Factsheet 16/04

Hardy Nursery Stock

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Control of *Phytophthora, Pythium* and *Rhizoctonia* in container-grown hardy ornamentals

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Root, crown and basal stem rots caused by species of *Phytophthora, Pythium* and *Rhizoctonia* are economically important diseases of container-grown hardy ornamentals. This factsheet describes the symptoms caused by these pathogens, their biology, and a management strategy for disease control. It does not deal with the diseases caused by *Phytophthora ramorum* (see factsheet 19/03), or with the less common crown and root rot diseases caused by other fungal pathogens.

Action points

Stockplant management

- Ensure stock plants are free from *Phytophthora*, *Pythium* and *Rhizoctonia* and take appropriate cultural and other measures to maintain their health (see provision of healthy propagating material).
- If possible, grow stock plants in containers, in well drained growing media with high air capacity.
- Where feasible, train stock plants to discourage prostrate growth and stimulate production of cutting material higher up.

Optimal root growth

- Ensure that cultural conditions are optimal for good root growth. In particular, manage watering so that the growing media is neither too wet nor too dry, preferably using trickle or sub-irrigation.
- Avoid high conductivity, incorrect pH or nutrient imbalance in the growing media, or other factors that may check root growth, as these may encourage *Phytophthora* and *Pythium.*
- Monitor root health with regular visual checks and, where necessary, accurate expert diagnosis.

Nursery hygiene

- Implement a nursery hygiene regime that covers all the stages of propagation and production to include cleaning and/or disinfecting beds, pots, tools, machinery, water and irrigation equipment. Consider creating a plant quarantine area (see section on hygiene).

Use of fungicides

- Cuttings are particularly susceptible to *Rhizoctonia* during rooting because of the high humidity. If necessary, use a protectant fungicide treatment.
- Where there is significant disease risk, include appropriate fungicide treatment(s). Early fungicide treatment, before the disease is established, is important for effective control.

1 Stock plants grown in containers with trickle or sub-irrigation will minimise disease risk

Background

A wide range of container-grown hardy ornamentals are susceptible to root rot caused by species of *Phytophthora*, *Pythium* and *Rhizoctonia.* Infection arising during propagation can lead to widespread losses.

Pythium species are probably the most common and are particularly damaging during propagation and on young plants, although mature plants sometimes can also be severely affected. HDC project PC 97a revealed pathogenic *Pythium* species to be widespread on many UK nurseries growing pot or bedding plants and the situation with hardy nursery stock production is likely to be similar.

The damage caused by *Phytophthora* species is often much more severe than that caused by *Pythium* species, with larger as well as smaller roots being attacked and rotting sometimes extending into the crown or stem base. Infection may occur on both young and mature plants.

Pythium and *Phytophthora* species, sometimes known as water moulds, are closely related. For example, both are exacerbated by abundant moisture, are similar in their sensitivity to fungicides and share other common features.

Rhizoctonia solani has a wide host range and causes damping-off, root rot, wire-stem, crown rot and occasionally a leaf and stem blight. Mature plants are generally less susceptible.

Symptoms

Symptoms caused by species of *Phytophthora, Pythium* and *Rhizoctonia* are not always sufficiently distinctive to enable reliable visual diagnosis to be made. Accurate diagnosis is important for appropriate fungicide selection. Therefore, seek expert help where there is doubt.

Phytophthora root, crown and basal stem rot

The effect of root rotting is often first evident from symptoms on aerial parts of the plant, namely poor growth, leaf yellowing, symptoms of nutrient deficiency (pale or off-colour foliage), wilting or a rapid collapse of the plant. Close examination of the root system will reveal some or most roots to be water-soaked, brown or black in colour and soft. The root cortex (outer sheath) is easily sloughed off to expose the central vascular column (the stele). Large as well as fine roots are frequently affected.

Sometimes the fungus progresses into the stem base, causing a reddish brown discolouration of the wood, and wilting and withering of shoots or even the entire aerial parts of the plant. Root and stem base rot caused by various *Phytophthora* species is common on a range of hardy ornamentals. Table 1 overleaf lists susceptible species commonly grown in the UK.

Phytophthora leaf and shoot blight

Occasionally, leaves and shoots may be directly attacked by *Phytophthora* species spread by splash from growing media or plant material contaminated with the fungus. This is most likely to happen during heavy rain in outdoor production, but can also occur on container grown stock under protection, mainly where overhead sprinklers are used.

The first evidence of infection is a small, grey or brown water-soaked area on expanding leaves and young shoots. These areas then expand until entire leaves are destroyed and stems become affected and die back. Notable nursery stock subjects so affected include *Ceanothus* and *Ilex*, both of which are widely grown in containers outdoors and under protection. Wounded tissue created by pruning cuts or physical damage is also a common entry point for infection.

Pythium root and stem base rot

Symptoms induced on the aerial parts of the plant by *Pythium* root rot are similar to those induced by infection of roots by *Phytophthora* species (see opposite). Close examination of the root system will reveal many or most of the roots to be discoloured and rotting. Rotting may sometimes be confined to root tips or thin lateral roots. Typically, affected roots appear water-soaked, grey or brown and shrivelled. The cortex sometimes falls away easily, leaving just the central stele. When such symptoms are extensive, they seriously impede root action.

In non-woody species, the fungus may extend into the stem causing a basal stem or crown rot. Occasionally, *Pythium* species cause a basal stem rot in the absence of obvious root rot.

Seedlings and cuttings affected by *Pythium* species collapse (damping-off) or in the case of seedlings, they may fail to emerge. Rot caused by *Pythium* which results in damping-off, usually progresses back from the root tips, whereas that caused by *Rhizoctonia* (see opposite) usually

2 The effect of root rotting is often first evident as leaf yellowing and poor growth, as here with *Phytophthora cryptogea* on *Hebe pinguifolia* 'Pagei' (affected plant on the right)

3 *Pythium* root rot in *Penstemon*, resulting in loss of fine roots (left) and brown spots on larger roots (right)

develops on roots and the stem base at or just below the compost surface. It is possible that seedlings and cuttings only slightly affected may go unnoticed and be potted on, and the growing plants will then be unthrifty.

Rhizoctonia root and stem base rot

R. solani is the principal *Rhizoctonia* species and is commonly found on nurseries affecting a very wide range of ornamental plants. Susceptible species are listed in Table 2. The fungus causes damping-off of seedlings and cuttings, root rotting, crown rotting and occasionally a leaf and stem blight.

On seedlings and young plants, the stem base is often discoloured and typically constricted at the compost surface, this symptom being termed wire-stem.

On cuttings, infection results in a dry, brown stem lesion progressing inwards. Sometimes strands of the fungus are visible, growing over affected tissues and across the surface of the propagation medium. The damaged tissues may subsequently be colonised by the grey mould fungus, *Botrytis cinerea.*

On established woody plants, the most common stem symptom is a brown sunken lesion at or just above the compost surface. Sometimes these lesions do not penetrate the stem deeply enough to seriously affect growth but they can split and become cankerous.

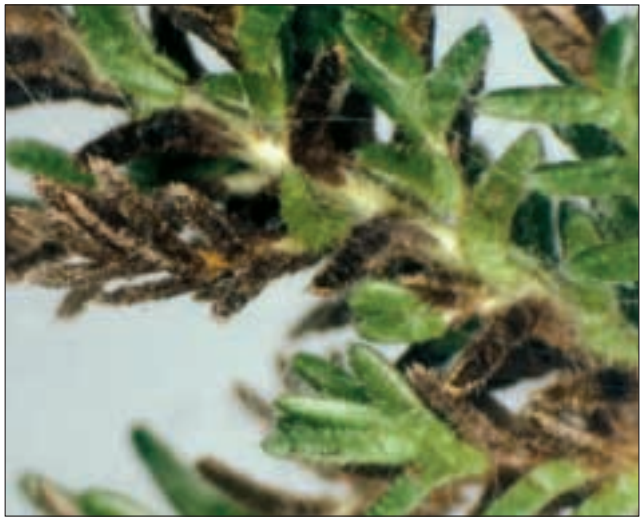
Crown and stem base rotting may result either from progression of the fungus from the roots, or from direct attack of the crown or stem base tissues.

Root rotting caused by *R. solani* typically shows as discrete brown lesions, consisting of rotting of the outer root tissues, scattered along the length of the root. New root growth may be inhibited. These root symptoms are less common than those of stem and crown rotting.

Rhizoctonia web blight and leaf rot

Under warm, humid conditions, strands of *R. solani* may be seen as a webbing growing over the leaves, which subsequently rot. This symptom is known as web-blight and *Calluna* cuttings are particularly vulnerable. Occasionally, during heavy rain, on plants growing outdoors, leaf symptoms may result from direct infection caused by splash of contaminated growing medium or plant material.

4a *Rhizoctonia solani* infection resulting in root rot in *Calluna*



4b Characteristic webbing (web blight) growing over the leaves of *Calluna* caused by *Rhizoctonia solani*

Table 1
Some common container-grown hardy ornamentals susceptible to *Phytophthora* root, crown and basal stem rot

Hardy nursery stock
Abies
Acer
Aesculus
Alnus
Buxus
Calluna/Erica
Castanea
Chamaecyparis
Cypressus
x Cupressocyparis leylandii
Choisya
Cordyline
Escallonia
Eucalyptus
Fagus
Fremontodendron
Gaultheria
Hebe
Juniperus
Lavendula
Malus
Oleaeria
Picea
Prunus
Pittosporum
Rhododendron
Ribes
Rosemarinus
Rubus
Sambucus
Senecio
Sorbus
Syringa
Taxus
Thuja
Vaccinium
Viburnum
Herbaceous perennials
Cheiranthus
Clematis
Hellebore
Meconopsis
Nymphaea
Saxifrage

Table 2
Some common container-grown hardy ornamentals susceptible to *Rhizoctonia* root, crown and basal stem rot

Hardy nursery stock
Azalea
Calluna
Ceanothus
Cupressus
Erica
Euonymus
Forsythia
Ilex
Rhododendron
Rose
Vinca
Weigela
Herbaceous perennials
Campanula
Cheiranthus
Convolvulus
Dianthus
Euphorbia
Hellebore
Lavendula
Lupin
Nepeta
Saxifrage

Disease sources and spread

Much of the propagation of hardy ornamentals is by vegetative means. If this process takes place using infected plants or cuttings contaminated with *Phytophthora*, *Pythium* or *Rhizoctonia,* extensive disease spread may occur. Hence the importance of producing healthy stock plants.

Phytophthora* and *Pythium

Phytophthora and *Pythium* are not seed-bourne but are often introduced to a nursery by infected cuttings. The means by which they survive and spread are very similar. Within infected tissues, spread is by fungal strands which can also cause new infections. Survival is by micro-scopic but very resilient resting structures produced within infected tissue. When these tissues decay, the resting structures can survive for long periods (months or possibly years) in a dormant state in the ground, in compost, in dust blown around the nursery, in aquatic environments such as puddles and surface drainage water, or within irrigation tanks or reservoirs, hence the importance of good nursery hygiene.

New infections are initiated when resting spores are stimulated to germinate by exudates released from the roots of a potential host plant. Germination of a resting spore results in release of myriads of spores which

5 *Phytophthora* root and stem rot in *Chamaecyparis lawsoniana*. Affected plants initially lose colour and wilt and later turn brown (above)

are motile in films of moisture and may be attracted by roots of susceptible hosts.

Occasionally, when conditions are exceptionally wet, for example where plants outdoors are subjected to heavy rainfall, significant direct spread to leaves and shoots may occur as a consequence of rain splash of contaminated material. This aerial spread occurs much more commonly with *Phytophthora* than with *Pythium.*

Rhizoctonia

Rhizoctonia is able to survive as fungal strands in and on dead plant material and in the soil, from one growing season to the next. The fungus also produces structures consisting of densely aggregated strands of the fungus (sclerotia). These range in size from being barely visible to as much as 6 mm across and are variable in shape and flattened in appearance. They are longer lived than fungal hyphae, probably for a year or more, but their precise role as a means of perpetuation of the pathogen in commercial nursery stock production is not clear.

Unlike many other fungi, spore production by *R. solani* is not considered to be significant for disease spread on hardy perennials in the UK. Spread usually occurs by growth of the fungus, over the compost surface from an infected cutting or plant to a healthy one nearby. This can happen very rapidly where cuttings are being rooted but is much slower once plants are in individual containers and spaced out.

As with *Phytophthora* and *Pythium* species, when conditions are exceptionally wet significant direct spread and damage to aerial plant parts may occur as a consequence of rain splash spreading material contaminated with the fungus.

Conditions conducive to disease development

Phytophthora* and *Pythium

The presence of a water film is essential for spore movement and infection. Consequently, disease development is almost invariably more rapid and more extensive where the growing regime is wetter than that optimum for growth.

Temperature also plays an important part in the speed of disease development. However, the ranges over which activity occurs, and those which are optimum for disease development, vary considerably between the different species of *Phytophthora* and *Pythium*. For example, some species of *Pythium* grow well at temperatures below 15°C whereas others grow best at 25–30°C. With *Phytophthora*, there is little or no germination of resting spores below 10°C and most species are much more active in the 20–30°C range.

There is evidence that in addition to excess moisture, other adverse cultural factors (eg moisture stress, nutrient imbalance, excessively high conductivity, incorrect pH, or other factors resulting in root loss or a check to root growth) may encourage development of *Phytophthora* and *Pythium*. Therefore, the risk of significant damage is almost invariably greater where the root environment is less than ideal for growth.

Rhizoctonia

Information about conditions that are particularly conducive to attack by *Rhizoctonia* is not very precise. However, there is general agreement that the fungus is more damaging when the growing medium is kept wetter than optimum and the aerial environment is humid. Temperature can also markedly affect activity, 20-30°C being the most favourable.

Plant tissues and stem bases while still young and soft are particularly susceptible to damaging attack, hence any adverse cultural factor which slows or delays establishment and growth will increase the risk of *Rhizoctonia* being a problem. Cuttings are thus particularly vulnerable to *Rhizoctonia* during rooting because of the high humidity conditions necessary for rooting, which also encourage growth of the fungus.

6 *Phytophthora* root infection may progress into the stem base causing a red brown discolouration of the wood (left: *Chamaecyparis*; right: *Fremontodendron*).

Control strategy

Use of healthy propagation material and maintenance of a very high standard of hygiene is crucial for controlling *Phytophthora, Pythium* and *Rhizoctonia*. For a strategy to be wholly successful, these measures must be combined with good cultural management and rational and responsible use of fungicides.

Provision of healthy propagation material

- Carefully inspect cuttings arriving on the nursery and reject any showing symptoms of root disease.
- Select stock plants to take cuttings from which are vigorous, have strong,healthy-looking root systems and which are free from obvious or suspected disease.
- Take cuttings from stock plants from sites where there has been no recent history of root disease problems.
- Because *Rubus* species are both very susceptible to *Phytophthora* root rot, and are propagated by root cuttings, there is a high risk of perpetuating the fungus during propagation. Growers are best advised to obtain rooted plants of *Rubus* species from reputable specialist propagators.
- Where possible, grow stock plants in free-draining growing media in individual containers with generous spacing between plants.
- Preferably locate the standing area under protection and ensure that it is disinfected with Jet 5 prior to use and is very well drained.
- Where possible, water stock plants individually, by trickle irrigation.
- Ensure that watering is well managed so that the growing medium is never too wet nor too dry.
- Where feasible, train plants to discourage prostrate growth and stimulate production of cutting material higher up.
- Follow a comprehensive regime of preventative fungicide treatments for stock plants.
- Promptly and carefully remove suspected diseased plants and dispose of them safely.

7 Branch dieback of *Ribes* caused by *Phytophthora*

Nursery hygiene

There are many means whereby *Phytophthora, Pythium* and/or *Rhizoctonia* can survive on a nursery and rapidly cause problems. It is therefore important that a comprehensive hygiene regime is developed and implemented.

- Remove dead and dying plants promptly. Thoroughly collect up and dispose of plant debris and used growing media into a covered skip or bin.
- When beds are empty, clean and disinfect the surface (eg with Jet 5). Where there has been a significant root disease problem recently, replace any ground-covering material.
- Only use new or thoroughly cleaned and sterilised pots and containers. Store them where they will not become contaminated with dust, water or debris.
- Regularly clean and disinfect the propagation area, including tools, equipment and benches. Before disinfecting, remove as much plant debris, dirt, spent media and dust as possible. Rooting media should be sterile and not re-used.
- Regularly clean and disinfect all working areas and machinery linked to potting operations and the preparation of growing media.
- Disinfectants with activity against *Pythium* and *Phytophthora* include Jet 5 and sodium hypochlorite.
- Use proprietary growing media and substrates for use in own-mixes from a reliable source and store where they will not become contaminated.
- Ensure good bed drainage to minimise surface puddling and run-off.
- Check irrigation systems, especially overhead spray lines for leaks, drips or application irregularities.
- Maintain roadways to minimise surface puddling.

Irrigation

- Preferably use mains or borehole water, or otherwise use water from a source where there is minimal risk of pathogen contamination.

- Check irrigation water at the point of application several times each year to ensure it is not contaminated by *Pythium.*

- Regularly clean and disinfect water storage tanks and irrigation lines (eg with sodium hypochlorite or Jet 5). Tanks should be covered to prevent contamination.

- Where there is a known higher risk of pathogen contamination (eg where water is collected and recycled), unless this can be minimised by other means, have a facility to treat it prior to use (eg UV-light, chlorine treatment or slow sand-filtration), particularly in propagation situations. A grower's guide to slow sand filtration is available from the HDC.

8 Puddled roadways can allow spread of *Pythium* and *Phytophthora* on vehicle wheels, shoes and by direct water-splash

Cultural control during production

- Regularly monitor plant roots for the presence of disease.

- Manage watering so that the growing media is neither too wet nor too dry. This requirement can be much better met if production takes place under protection.

- Use well-managed trickle or sub-irrigation as much as possible eg drip-point irrigation, capillary sand-beds or ebb & flow, where appropriate, are ideal.

- Space plants as generously as the economics of production allow.

- Manage the aerial environment to minimise surface wetness and periods of high humidity.

- Use a growing medium which has the physical and nutritional properties eg texture, drainage, air-filled porosity, nutrient balance and level, which is most appropriate for the needs of the plant species being grown, and monitor nutrient levels to assess on-going needs.

9 Space plants well and use trickle or sub-irrigation where possible to minimise leaf wetness

Use of fungicides

Successful, cost effective control of the major root and crown rot diseases means:

- Use commercially economic non-pesticide measures as much as possible.
- Where there is significant disease risk, use a preventative fungicide treatment. Early fungicide treatment before the disease is established, is important for effective control.
- Ensure fungicide products for *Pythium* and *Phytophthora* are incorporated evenly into the compost or applied to the compost surface according to the label recommendations.
- Alternate fungicides from different groups to avoid the build up of resistant pathogen strains.
- Determine frequency of fungicide treatment based on duration of protection afforded by any previous treatment and the current level of threat from the diseases eg more frequent treatment may be required after a particularly wet spell, or following damage to roots.
- Ensure that each fungicide application is applied thoroughly and at the correct rate of use.

Product selection

There are a limited number of fungicides with activity against *Phytophthora*, *Pythium* and *Rhizoctonia* (Tables 3 and 4). The range of fungicides permitted on HNS and likely to be effective against one or more of these diseases, is very much more extensive than that listed in these tables, particularly for production outdoors. This is because the Long Term Arrangements for Extension of Use (LTAEU) allow extrapolation of use from a label approval or SOLA to use on an ornamental crop at grower's own risk. However, use must be in a similar manner and rate as that specified on the label or Specific Off-Label instructions; be cautious as some treatments may prove to be phytotoxic. Fungicides which are effective against *Phytophthora* and *Pythium* are not usually effective against *Rhizoctonia*, and *vice versa*.

Fungicide application

Effective protection against *Phytophthora* and *Pythium* requires the fungicide to be thoroughly and evenly incorporated throughout the compost. This can be achieved either by thoroughly mixing etridiazole products or fosetyl aluminium directly with the growing media just prior to use, or using these products or propamocarb hydrochloride, applied

Table 3
Fungicide products with label approval for use on container grown hardy ornamentals and activity against *Phytophthora* and *Pythium*

Fungicide group	Active ingredient	Product	Use outdoors (O) Under protection (P)	Level of disease control		Comment
				Phytophthora	*Pythium*	
Thiadiazole	Etridiazole	Standon Etridiazole 35	O & P	✓	✓	Label approval. Do not use on *Escallonia* or *Pyracantha* spp.
		Terrazole 35 WP	O & P	✓	✓	Label approval. Do not use on *Escallonia* or *Pyracantha* spp.
Phosphonate	Fosetyl-aluminium	Aliette 80 WG	O & P	✓	(✓)	Label approval for use outdoors; use under protection is by extrapolation from LTAEU and therefore at growers own risk.
		IT Fosetyl-AL	O & P	✓	(✓)	
		Standon Fosetyl-AL 80 WG	O & P	✓	(✓)	
Carbamate	Propamocarb hydrochloride	Filex	O & P	✓	✓	Label approval.
		Proplant	O & P	✓	✓	Label approval.

✓ control
(✓) partial control

Note:
All products should be incoporated throughly and evenly into the compost or applied as a drench to the compost surface, according to the label recommendation.

Table 4
Fungicide products with label approval for use on container grown hardy ornamentals and activity against *Rhizoctonia*

Fungicide group	Active ingredient	Product	Use outdoors (O) Under protection (P)	Level of disease control	Comment
Benzimidazole (MBC)	Carbendazim	Cleancrop Curve	O & P	(✓)	SOLA 1213/2004. Apply as a drench treatment.
		Delsene 50 Flo	O & P	(✓)	Permitted by extrapolation from SOLA 1004/2004. Apply as a drench treatment.
Dicarboximide	Iprodione	Rovral WP	O & P	(✓)	Extrapolation under LTAEU from various crops. Use as a foliar spray; not approved as a growing medium drench treatment.
		Cleancrop Gavotte WP	O & P	(✓)	As for Rovral WP.
		IT Iprodione	O & P	(✓)	As for Rovral WP.
		Ipromex 50% WP	O & P	(✓)	As for Rovral WP.
		Standon Iprodione 50 WP	O & P	(✓)	As for Rovral WP.
Organo-phosphorus	Tolclofos-methyl	Basilex	O & P	✓	Label approval. Do not use on heathers. Apply as a drench treatment. Use by hand-held equipment is not permitted. An organo-phosphorus pesticide.
Strobilurin (QoI)	Azoxystrobin	Amistar	O & P	✓	Limited information on efficacy. Permitted by LTAEU from various SOLAs (eg 1687/02 on outdoor salad onions; 1533/02 on protected tomato). Use as foliar spray, needs to be high volume.

✓ **control**
(✓) **partial control**

- Some products recently widely used for root disease control (eg Aaterra WP, Fongarid, Bavistin DF) are no longer produced, although some stocks may still be available.
- Always follow label recommendations, including rate of use, and check the range of ornamentals listed which can be safely treated.
- Contact the Pesticide Safety Directorate Information Service (01904 640500 or visit www.pesticides.gov.uk) or seek other professional advice if in doubt about which fungicide products are permissible on HNS or how to correctly use them.
- **Important –** Growers must always check the current approval status of products listed in this factsheet before intended use as this could have changed since it was produced.

as a drench to the surface. Drench treatment is usually best started immediately after sticking or potting. Where there is continuing risk of attack, additional fungicide application will be required. This interval should be adjusted according to the time of year. For example, few if any applications may be needed during the winter period in the cooler parts of the UK, especially where plants are stood outdoors.

For protection against *Rhizoctonia,* the fungicide may only need incorporation into a shallow surface zone (1–2 cm deep). Plants are most vulnerable to stem and root rot attack when young, and become progressively less so as they mature. Early treatments are very important. Where there is a continuing risk of attack, additional applications will be required. Basilex, Cleancrop Curve and Delsene 50 Flo are permitted as drench treatments while iprodione products are permitted as a foliar spray.

Fungicide resistance

If certain fungicides are used intensively, there is risk of selecting out strains of fungal pathogens that are resistant.These fungicides then become much less effective or completely ineffective.This has occurred with certain fungicides which have been widely used in the past for controlling *Phytophthora* and *Pythium* on hardy ornamentals but which are no longer available (eg *Pythium* species resistant to furalaxyl, the active ingredient in Fongarid). The fungicides currently approved and widely used for several years for controlling these pathogens (etridiazole, fosetyl aluminium and propamocarb hydrochloride) have not to date given rise to a resistance problem.

Currently, effective fungicidal control of *Rhizoctonia* on hardy nursery stock in the UK is very largely reliant on tolclofos-methyl. Fortunately, even though this fungicide has been used widely for many years, instances of resistance have been very rare, and none confirmed in the UK. Products based on iprodione (eg Rovral WP) and Carbendazim (eg Delsene 50 Flo) may also give control when applied as a drench to the growing media.

Biocontrol and the use of disease suppressive growing media

There is continuing interest in the development of disease suppressive growing media. These may utilise biocontrol agents, such as species of the fungus *Trichoderma*, or suppressive substances produced in bark or during composting. There are also products being marketed, eg compost teas, which claim to enhance the vigour and health of plant growth, and thereby strengthen the plant's resistance to disease attack. Although there is limited information on the reliability of such methods under nursery conditions and in comparison with fungicides, some results have been promising.

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Further information: A full copy of the final report for HDC project PC 97a is available from the HDC office (01732 848383).

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