by wilt increased most rapidly where plants were grown in peat with no fungicide or biocontrol drenches applied. All fungicide and biocontrol treatments appeared to reduce the occurrence of wilt, with Octave the most effective of the fungicides and chitin the most effective of the biocontrol agents. When plants were in flower in early December, the incidence of wilt was significantly reduced by bark, chitin, Octave and Bavistin/Octave (Table 6). Drenching with Bavistin and incorporation of a mycorrhizal inoculant did not significantly reduce the disease. Drenching with Mycostop resulted in a significant reduction in the incidence of wilt at one assessment (26 August). Further results of disease assessments are shown in Appendix 3.

Phytotoxicity

Treatment with the experimental fungicide at 1g/l resulted in stunted plant growth. None of the other treatments had a visible effect on growth.

Plant Quality

The quality of surviving plants on 7 January is shown in Table 7. Results should be treated with caution as there were relatively few surviving plants to assess. Both of the experimental fungicide treatments appeared to reduce root growth. There was little difference between treatments in the quality of top growth.

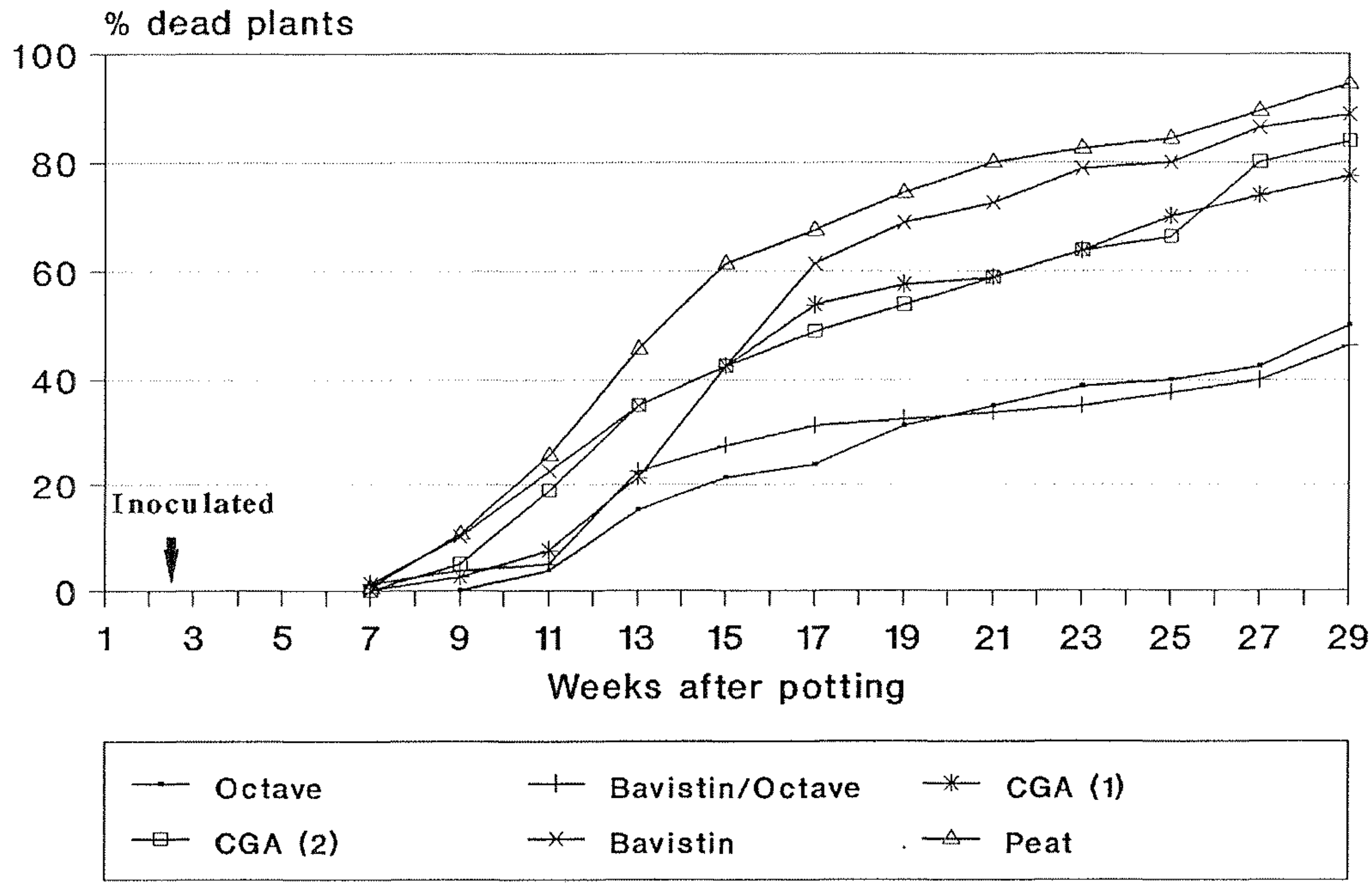
Actinomycetes

The number of actinomycete bacteria (eg. *Streptomyces* spp.) in peat and peat + chitin media was determined for samples taken in January 1993. The total number of actinomycete bacteria was increased approximately 20-fold where chitin was present, from 2.5×10^6 to $5.5\ 10^7$ per gram fresh weight of compost.

Mycorrhiza

Plants grown in peat with VAM amendment and examined in January 1993 were found to have low but significant proportion of roots infected with mycorrhiza.

Fig 8. Effect of fungicides on control of cyclamen fusarium wilt - 1992



MKMFun92

Fig 9. Effect of biocontrol treatments on control of fusarium wilt - 1992

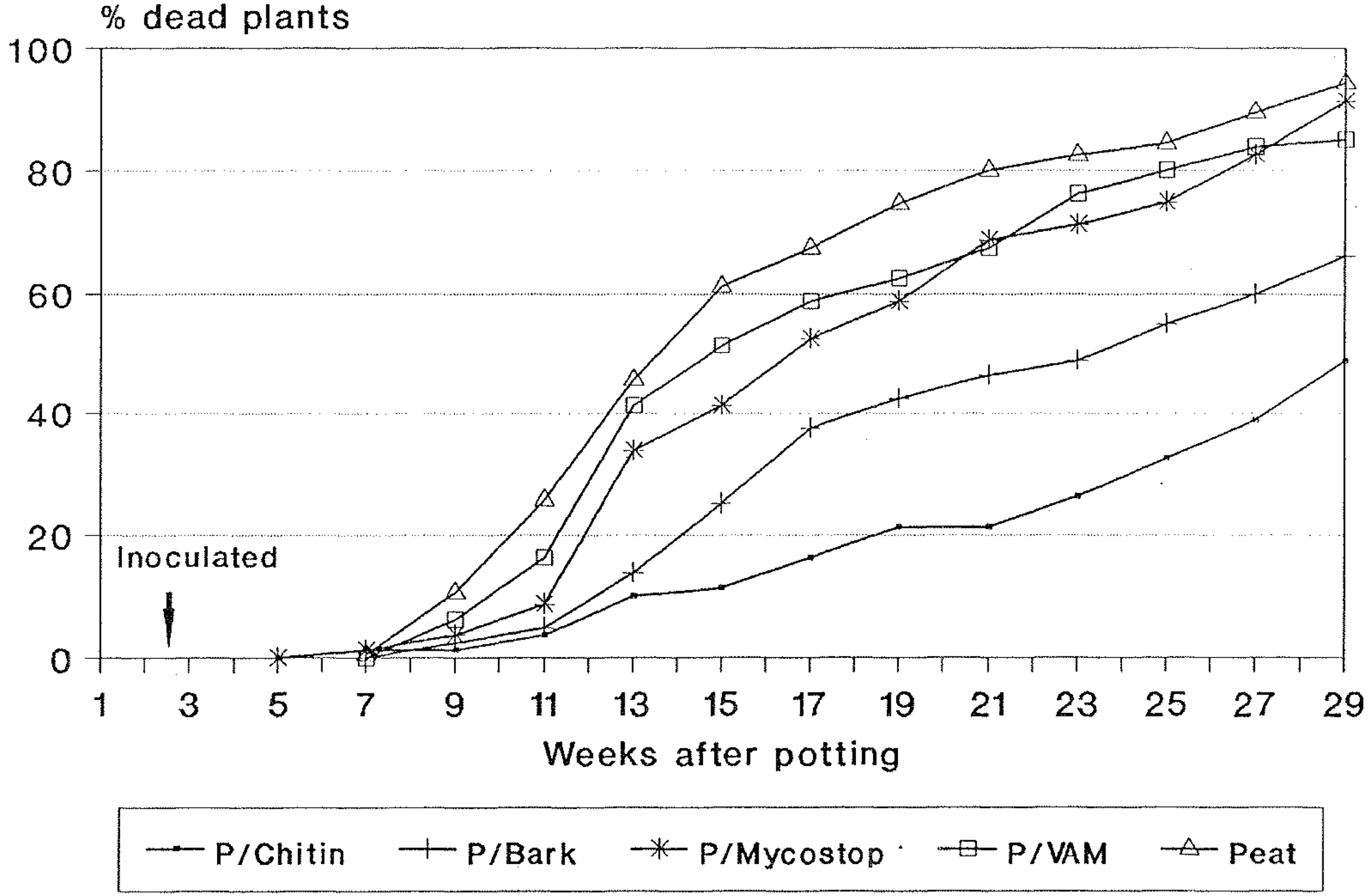


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Table 6. Effect of fungicides and biocontrol treatments on control of cyclamen fusarium wilt (Exp. 3)

Treatment	9 September		21 October	
1 Peat (control)	45.6	(42.4)d	74.4	(61.6)e
2 Peat/bark	13.7	(20.5)a	42.5	(40.6)abc
3 Peat/chitin	10.0	(17.9)a	21.2	(27.3)a
4 Peat + Bavistin (x4)	35.0	(36.0)bcd	68.7	(56.3)de
5 Peat + Octave (x4)	15.0	(21.4)a	31.2	(32.6)a
6 Peat + Bav (x1) + Oct (x3)	22.5	(27.6)abc	32.5	(34.3)ab
7 Peat + Exp.(1g/l)	21.2	(26.5)ab	57.5	(49.4)cde
8 Peat + Exp.(0.5g/l)	35.0	(36.1)bcd	53.7	(47.2)bcd
9 Peat + Mycostop (x4)	33.7	(34.7)bcd	58.7	(50.3)cde
10 Peat/VAM	41.2	(39.7)cd	62.5	(52.3)cde
SED between treatments	8.62	(5.79)	9.58	(6.62)
control vs treatments	7.46	(5.02)	8.30	(5.73)
F prob	-	<0.001	-	<0.001

Treatment	2 December		7 January	
1 Peat (control)	84.4	(68.6)c	94.4	(79.2)d
2 Peat/bark	55.0	(48.0)ab	66.2	(54.7)ab
3 Peat/chitin	32.5	(34.3)a	48.7	(44.4)a
4 Peat + Bavistin (x4)	80.0	(65.0)c	88.7	(73.9)cd
5 Peat + Octave (x4)	40.0	(38.4)a	50.0	(44.8)a
6 Peat + Bav (x1) + Oct (x3)	37.5	(37.5)a	46.2	(42.9)a
7 Peat + Exp.(1g/l)	70.0	(57.5)bc	77.5	(62.4)bc
8 Peat + Exp.(0.5g/l)	66.2	(54.6)bc	83.7	(66.9)bcd
9 Peat + Mycostop (x4)	75.0	(63.7)bc	91.2	(75.4)cd
10 Peat/VAM	80.0	(64.6)c	85.0	(68.5)bcd
SED between treatments	10.45	(7.48)	8.45	(6.76)
control vs treatments	9.05	(6.48)	7.50	(5.85)
F prob	-	<0.001	-	<0.001

Angular transformed values are shown in parenthesis

Values in the same column followed by a common letter are not significantly different at P = 0.05.

Table 7 Effect of fungicides and biocontrol treatments on quality of surviving cyclamen - 7 January 1993

Treatment		Quality index (1-5)	Root extent (0-5)	Root rot (0-5)	No. Plants assessed
1	Peat	3.4	5.0	1.8	14
2	Peat/bark	3.3	4.8	1.5	25
3	Peat/chitin	2.9	4.2	1.4	42
4	Peat + Bavistin (x4)	3.8	4.4	1.7	9
5	Peat + Octave (x4)	3.1	3.9	1.6	38
6	Peat + Bav (x1) + Oct (x3)	3.2	3.8	1.7	42
7	Peat + Exp.(1g/l)	3.4	2.3	1.1	18
8	Peat + Exp.(0.5g/l)	3.3	3.4	1.1	14
9	Peat + Mycostop (x4)	3.6	4.8	1.5	7
10	Peat/VAM	3.8	4.0	2.1	11

Quality index:

1 - Sparse growth of leaves and flowers
2 - Poor growth of leaves and flowers
3 - Reasonable canopy of leaves and number of flowers
4 - Well developed leaf canopy and good number of flowers
5 - Well developed and even leaf canopy; good number of flowers/buds

Root extent:

0 - No roots visible
1 - Very poor root growth
2 - Poor root growth
3 - Moderate root growth
4 - Good root growth (part of root ball)
5 - Good root growth (all root ball)

Root rot:

0 - No rot visible
1 - Very slight rot
2 - Slight rot
3 - Moderate rot
4 - Severe rot (part of exposed root)
5 - Severe rot (all of exposed root)

DISCUSSION

Drenching plants four times at monthly intervals with Bavistin DF appeared to give slight control of wilt, but the disease reduction was not significant at most assessments. Tests showed that the isolate of *F.oxysporum* f. sp. *cyclaminis* used in the trial was able to grow on benomyl at 2 mg/l ai, but not at 20 mg/l ai, indicating low level resistance to MBC fungicides. This probably accounts for the poor control achieved with Bavistin DF.

Drenching plants with Octave four times at 0.5g/l at monthly intervals after potting or three times at 1 g/l from one month after potting both gave very good control of wilt. There was no significant difference between the two treatments, both giving approximately 50% control 6 months after inoculation. No adverse effect on plant growth was observed. These results confirm those obtained in 1991 (PC50).

Drenching with Mycostop four times gave a significant reduction in the incidence of wilt 8 weeks after inoculation. The level of control declined as plants became older and with increasing time after the last application. By mid-December the incidence of wilt in Mycostop-treated plants was only slightly less than that of untreated plants. Previous workers have also noted that the effect of Mycostop on cyclamen fusarium wilt is most evident in young plants and declines with time (Ruegg *et al.*, 1992).

Incorporation of crushed crab shells into the growing medium resulted in very good control of wilt, slightly better than that achieved by Octave for most of the season. This result contrasts with that obtained in 1991 when only a slight reduction was observed. This year amendment with chitin was associated with a 20-fold increase in numbers of actinomycete bacteria, compared to a doubling in 1991. Possibly actinomycete bacteria are involved in the suppression of wilt by chitin. Adding plant residues or chitin to increase actinomycete populations has resulted in reduced incidences of some other fusarium diseases (Chisnall Hampson & Coombes, 1991; Meredith, 1946; Mitchell and Alexander, 1962; 1963).

Incorporation of VAM into the growing medium did not reduce the incidence of wilt. Nutrient condition at potting were as recommended for cyclamen production and the phosphate level was not deliberately reduced to favour mycorrhizal establishment. A period of 18 days was allowed for mycorrhizal development before inoculating with *F.oxysporum* f.sp. *cyclaminis*. As it is known that nutrient status affects establishment of mycorrhiza on plant roots (Cargeeg, AGC Ltd, Rothamsted, pers. comm.) it may be worth evaluating VAM inoculation using different nutrient concentrations before inoculation with the fungal pathogen.

EXPERIMENT 4: EFFECT OF GROWING MEDIUM AMENDMENTS, FUNGICIDES AND BIOCONTROL AGENTS ON CONTROL OF PHYTOPHTHORA ROOT ROT OF SAINTPAULIA

Objective

To investigate the effect of three fungicides, five growing medium amendments and two biocontrol agents on control of phytophthora root rot.

Treatments

1. Peat (pH 5.5)
2. Peat+Aaterra (1 g/l)
3. Peat+Filex (1.5 ml/l)
4. Peat+Fongarid 25 WP (1 g/l)
5. Peat/Bark (Cambark Fine)
6. Peat/Bark+Aaterra (1 g/l)
7. Peat/Bark+Filex (1.5 ml/l)
8. Peat/Bark+Fongarid (1 g/l)
9. Peat/Woodfibre
10. Peat/Perlite
11. Peat/Fi-Pro straw
12. Finnish peat
13. Peat+VAM inoculant (5%)
14. Peat+Mycostop (2 g/201 and 50 ml/plant)

Results

Nutrition

Nutrition levels were determined on 7 September, six weeks after potting, and were found to be satisfactory (see below). Liquid feed (120 mg/l N and 120 mg/l K_2O) was applied from 19 August with each watering.

Treatment	pH	Cond. µS (index)	P mg/l (index)	K mg/l (index)	Mg mg/l (index)	NO_3 mg/l (index)	NH_4 mg/l (index)
Peat	5.6	393 (2)	62 (7)	158 (3)	83 (6)	145 (5)	27 (1)

Plant Quality

The effect of treatments on flowering is shown in Table 8. Amendment of peat with bark significantly reduced flowering.

The effect of treatments on final plant quality, root extent and root browning assessed on 29 September, is shown in Table 9. Amendment with bark reduced the final plant quality. Amendment with bark, perlite or VAM and drenching with Aaterra reduced root extent.

Disease

Plants were examined on 19 August, 8 September and 29 September and on each occasion there were no symptoms typical of phytophthora root or stem base rot.

A few unthrifty plants were examined and *Pythium* sp. and *Cylindrocarpon destructans* were recovered from rotting roots. Ten plants from each treatment were retained until 31 December for further observation and examination. No rotting developed and *Phytophthora* sp. was not found on the roots.

Mycorrhiza

No colonisation of roots by mycorrhiza was found in plants grown in peat with VAM amendment. This may have been due to the high phosphate level.

Table 8 Effect of bark, other amendments and fungicides on flowering of saintpaulia - Exp. 4.

Factor	No. of replicates	No open flowers/plant 31 Aug	8 Sep	14 Sep	21 Sep	28 Sep	6 Oct
Bark							
Peat	16	0.11	0.18	0.28	0.42	0.51	0.77
Peat/bark	16	0.06	0.09	0.13	0.22	0.31	0.51
SED		0.023	0.029	0.043	0.071	0.094	0.095
F prob		0.038	0.004	0.001	0.006	0.037	0.015
Fungicides							
Water	8	0.06	0.10	0.16	0.25	0.35	0.59
Aaterra	8	0.13	0.16	0.21	0.38	0.45	0.73
Filex	8	0.06	0.11	0.22	0.31	0.40	0.63
Fongarid	8	0.10	0.15	0.23	0.34	0.45	0.66
SED		0.033	0.042	0.061	0.099	0.133	0.135
F prob		NS	NS	NS	NS	NS	NS
Amendments							
Woodfibre	4	0.08	0.13	0.25	0.38	0.44	0.69
Perlite	4	0.03	0.06	0.14	0.20	0.23	0.48
Straw	4	0.09	0.13	0.20	0.23	0.41	0.78
Finnish peat	4	0.03	0.03	0.09	0.22	0.36	0.61
VAM	4	0.09	0.09	0.19	0.31	0.41	0.80
Mycostop	4	0.02	0.02	0.06	0.08	0.11	0.39
SED		0.047	0.059	0.086	0.141	0.188	0.191
F prob		NS	NS	NS	NS	NS	NS

Table 9 Effect of bark, other amendments and fungicides on quality of saintpaulia (Exp. 4)

Factor	No. of replicates	Plant quality (1-5)	Root extent (0-5)	Root browning (0-5)
Bark				
Peat	16	3.7	2.9	2.5
Peat/bark	16	3.4	2.4	2.3
SED		0.152	0.098	0.164
F prob		0.040	<0.001	NS
Fungicides				
Water	8	3.5	2.8	2.6
Aaterra	8	3.4	2.0	2.1
Filex	8	3.6	2.8	2.4
Fongarid	8	3.6	2.8	2.4
SED		0.216	0.39	0.232
F prob		NS	<0.00	NS
Amendments				
Woodfibre	4	3.3	4.3	3.6
Perlite	4	3.4	2.4	1.6
Straw	4	3.4	3.0	3.4
Finnish peat	4	3.4	2.6	3.0
VAM	4	3.6	2.4	3.0
Mycostop	4	3.5	2.5	1.9
SED		0.305	0.197	0.328
F prob		NS	<0.001	<0.001

Quality index:
1 - Sparse growth of leaves and flowers
2 - Poor growth of leaves and flowers
3 - Resonable canopy of leaves and number of flowers
4 - Well developed leaf canopy and good number of flowers
5 - Well developed and even leaf canopy; good number of flowers/buds

Root extent:
0 - No roots visible
1 - Very poor root growth
2 - Poor root growth
3 - Moderate root growth
4 - Good root growth (part of root ball)
5 - Good root growth (all root ball)

Root rot:
0 - No rot visible
1 - Very slight rot
2 - Slight rot
3 - Moderate rot
4 - Severe rot (part of exposed root)
5 - Severe rot (all of exposed root)

DISCUSSION

A mycelial disc of *P.cryptogea* on PDA placed at the base of pots did not result in root rot. Possible reasons for the lack of disease development include low or nil pathogenicity to saintpaulia, conditions were unfavourable to infection, or the inoculum died before it came into contact with roots.

The species of *Phytophthora* most frequently associated with saintpaulia is *P.nicotianae* var. *parasitica* (Rattink, 1981). An isolate of *P.nicotianae* var. *parasitica* obtained from saintpaulia in 1992 was evaluated in preliminary tests. Application of mycelium to leaves or roots and incorporation of mycelium into a basal layer of compost did not cause disease. This isolate was therefore discarded as a suitable isolate for inoculation. *P.cryptogea* causes a root rot of many pot plants including saintpaulia. The isolate used to inoculate plants in our trial was successfully used in 1991 to inoculate gerbera, by placing a mycelial disc on agar in the compost. Possibly this isolate was pathogenic to gerbera and not to saintpaulia.

A further possible explanation is that the variety Jupiter has resistance to phytophthora root rot. Differences in varietal susceptibility to *P.nicotianae* were recorded by Strider (1978). Discussion with growers indicates that Jupiter is susceptible, although not as susceptible as some other varieties. A successful artificial inoculation technique needs to be developed before any further work on control of phytophthora root rot of saintpaulia is undertaken.

EXPERIMENT 5: EFFECT OF GROWING MEDIUM AMENDMENTS, BIOCONTROL AGENTS AND BAVISTIN ON CONTROL OF BLACK ROOT ROT (*THIELAVIOPSIS BASICOLA*) OF PANSY.

Objectives

To investigate the effect of seven growing media, two biocontrol treatments and Bavistin drenches on control of black root rot in pansies after potting.

Treatments

	Fungicide
1. Peat (pH 5.5)	Nil
2. Peat/Bark Cambark Fine)	"
3. Peat/Woodfibre (fine)	"
4. Peat/Perlite (Silva Perle, Standard)	"
5. Peat/Fi-Pro straw	"
6. Peat/Low pH (5.0) & low ammonium N	"
7. Special Irish peat	"
8. Peat + VAM inoculant (incorporated at 5% V/V)	"
9. Peat + Mycostop drenches (monthly) (2 g/20 l & 50 ml/plant)	"
10. Peat	Bavistin DF
11. Peat/Bark	"
12. Peat/Woodfibre	"
13. Peat/Perlite	"
14. Peat/Fi-Pro straw	"
15. Peat/Low pH (4.6) & low ammonium N	"
16. Special Irish peat	"
17. Peat + VAM inoculant	"
18. Peat + Mycostop drenches (monthly)	"

Results

Nutrition and husbandry

Nutrient levels of media before potting were satisfactory, although in the low pH treatment the value achieved (4.6) was slightly lower than the target value (5.0). The ammonium-N level (20 mg/l) was suitably low. Plants were grown outside and suffered from heavy rain in August, soon after potting. This resulted in extremely low nutrient levels (N, P, K, P, Mg) by October and a few plants in several treatments suffered a bacterial soft rot at the stem base and died.

Plant Quality

The effect of treatments on the mean number of flowers and buds/plant in uninoculated plots on 8 October is shown in Table 10. The number of flowers was greatest in the VAM treatment and least in the peat /bark treatment.

Mycorrhiza

There was slight mycorrhizal colonisation of roots of gold pansies and not of blue following VAM amendment.

Table 10. Effect of growing medium amendments and biocontrol agents on flowering of pansy (Exp. 5) - 8 October 1992.

Treatment	Mean number flowers and buds per plant
Uninoculated	
1. Peat	10.4
2. Peat/Bark	6.3
3. Peat/Woodfibre	11.3
4. Peat/Perlite	9.2
5. Peat/Fi-pro straw	7.4
6. Low pH	6.7
7. Irish peat	9.1
8. VAM	12.3
9. Mycostop	6.7

Mean of 18 plants

Disease

Thielaviopsis basicola was first confirmed four weeks after inoculation. It was subsequently confirmed on several unthrifty plants removed from the trial at intervals. At the final assessment on 10 December, *T.basicola* was not found on white or pale brown roots of apparently healthy plants; *Pythium* sp was confirmed on some plants with pale brown roots (see below).

Occurrence of pathogens on roots of unthrifty pansy plants.

Sampling date	Number of plants affected by: *T.basicola*	*Pythium* sp
13 August	$0/_5$ (stem base rot)	$0/_5$ (stem base rot)
19 August	$0/_5$ (stem base rot)	$0/_5$ (stem base rot)
10 September	$1/_{23}$ (stem base rot)	$0/_{23}$ (stem base rot)
8 October	$8/_{10}$ (grey black root)	$0/_{10}$ (grey black roots)
10 December	$11/_{12}$ (grey/black root)	$3/_{10}$ (brown roots)
	$0/_6$ (white roots)	

Potted 30 July; inoculated 13 August.

Yellowing of lower leaves, a symptom suggestive of black root rot, was assessed on 22 October and 5 November. The incidence of yellowing plants was significantly reduced by Bavistin (from 42% to 26%) and appeared to be reduced by bark, perlite and straw amendment. The effect of bark, perlite and straw was not significant (Table 11). Bavistin significantly increased plant size (Table 11). There were slight but significant differences between the two colours in leaf yellowing and plant size.

When plants were de-potted and assessed on 10 December, sectors of grey-black root rotting were observed at the sides and bottoms of the root balls on some plants, and abundant sporulation of *T.basicola* was subsequently confirmed on affected roots. The incidence of plants affected by black root rot was reduced from 16% to less than 1% by treatment with Bavistin. None of the other treatments affected the level of black root rot (Table 12).

The quality of plants was significantly improved by treatment with Bavistin; treated plants had better top growth and more extensive roots. Amendment with perlite significantly improved root extent but not top growth (Table 12).

Table 11 Effect of Bavistin and other treatments on yellowing and size of pansy - December 1992 (Exp. 5)

Factor	Replication	% plants yellowing 22 Oct		% plants yellowing 5 Nov		Plant size (0-5) 22 Oct	Plant size (0-5) 5 Nov
Fungicide							
Nil	80	26.7	(28.3)	42.1	(40.3)	3.7	4.0
Bavistin	80	17.4	(21.1)	25.8	(29.1)	4.2	4.4
SED		3.19	(2.84)	2.55	(1.63)	0.11	0.11
F prob		-	(0.014)	-	(<0.001)	<0.001	<0.001
Colour							
Gold	80	20.1	(22.7)	30.8	(32.5)	3.6	3.6
Blue	80	23.9	(26.7)	37.1	(36.9)	4.2	4.4
SED		1.79	(1.58)	1.84	(1.32)	0.10	0.08
F prob		-	(0.015)	-	(0.001)	<0.001	<0.001
Treatment							
Peat (control)	32	19.1	(21.8)	37.2	(37.1)	4.0	4.3
Peat/bark	16	20.8	(24.9)	26.4	(30.2)	4.1	4.4
Peat/woodfibre	16	27.1	(29.0)	31.3	(33.5)	3.8	4.1
Peat/perlite	16	19.4	(24.1)	29.9	(30.9)	3.5	4.1
Peat/straw	16	15.3	(18.1)	25.7	(29.1)	4.2	4.1
Low pH	16	21.5	(25.3)	36.8	(36.0)	3.5	4.1
Irish peat	16	25.7	(29.0)	39.6	(38.7)	4.0	4.4
VAM	16	31.3	(31.8)	38.2	(37.6)	3.9	4.3
Mycostop	16	20.8	(21.4)	37.5	(36.6)	4.2	4.1
SED between treatment		7.12	(6.34)	5.71	(3.64)	0.25	0.25
control vs treatment		6.17	(5.51)	4.94	(3.15)	0.22	0.22
F prob		-	NS	-	NS	0.049	NS

Angular transformed values are shown in parenthesis

Plant size:

0 - Plant dead
1 - Very poor (small plant; many yellow/purple leaves)
2 - Poor (small plant, some yellow/purple leaves)
3 - Average (small plant; a few yellow leaves)
4 - Above average (good size; a few yellow leaves)
5 - Excellent (many leaves; no yellowing)

Table 11 Continued

Factor	Replication	% plants yellowing 22 Oct		% plants yellowing 5 Nov		Plant size (0-5) 22 Oct	Plant size (0-5) 5 Nov
Fungicide x Treatment							
Nil Peat	16	24.3	(24.8)	46.5	(43.0)	3.8	4.1
Peat/bark	8	26.4	(30.3)	31.9	(33.9)	4.0	4.3
Peat/woodfibre	8	33.3	(34.4)	36.1	(36.8)	3.4	3.6
Peat/perlite	8	22.2	(25.9)	39.3	(30.9)	3.0	3.5
Peat/straw	8	15.3	(18.0)	33.3	(34.8)	4.1	3.8
Low pH	8	27.8	(30.9)	45.8	(42.5)	3.1	4.3
Irish peat	8	31.9	(33.8)	50.0	(45.1)	4.0	4.4
VAM	8	36.1	(36.4)	43.1	(40.5)	3.6	4.0
Mycostop	8	25.0	(24.0)	47.2	(43.7)	4.0	3.9
Bav.Peat	16	13.9	(18.7)	27.8	(31.3)	4.2	4.5
Peat/bark	8	15.3	(19.6)	20.8	(26.4)	4.1	4.5
Peat/woodfibre	8	20.8	(23.5)	26.4	(30.3)	4.3	4.5
Peat/perlite	8	16.7	(22.3)	19.4	(22.5)	4.0	4.6
Peat/straw	8	15.3	(18.1)	18.1	(23.3)	4.3	4.4
Low pH	8	15.3	(19.6)	27.8	(29.6)	3.9	3.9
Irish peat	8	19.4	(24.2)	29.2	(32.3)	4.0	4.5
VAM	8	26.4	(27.3)	33.3	(34.7)	4.3	4.6
Mycostop	8	16.7	(18.8)	27.8	(29.5)	4.4	4.4
SED between treatments		10.07	(8.99)	9.07	(5.14)	0.36	0.36
control vs treatments		8.72	(7.79)	6.99	(4.45)	0.31	0.32
F prob		-	NS	-	NS	NS	NS

Angular transformed values are shown in parenthesis

Table 12 Effect of Bavistin and other treatments on plant growth and black root rot of pansy - December 1992 (Exp. 5)

Factor	Replication	Top growth (0-100)	Root extent (0-100)	Black root rot Index (0-100)	Black root rot % affected
Fungicide					
Nil	80	64.9	69.8	3.3	16.3
Bavistin	80	68.6	80.2	0.2	0.9
SED		1.27	1.73	0.492	2.46
F prob		0.002	<0.001	<0.001	<0.001
Colour					
Gold	80	65.1	73.8	1.9	9.6
Blue	80	67.9	76.2	1.5	7.6
SED		0.77	1.13	0.245	1.23
F prob		<0.001	0.035	NS	NS
Treatment					
Peat	32	67.0	73.6	2.0	9.8
Peat/bark	16	66.4	77.4	1.1	5.6
Peat/woodfibre	16	64.9	74.8	1.1	5.6
Peat/perlite	16	66.3	84.3	1.0	5.1
Peat/straw	16	66.2	65.6	2.8	13.8
Low pH	16	68.3	75.9	1.9	9.3
Irish peat	16	68.1	78.4	1.1	5.4
VAM	16	64.2	75.2	2.6	12.8
Mycostop	16	66.9	71.2	1.8	8.9
SED between treatments		2.83	3.87	1.10	5.51
control vs treatments		2.45	3.35	0.95	4.77
F prob		NS	0.002	NS	NS

Top growth, root extent and black root rot were all assessed on a 0-5 scale and a weighted index was then calculated.

Plant size:	Root extent:	Black root rot:
0 - Plant dead	0 - None visible	0 - Nil
1 - Very poor	1 - 1-20% surface area	1 - 1-5%
2 - Poor	2 - 21-40% " "	2 - 6-10%
3 - Average	3 - 41-60% " "	3 - 11-20%
4 - Above average	4 - 61-80% " "	4 - 21-50%
5 - Excellent	5 - 81-100% " "	5 - 51-100%

Table 12 continued

Effect of Bavistin and other treatments on plant growth and black root rot of pansy - December 1992 (Exp. 5)

Factor	Replication	Top growth (0-100)	Root extent (0-100)	Black root rot Index (0-100)	Black root rot % affected
Fungicide x Treatments					
Nil Peat (control)	16	64.4	69.0	3.5	17.7
Peat/bark	8	62.4	72.2	2.3	11.3
Peat/woodfibre	8	64.4	67.7	2.2	11.1
Peat/perlite	8	64.5	80.8	2.0	10.1
Peat/straw	8	65.5	54.8	5.5	27.6
Low pH	8	66.9	74.2	3.4	17.2
Irish peat	8	64.2	74.4	1.9	9.4
VAM	8	64.9	73.0	5.1	25.6
Mycostop	8	63.3	62.9	3.2	15.8
Bav.Peat (control)	16	69.6	78.2	0.4	2.1
Peat/bark	8	70.5	82.5	0.0	0.0
Peat/woodfibre	8	65.3	81.8	0.0	0.0
Peat/perlite	8	68.0	87.9	0.0	0.0
Peat/straw	8	66.8	76.3	0.0	0.0
Low pH	8	69.8	77.7	0.3	1.4
Irish peat	8	72.0	82.5	0.3	1.4
VAM	8	63.5	77.4	0.0	0.0
Mycostop	8	70.5	79.6	0.4	2.1
SED between treatments		3.99	5.47	1.56	7.79
control vs treatments		3.46	4.73	1.35	6.74
F prob		NS	NS	NS	<0.001

DISCUSSION

Contrary to grower experience in 1991, black root rot of pansy appears not to have been a major problem on pansies in the summer of 1992. This was also true in the experiment reported here where plug plants were drenched with a suspension of *T.basicola* spores soon after potting (30 July) and most plants showed no symptoms of black root rot until October, when leaf yellowing developed. When small samples of plants were examined during September and October the roots of some were affected by *T.basicola*. When roots of all plants were assessed in mid-December, 9-28% of plants in treatments not drenched with Bavistin were affected by *T.basicola*. These observations suggest that infection and/or the development of root rot by *T.basicola* is relatively slow under certain growing conditions. In a preliminary trial in a glasshouse at ADAS Cambridge in June 1992, young plants drenched with a suspension of *T.basicola* spores developed severe root rot and leaf yellowing 3-6 weeks after inoculation. Koranski (Iowa State University, USA; pers. comm.) reported that 'stress' was a major factor affecting the development of black root rot in pansy. Possibly high temperatures, low nutrient levels and cool, wet growing conditions can all act as stress factors and favour development of black root rot.

Drenching plants with Bavistin DF three times at monthly intervals gave very good control of black root rot. The first treatment was applied before plants were inoculated. Other HDC-funded work (PC38) has shown that Bavistin may not give good control if plants are infected before treatment is applied.

Amendment of peat with bark or perlite appeared to reduce leaf yellowing and the number of plants affected by *T.basicola*, although differences were not significant. Further work is needed to see if benefits can be identified.

EXPERIMENT 6: EFFECT OF GROWING MEDIUM AMENDMENTS, FUNGICIDES AND BIOCONTROL AGENTS ON CONTROL OF PYTHIUM ROOT ROT OF POINSETTIA

Objective

To investigate the effect of eight growing media, three fungicides and two biocontrol agents on control of pythium root rot.

Treatments

1. Peat (pH 5.5)
2. Peat+Aaterra (1 g/l)
3. Peat+Filex (1.5 ml/l)
4. Peat+Fongarid 25 WP (1 g/l)
5. Peat/Bark (Cambark Fine)
6. Peat/Bark+Aaterra (1 g/l)
7. Peat/Bark+Filex (1.5 ml/l)
8. Peat/Bark+Fongarid (1 g/l)
9. Peat/Woodfibre
10. Peat/perlite
11. Peat/Fi-Pro Straw
12. Special Irish peat
13. Finnish peat
14. Russian peat
15. Peat + Polygandron
16. Peat + VAM inoculant

Results

Nutrition

Nutrient levels of media before potting were satisfactory. Nutrient levels were determined 8 weeks after potting by which time there was low P & N. Liquid feed was subsequently applied with each watering.

Plant Quality

Plant vigour and quality were assessed at intervals after potting. In the uninoculated comparison plants with woodfibre, Fi-pro straw and Polygandron appeared most vigorous at the first assessment; plants in Irish peat, Finnish peat and with VAM amendment were most vigorous at the final assessment. Leaf chlorosis was initially most pronounced in plants in Russian peat and with woodfibre amendment; at the last assessment it was most pronounced in plants growing with bark, woodfibre and straw amendment.

In the inoculated trial (Table 13) treatment with Aaterra or Fongarid increased plant vigour and reduced leaf chlorosis. Amendment with straw, perlite or woodfibre increased leaf chlorosis.

Plant size, shoot number and bract colour were assessed 14 weeks after potting. Uninoculated plants grown with perlite or Polygandron amendment were considerably smaller than other plants. In the inoculated trial there was a very marked effect from fungicide treatment. Drenching with Aaterra or Fongarid significantly improved plant size and shape (Table 14); drenching with Filex did not. Plants grown with bark amendment were slightly but significantly smaller, of poorer shape and had less bract colour than plants grown in peat. None of the other growing medium amendments or biocontrol treatments significantly improved plant size or shape.

Mycorrhiza

Plants grown in peat with VAM amendment had a small but significant proportion of roots infected by mycorrhiza.

Disease

Two weeks after inoculation five plants showed severe wilting and root rotting and *Pythium* sp. was isolated from them. A further four dying plants were removed in September and October and *Pythium* sp. was again confirmed. The dying plants all occurred in plots which were not treated with fungicide. Many of the plants showed poor shoot growth and when examined these were found to have pythium root rotting.

The number of plants judged to be saleable as pot plants was determined as an indication of the effectiveness of treatments in controlling *pythium* root rot (Table 15). Treatment with Aaterra, Filex or Fongarid significantly increased the number of saleable plants, the % saleable on 22 October being 98% (Aaterra), 91% (Fongarid), 29% (Filex) and 5% (Untreated). The Filex treatment appeared to be more effective when used on plants grown in peat (48% saleable) than on plants in peat/bark (10% saleable). Amendment with bark did not affect the number of saleable plants. Incorporation of VAM into the growing medium resulted in a slight increase in the number of saleable plants (33%), although these plants were considerably smaller in size than plants treated with Aaterra or Fongarid.

Surviving plants were de-potted on 17 December and root extent, root rotting and a plant quality index were determined (Table 16). Amendment with bark had no significant effect on root extent or root rotting and slightly but significantly reduced plant quality. Treatment with Aaterra or Fongarid significantly reduced root rot and increased root extent and plant quality. Many of the plants not treated with fungicide had very little healthy root remaining outside of the initial root ball. Of the non-bark amendments, perlite significantly reduced root extent and increased root rotting.

Table 13. Effect of fungicide and compost amendments on vigour and leaf chlorosis of poinsettia - (Exp. 6)

Treatments	No. of reps.	Plant vigour (0-5) 26 Aug	8 Oct	Chlorosis (0-5) 26 Aug	8 Oct
Bark					
Peat	16	2.4	3.3	0.4	1.6
Peat/Bark	16	2.4	3.5	0.35	1.6
SED		0.19	0.23	0.2	0.26
F prob		NS	NS	NS	NS
Fungicides					
Untreated	8	2.1	2.1	0.5	2.3
Aaterra	8	2.5	4.4	0.4	1.1
Filex	8	2.3	2.6	0.3	2.0
Fongarid	8	2.6	4.4	0.3	1.0
SED		0.27	0.33	0.34	0.37
F prob		NS	<0.001	NS	0.002
Amendments					
Peat/Woodfibre	4	2.0	2.3	2.8	2.5
Peat/perlite	4	2.0	2.0	3.5	1.8
Peat/straw	4	2.0	2.0	2.8	2.8
Irish peat	4	2.0	2.3	0.	1.5
Finnish peat	4	1.8	2.3	2.2	2.8
Russian peat	4	1.8	2.5	1.5	2.3
Peat + Polygandron	4	2.0	2.5	2.0	1.8
Peat + VAM	4	2.5	2.8	0.8	2.0
SED		0.38	0.47	0.48	0.53
F prob		NS	NS	<0.001	NS
Bark x Fungicides					
Peat-Untreated	4	2.0	2.0	0.5	2.3
Aaterra	4	2.8	4.0	0.5	1.3
Filex	4	2.3	3.0	0.3	2.0
Fongarid	4	2.5	4.0	0.5	1.0
P/Bark-Untreated	4	2.3	2.3	0.5	2.3
Aaterra	4	2.3	4.8	0.3	1.0
Filex	4	2.3	2.3	0.3	2.0
Fongarid	4	2.8	4.8	0.0	1.0
SED		0.3	0.47	0.48	0.53
F prob		NS	NS	NS	NS

Vigour and chlorosis indices - see next page.

Indices used for plant vigour and leaf chlorosis assessments:

Plant vigour

August

0 - No shoot development
1 - Slight shoot growth on some plants
2 - Slight shoot growth on most plants
3 - Moderate shoot growth on some plants
4 - Moderate shoot growth on most plants
5 - All shoots well developed

October

0 - No growth (stunted)
1 - Very poor growth
2 - Poor growth; moderate height reduction
3 - Moderate vigour; slight height reduction
4 - Generally vigorous; not uniform
5 - Vigorous growth, uniform plants

Chlorosis

August and October

0 - None
1 - Slight on some leaves
2 - Slight on most leaves
3 - Moderate on some leaves
4 - Moderate on most leaves
5 - Severe

Table 14. Effect of fungicide and growing medium amendments on quality of poinsettia - 16 November 1992 (Exp. 6)

Treatments	No. of reps.	Plant size (cm) Height	Width	No of shoots	Shape (0-5)	Bract colour (0-5)
Bark						
Peat	16	16.9	25.9	5.8	2.3	3.5
Peat/Bark	16	15.0	22.4	4.5	1.7	2.8
SED		0.64	1.08	1.84	0.23	0.30
F prob		0.006	0.002	NS	0.007	0.034
Fungicides						
Untreated	8	10.4	17.5	3.7	0.8	3.2
Aaterra	8	22.3	31.8	6.2	3.2	3.3
Filex	8	11.2	17.8	4.7	1.1	2.9
Fongarid	8	19.9	29.6	6.1	2.9	3.3
SED		0.91	1.52	2.61	0.33	0.42
F prob		<.001	<0.01	NS	<.001	NS
Amendments						
Peat/Woodfibre	4	11.2	17.4	5.2	0.2	2.3
Peat/perlite	4	9.9	15.5	14.1	0.0	3.8
Peat/straw	4	12.2	19.1	5.3	0.6	2.4
Irish peat	4	11.5	17.6	5.4	0.9	3.6
Finnish peat	4	10.9	19.0	4.8	0.8	2.3
Russian peat	4	12.1	20.0	5.5	1.1	3.5
Peat + Polygandron	4	10.8	17.6	4.0	0.6	3.5
Peat + VAM	4	12.4	19.8	5.1	1.4	3.5
SED		1.28	2.15	3.69	0.47	0.59
F prob		NS	NS	<0.001	NS	0.039
Bark x Fungicides						
Peat-Untreated	4	11.1	20.6	4.9	1.2	3.6
Aaterra	4	24.1	34.2	6.4	3.2	3.0
Filex	4	13.3	20.7	6.0	1.9	3.5
Fongarid	4	18.9	28.1	6.2	3.1	3.8
P/Bark-Untreated	4	9.7	14.5	2.6	0.5	2.8
Aaterra	4	20.5	29.5	5.9	3.2	3.5
Filex	4	9.0	14.8	3.5	0.3	2.3
Fongarid	4	20.8	31.0	6.0	2.8	2.8
SED		1.28	2.15	3.69	0.47	0.59
F prob		0.006	0.014	NS	NS	NS

Shape: 0 - poor: 5- excellent
Colour: 0 - none: 5- full red

Table 15. Effect of fungicides and growing medium amendments on number of saleable poinsettia - (Exp. 6)

Treatments	No. of reps.	% plants saleable 22 Oct		5 Nov	
Bark					
Peat	16	60.0	(52.2)	54.4	(47.8)
Peat/Bark	16	51.2	(47.4)	53.7	(48.2)
SED		-	(4.76)	-	(5.79)
F prob		-	NS	-	NS
Fungicides					
Untreated	8	5.0	(6.6)	11.3	(12.1)
Aaterra	8	97.5	(86.7)	87.5	(78.8)
Filex	8	28.7	(26.4)	27.5	(25.6)
Fongarid	8	91.3	(79.5)	90.0	(75.6)
SED		-	(6.74)	-	(8.19)
F prob		-	(<0.001)	-	(<.001)
Amendments					
Peat/Woodfibre	4	0.0	(0.0)	2.5	(4.6)
Peat/perlite	4	0.0	(0.0)	0.0	(0.0)
Peat/straw	4	0.0	(0.0)	2.5	(4.6)
Irish peat	4	5.0	(6.6)	7.5	(11.3)
Finnish peat	4	0.0	(0.0)	2.5	(4.6)
Russian peat	4	2.5	(4.6)	2.5	(4.6)
Peat + Polygandron	4	5.0	(6.6)	5.0	(6.6)
Peat + VAM	4	32.5	(33.7)	32.5	(34.0)
SED		-	(9.53)	-	(11.58)
F prob		-	(0.014)	-	NS
Bark x Fungicides					
Peat-Untreated	4	5.0	(6.6)	7.5	(8.3)
Aaterra	4	95.0	(83.4)	77.5	(72.1)
Filex	4	47.5	(39.9)	42.5	(36.7)
Fongarid	4	92.5	(78.8)	90.0	(74.1)
P/Bark-Untreated	4	5.0	(6.6)	15.0	(15.9)
Aaterra	4	100.0	(90.0)	97.5	(85.4)
Filex	4	10.0	(12.9)	12.5	(14.4)
Fongarid	4	90.0	(80.2)	90.0	(77.1)
SED		-	(9.53)	-	(11.58)
F prob		-	NS	-	NS

Angular transformed values are shown in parenthesis

Unmarketable plants were of very poor size and/or shape and generally spread was less than the pot width.

Table 16. Effect of fungicides and compost amendments on root extent, root rotting and plant quality - 17 December 1992 (Exp. 6)

Treatments	No. of reps.	Root extent (0-100)	Root rot (0-100)	Plant Quality (0-100)
Bark				
Peat	16	60.2	66.6	48.8
Peat/Bark	16	62.4	74.8	39.4
SED		4.38	5.24	3.95
F prob		NS	NS	0.023
Fungicides				
Untreated	8	43.1	86.7	28.6
Aaterra	8	76.0	56.6	59.7
Filex	8	52.8	81.8	33.8
Fongarid	8	73.4	57.7	54.5
SED		6.19	7.41	5.58
F prob		<.001	<.001	<.001
Amendments				
Peat/Woodfibre	4	98.2	64.6	25.2
Peat/perlite	4	35.9	90.9	21.4
Peat/straw	4	74.3	53.7	33.5
Irish peat	4	45.0	72.7	31.4
Finnish peat	4	46.1	60.7	27.9
Russian peat	4	52.8	62.6	31.6
Peat + Polygandron	4	58.8	54.7	25.5
Peat + VAM	4	54.0	64.0	44.2
SED		8.76	10.48	7.89
F prob		<.001	0.031	NS
Bark x Fungicides				
Peat-Untreated	4	44.4	83.5	36.7
Aaterra	4	74.9	47.4	61.4
Filex	4	53.4	78.8	38.8
Fongarid	4	68.2	57.0	58.5
P/Bark-Untreated	4	41.8	89.8	20.4
Aaterra	4	77.0	66.0	58.0
Filex	4	52.1	84.9	28.8
Fongarid	4	78.5	58.4	50.6
SED		8.76	10.48	7.89
F prob		NS	NS	NS

Assessment keys for root extent and root rot are described below Table 12. The key for assessment of plant quality is described overleaf.

<u>Key for assessment of poinsettia quality - 17 December</u>

0: Unmarketable as a pot plant
(Possibly marketable for bowl work)
Too small in height and width
Generally spread is less than pot width

1: <<4 breaks
+/- circular shape
small height or width

2: <4 breaks
non-circular head

3: <4 breaks
circular shape
height and width not in proportion

4: 4 or more breaks
circular shape
height and width <u>not</u> in proportion (slightly unbalanced plant)

5: 4 or more breaks of equal height
regular (circular shape)
height and width in proportion.

A weighted index was calculated and converted to a % score from the above classes.

Discussion

Young poinsettia plants planted in growing media contaminated in the basal layer with a *Pythium* sp.isolated from poinsettia developed a severe root rot. Drenching plants with Aaterra or Fongarid one week after potting and twice more at monthly intervals gave excellent control of the disease. Drenching with Filex gave slight control. These results provide information on the relative efficacy of different products. In the last few years isolates of *Pythium* spp. resistant to furalaxyl (Fongarid) have occasionally been detected from pot plant hosts. In order that Fongarid should continue to provide good control of pythium root rot of poinsettia it would be wise to include Aaterra and/or Filex in fungicide programmes used where *Pythium* is present, or where there is a high risk of *Pythium*.

Neither pine bark nor other growing medium amendments used in the experiment significantly reduced pythium root rot. Daft *et al.* (1979), found that composted hardwood bark could be used as substitute for sterilisation and fungicides for control of crown and root rot of poinsettia caused by *Rhizoctonia solani* and *Pythium ultimum*. Type of bark may explain the different results obtained here. The biocontrol agent Polygandron and different types of peat (Finnish, Irish and Russian) were also ineffective. Boehm & Hoitink (1992) found that potting mixes prepared with Canadian sphagnum peat varied in suppressiveness to root rot of poinsettia caused by *Pythium* sp. Light coloured, least-decomposed peats were the most suppressive. Further work is needed to try and identify suppressive media or biocontrol agents for control of pythium root rot in poinsettia.

Inoculation of peat with mycorrhizal inoculant appeared to give moderate control of pythium root rot as determined by the number of saleable plants in October and November. It is interesting to note that the peat/VAM medium was low in phosphorus on 8 October (8 weeks after potting) and that in December the roots were found to have small but significant infection by mycorrhiza.

CONCLUSIONS

Cyclamen

1. Following inoculation of growing media with a suspension of *Fusarium oxysporum* f.sp *cyclaminis* spores, the incidence of plants affected by fusarium wilt was significantly less in peat amended with 40% pine bark, wood fibre processed straw, composted larch and spruce bark, composted bark and paper and composted pine bark than in peat. Composted pine bark and composted bark and paper gave better disease control than other bark amendments.

2. Development of fusarium wilt was rapid in standard sphagnum peat and a Russian peat and relatively slow in a Finnish peat and an Irish peat.

3. Drenching plants on four occasions at monthly intervals after potting with Octave (0.5 g/l) gave very good control of wilt and had no adverse effect on plant growth.

4. Drenching plants once with Bavistin (1 g/l) and then three times with Octave (1 g/l) at monthly intervals gave very good control of wilt and had no adverse effect on plant growth.

5. Drenching plants four times with Bavistin DF (1 g/l) at monthly intervals appeared to give slight control of wilt.

6. Drenching plants four times with Mycostop (0.05 g/l) at monthly intervals gave a significant reduction in the incidence of wilt 8 weeks after inoculation. The level of control declined when treatment with Mycostop ceased. No effect on plant growth or flowering was observed.

7. Incorporation of crushed crab shells (1%) into the growing medium gave excellent control of wilt. The number of actinomycete bacteria in peat amended with chitin was significantly greater (approximately 20 times) than in unamended peat.

8. Incorporation of a mycorrhizal inoculant (5%) into the growing medium appeared to give slight control of wilt but it did not become well established on roots.

9. The rate of development of wilt was greater (1) in peat than in peat /bark medium; (2) with overhead watering than watering via capillary matting; (3) with an inoculum of 10^5 spores/pot than 10^3 spores/pot; (4) with inoculation by drenching from above than by standing plants in a saucer of spore suspension.

10. The suppression of wilt by bark amendment was most effective at low disease pressure.

11. Leaching of pine bark with water in an attempt to remove water-soluble fungitoxic substances did not remove its disease suppressive effect; and the leachate did not inhibit mycelial growth of *F.oxysporum* f.sp *cyclaminis* in culture.

12. Autoclaving bark twice for 15 minutes at 15 psi did not destroy its disease suppressive properties.

Saintpaulia

1. Inoculation of the basal layer of growing medium with a 1 cm disc of *Phytophthora cryptogea* on agar did not result in root rot.

2. Plants grown in peat amended with 40% perlite, processed straw and wood fibre produced marketable plants not significantly different in quality from plants grown in 100% peat. Amendments with bark reduced flowering and plant quality.

3. Drenching plants three times with Aaterra (1 g/l), Filex (1.5 ml/l) and Fongarid (1 g/l) had no adverse effect on plant growth.

Pansy

1. Inoculation of pansies 2 weeks after potting with a suspension of *Thielaviopsis basicola* spores resulted in black root rot. The disease developed slowly during September and October but some plants were severely affected by December.

2. Drenching with Bavistin DF (1 g/l) three times at monthly intervals significantly reduced the incidence and severity of black root rot, from 16% of plants affected to less than 1%.

3. Amendment of peat with 40% bark, perlite or processed straw appeared to reduce leaf yellowing, a symptom associated with black root rot, but differences were not quite significant at the 5% level.

4. A low starting pH (4.6) and low ammonium-N gave no reduction in black root rot.

5. Drenching plants three times with Mycostop, inoculation of the growing medium with a mycorrhizal inoculant, use of a different type of peat (Irish) and amendment with woodfibre did not reduce black root rot.

Poinsettia

1. Inoculation at potting by laying a 1 cm layer of pythium-infested peat at the bottom of pots resulted in a high incidence of pythium root rot. The disease first appeared two weeks after potting and severe root rot was observed at the final assessment in December; in some plants there was no healthy root remaining outside the initial root plug.

2. Leaf chlorosis was evident soon after potting in plants grown with wood fibre amendment and in Russian peat; at the final assessment in December chlorosis was evident in plants with bark, straw and wood fibre amendment. Uninoculated plants grown in peat amended with perlite or drenched with Polygandron were smaller than all other treatments; *Pythium* sp was subsequently confirmed on roots of these plants.

3. Drenching plants three times with Aaterra (1 g/l) or Fongarid (1 g/l) at monthly intervals gave excellent disease control. Drenching plants three times with Filex (1.5 ml/l) appeared to give slight control, and was more effective on plants in peat than on plants in peat/bark.

4. Amendment of peat with 40% bark, perlite, processed straw and wood fibre had no significant effect on pythium root rot.

5. Amendment of peat with 5% mycorrhizal inoculant appeared to give slight control of pythium root rot and increase the number of saleable plants. The level of control was similar to that achieved by drenching with Filex. At the end of the trial, roots were found to be moderately well colonised by vesicular-arbuscular mycorrhiza.

6. Drenching plants with Polygandron (0.5 g/l) and growing plants in different types of peat (Finnish, Russian and Irish) did not reduce root rot.

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Effect of growing amendments on cumulative incidence of cyclamen fusarium wilt - 1992 (Exp. 1)

Treatment		29 July	12 Aug	26 Aug	9 Sep
1	Peat	1.3	11.3	34.4	50.6
2	Peat/Bark	1.3	3.8	6.3	21.3
3	Peat/autoclaved bark	0	1.3	6.3	16.3
4	Peat/leached bark	0	2.5	7.5	17.5
5	Peat/wood fibre	0	0.0	3.7	5.0
6	Irish peat	0	2.5	6.3	22.5
7	Finnish peat	0	0.0	3.7	13.8
8	Russian peat	0	17.5	32.5	48.8
9	Peat/larch + spruce	0	1.3	7.5	22.5
10	Peat/bark + paper	0	0.0	1.2	5.0
11	Peat/composted pine bark	0	1.3	3.7	10.0
12	Peat/Fi-Pro straw	0	1.3	5.0	8.8

		23 Sep	7 Oct	21 Oct	4 Nov
1	Peat	62.5	71.3	78.1	82.5
2	Peat/Bark	33.7	45.0	57.5	58.7
3	Peat/autoclaved bark	27.5	40.0	43.7	51.2
4	Peat/leached bark	25.0	37.5	43.7	51.2
5	Peat/wood fibre	5.0	7.5	10.0	12.5
6	Irish peat	40.0	52.5	55.0	57.5
7	Finnish peat	16.2	18.8	25.0	28.7
8	Russian peat	58.7	68.8	76.3	78.8
9	Peat/larch + spruce	23.7	33.7	37.5	42.5
10	Peat/bark + paper	7.5	12.5	17.5	23.7
11	Peat/composted pine bark	12.5	18.7	22.5	25.0
12	Peat/Fi-Pro straw	12.5	13.7	18.7	25.0

Effect of growing amendments on cumulative incidence of cyclamen fusarium wilt - 1992 (Exp. 1)

Treatment		18 Nov	2 Dec	16 Dec	7 Jan
1	Peat	86.9	90.0	94.4	97.5
2	Peat/Bark	67.5	68.8	78.8	93.8
3	Peat/autoclaved bark	53.7	55.0	60.0	65.0
4	Peat/leached bark	53.7	61.3	68.9	83.8
5	Peat/wood fibre	16.2	16.3	22.5	26.2
6	Irish peat	67.5	76.3	80.0	85.0
7	Finnish peat	32.5	38.8	42.5	50.0
8	Russian peat	82.5	88.8	92.5	98.8
9	Peat/larch + spruce	42.5	50.0	56.2	73.8
10	Peat/bark + paper	28.7	35.0	42.5	48.7
11	Peat/composted pine bark	28.7	31.3	33.7	45.0
12	Peat/Fi-Pro straw	33.7	35.0	38.7	51.2

Factors affecting development of cyclamen fusarium wilt (Exp. 2)

	Treatment				Cumulative % plants dead at intervals	
	Medium	Level	Site	Water	14 weeks	25 weeks
1.	P	L	S	C	22.5 (34.2)	77.5 (72.3)
2.	B	L	S	C	27.5 (41.4)	55.0 (58.0)
3.	P	S	S	C	100.0 (100.0)	100.0 (100.0)
4.	B	S	S	C	100.0 (100.0)	100.0 (100.0)
5.	P	L	B	C	40.0 (49.1)	75.0 (74.3)
6.	B	L	B	C	15.0 (29.6)	67.5 (65.5)
7.	P	S	B	C	92.5 (86.2)	100.0 (100.0)
8.	B	S	B	C	85.0 (81.0)	95.0 (93.4)
9.	P	L	S	H	70.0 (66.9)	95.0 (90.8)
10.	B	L	S	H	27.5 (40.9)	65.0 (64.7)
11.	P	S	S	H	100.0 (100.0)	100.0 (100.0)
12.	B	S	S	H	100.0 (100.0)	100.0 (100.0)
13.	P	L	B	H	30.0 (42.2)	65.0 (63.8)
14.	B	L	B	H	2.5 (14.6)	35.0 (45.8)
15.	P	S	B	H	100.0 (100.0)	100.0 (100.0)
16.	B	S	B	H	95.0 (90.8)	100.0 (100.0)
	SED				- 7.60	- 6.64
	F prob				- NS	- NS

Angular transformed values are shown in parenthesis

Medium: P - Peat, B - Peat/Bark

Level: L - Low, S - Standard

Site: S - Surface, B - Base

Watering: C - Capillary matting H - Hand watering

Effect of bark, inoculum level, inoculation site and watering method on development of cyclamen fusarium wilt (Exp. 2)

	Cumulative % plants dead at intervals (weeks)			
	4	8	16	25
1. Effect of bark				
Peat	0	25.0	75.0	89.1
Peat/Bark	0.3	19.4	60.9	77.2
2. Effect of inoculum level				
Low	0	3.4	37.8	66.9
Standard	0.3	40.9	98.1	99.4
3. Effect of inoculations site				
Compost surface	0.3	38.4	72.8	86.6
Pot base	0	5.9	63.1	79.7
4. Effect of watering method				
Capillary matting	0.3	17.2	65.3	83.8
By hand	0	27.2	70.6	82.5

Factors affecting suppression of cyclamen fusarium wilt (Exp. 2)

		Cumulative % plants dead at intervals (weeks)			
		4	8	16	25
1.	Peat/Low inoc	0	2.5	51.3	78.1
2.	Bark/Low inoc	0	4.4	24.4	55.6
	Reduction with bark	0	+1.9	26.9	22.5
3.	Peat/Std inoc	0	47.5	98.8	100
4.	Bark/Std inoc	0.62	34.4	97.5	98.2
	Reduction with bark	+0.62	13.1	1.3	1.2
5.	Peat/surface	0	45.0	78.1	93.1
6.	Bark/surface	0.62	31.9	67.5	80.0
	Reduction with bark	+0.62	13.1	10.6	13.1
7.	Peat/base	0	5.0	71.9	85.0
8.	Bark/base	0	6.9	54.4	74.4
	Reduction with bark	0	+1.9	17.5	10.6
9.	Peat/Cap. matting	0	19.4	69.4	88.1
10.	Bark/Cap. matting	0.62	15.0	61.3	79.4
	Reduction with bark	+0.62	4.4	8.1	8.7
11.	Peat/hand water	0	30.6	80.6	90.0
12.	Bark/hand water	0	23.7	60.6	75.0
	Reduction with bark	0	6.9	20.0	15.0

Effect of inoculum level, inoculation site and watering method on the suppression of fusarium wilt by bark (Exp. 2).

		Cumulative % plants dead at intervals (weeks)			
		14 weeks		25 week	
1.	Peat/low inoc	40.6	(48.1)	78.1	(75.3)
2.	Bark/low inoc	18.1	(31.6)	55.6	(58.5)
	SED	-	3.36	-	3.40
	F Prob	-	0.006	-	0.003
3.	Peat/Std inoc	98.1	(96.5)	100	(100.0)
4.	Bark/Std inoc	95.0	(92.9)	98.8	(98.3)
	SED	-	3.36	-	3.40
	F prob	-	0.006	-	0.003
5.	Peat/surface	73.1	(75.3)	93.1	(90.8)
6.	Bark/surface	63.8	(70.6)	80.0	(80.7)
	SED	-	3.36	-	3.40
	F prob	-	NS	-	NS
7.	Peat/base	65.6	(69.4)	85.0	(84.5)
8.	Bark/base	49.4	(54.0)	74.4	(76.2)
	SED	-	3.36	-	3.40
	F prob	-	0.013	-	NS
9.	Peat/Cap. matting	63.8	(67.4)	88.1	(86.7)
10.	Bark/Cap. matting	56.9	(63.0)	79.4	(79.2)
	SED	-	4.88	-	3.40
	F prob	-	0.045	-	NS
11.	Peat/hand water	75.0	(77.3)	90.0	(88.6)
12.	Bark/hand water	56.3	(61.6)	75.0	(77.6)
	SED	-	4.88	-	3.40
	F Prob	-	0.045	-	NS

Angular transformed values are shown in parenthesis

Effect of fungicides and biocontrol treatments on control of cyclamen fusarium wilt - Exp. 3

	Treatment	Cumulative incidence % of dead plants		
		9 September	4 November	7 January
1	Peat	45.6 (42.4)	80.0 (65.4)	94.4 (79.2)
2	Peat/bark	13.7 (20.5)	46.2 (42.8)	66.3 (54.7)
3	Peat/chitin	10.0 (17.9)	21.2 (27.3)	48.8 (44.4)
4	Peat + Bavistin (x4)	35.0 (36.0)	72.5 (58.8)	88.8 (73.9)
5	Peat + Octave (x4)	15.0 (21.4)	35.0 (34.8)	50.0 (44.8)
6	Peat + Bav (x1) + Oct (x3)	22.5 (27.6)	33.7 (35.1)	46.3 (42.9)
7	Peat + Exp. (1 g/l)	21.2 (26.5)	58.7 (50.3)	77.5 (62.4)
8	Peat + Exp. (0.5 g/l)	35.0 (36.1)	58.7 (50.2)	83.8 (66.9)
9	Peat + Mycostop (x4)	33.7 (34.7)	68.8 (57.4)	91.3 (75.4)
10	Peat/VAM	41.2 (39.7)	67.5 (55.4)	85.0 (68.5)
	SED between treatments	8.62(5.79)	10.25(7.11)	8.65(6.76)
	Control vs treatments	7.46(5.02)	8.88(6.16)	7.50(5.85)
	F prob	- (0.003)	- (<0.001)	- (<0.001)

Initial nutrient levels of growing media*

Compost	pH	Conduct µS (index)	P mg/l (index)	K mg/l (index)	Mg mg/l (index)	NO_3 mg/l (index)	NH_4^+ mg/l (index)
1. Peat	5.4	362 (2)	63 (7)	167 (3)	67 (6)	120 (4)	42 (1)
2. Peat/Bark	5.2	447 (3)	72 (7)	234 (4)	78 (6)	187 (5)	88 (2)
3. Peat/Autoclaved bark	5.3	456 (3)	68 (7)	220 (4)	80 (6)	186 (5)	84 (2)
4. Peat/Leached bark	5.3	432 (3)	66 (7)	180 (4)	68 (6)	168 (5)	84 (2)
5. Peat/Woodfibre	5.0	438 (3)	68 (7)	218 (4)	80 (6)	149 (5)	66 (2)
6. Irish peat	5.4	333 (2)	57 (7)	170 (3)	64 (6)	112 (4)	48 (1)
7. Finish peat	5.2	410 (3)	57 (7)	224 (4)	71 (6)	135 (4)	48 (1)
8. Russian peat	5.4	415 (3)	73 (7)	203 (4)	70 (6)	148 (5)	65 (2)
9. Peat/Larch & spruce bark	6.1	457 (3)	66 (7)	243 (4)	33 (4)	139 (4)	129 (3)
10. Peat/Bark & paper	6.0	433 (3)	57 (6)	226 (4)	51 (6)	150 (5)	80 (2)
11. Peat/composted pine bark	5.2	465 (3)	65 (7)	252 (4)	88 (7)	174 (5)	75 (2)
12. Peat/Fi-Pro straw	5.1	525 (4)	95 (8)	270 (5)	81 (6)	164 (5)	78 (2)
13. Peat/Perlite	5.0	457 (3)	82 (8)	228 (4)	86 (7)	155 (5)	62 (2)
14. Peat/Low pH	4.6	498 (3)	76 (7)	212 (4)	120 (7)	191 (5)	20 (1)

* Mean results of 2 samples