Factsheet 17/04

Pot and bedding plants

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Control of *Pythium*, *Phytophthora* and *Rhizoctonia* in pot and bedding plants

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This factsheet describes the symptoms of *Pythium, Phytophthora* and *Rhizoctonia* diseases in bedding and pot plants, the biology of the causal organisms and a management strategy for disease control.

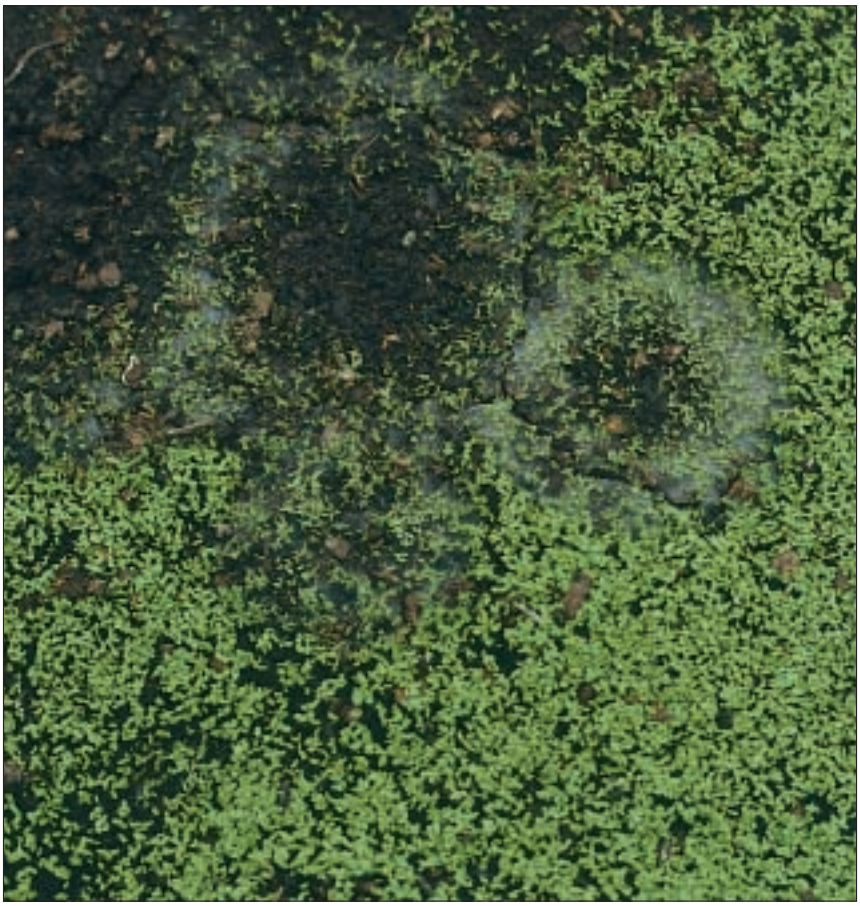
Action points

Nursery hygiene

- Use fresh growing media, straight from the bag, bale or covered bunker.
- Use new trays and pots, especially for propagation.
- Regularly clean and disinfect water storage tanks and irrigation lines and ensure water tanks are covered.
- Use mains or treated irrigation water and check at the point of application several times each year for contamination by *Pythium*.
- Eliminate standing water and treat leaks in roofs.
- Regularly change or sterilise capillary matting. Discard contaminated matting.
- Remove plant debris from glasshouse benches, floors and propagation beds and dispose of it outside of the glasshouse.
- Regularly clean and disinfect benches, floors, tools, trays and trolleys especially after an outbreak of a root disease.
- Control shore and sciarid fly populations.

Control during production

- Carefully inspect cuttings and plug plants before planting; reject any with symptoms of root disease.
- Good growing conditions including correct growing medium nutrient levels and pH, regular watering and free-draining compost will minimise risk of root disease. Most importantly, avoid over-watering and growth checks.
- Regularly monitor plants for the presence of disease. Where diseased plants occur, promptly remove and carefully dispose of them in a covered skip or bin.
- Where there is a significant disease risk, use a preventative fungicide spray programme.



1 Characteristic collapse of seedlings (lobelia) due to *Pythium*; note the white growth of *Pythium* at the edge of the bare patches

Introduction

Several soil-borne fungi and fungal-like micro-organisms are responsible for economically important root, stem base and crown rot diseases of bedding and pot plants. The fungi most commonly involved are species of *Pythium, Phytophthora* and *Rhizoctonia*. *Pythium* alone in bedding and pot plants is estimated to cause losses valued at £5.5 million annually, largely due to reductions in plant quality. Within intensive production systems, these pathogens can soon build up, causing serious losses and quality issues.

2 Collapse (damping off) of lobelia plugs due to *Pythium* infection

Background

Pythium is generally the most common cause of root rot and is particularly troublesome during propagation. In recent years, with the advent of plug production, *Pythium* damping-off of seedlings has become less common. It is most damaging on cuttings and young plants, although mature plants of certain crops (eg monstera, pelargonium, poinsettia) can also be severely affected. A recent HDC project (PC 97a) revealed pathogenic *Pythium* species to be widespread on many nurseries growing ornamentals.

Phytophthora is less frequent than *Pythium* but often causes more severe damage. Root and crown rot of mature plants is a common symptom. Certain pot plants (eg dieffenbachia, gloxinia, kalanchoe, primula, saintpaulia) are notably susceptible. *Pythium* and *Phytophthora* are closely related, belonging to a group of fungal-like micro-organisms. They are both favoured by abundant moisture, are similar in their sensitivity to fungicides, and share other common features. They will therefore be discussed together in some sections of this factsheet.

Rhizoctonia has a wide host range and commonly causes damping-off and wirestem of seedlings and stem base damage to cuttings and young plants. Mature plants are generally less susceptible.

3 *Phytophthora* often causes more severe damage than *Pythium* as seen here where *Phytophthora* root rot has caused wilting and plant collapse of cineraria

Symptoms

The symptoms caused by *Pythium* and *Phytophthora* are not usually sufficiently characteristic for reliable visual diagnosis to be made. Seek expert help where there is doubt.

Pythium on seedlings and cuttings

Pythium is most troublesome during propagation, attacking virtually all plant species. Seedlings affected by *Pythium* collapse ('damping-off') or fail to emerge. Where seedlings are grown in pots or trays, areas of affected plants enlarge leaving bare patches. The seedlings often collapse all in one direction.

Damping-off caused by *Pythium* usually progresses from the root tips upwards whereas damping-off caused by *Rhizoctonia solani* (see opposite) usually develops from the compost surface downwards. Damping-off is less common in trays of plug plants, where there is reduced opportunity for spread between seedlings. Nevertheless, occasionally whole trays of plants are affected, for example, when plants are past their optimum stage for potting on, or have been in transit for an extended period.

Cuttings infected with *Pythium* may fail to root and develop a basal soft rot, eventually leading to plant collapse. Less severely affected cuttings may go unnoticed and be potted on. After potting, infected plants can develop extensive root rot in wet conditions. These plants will fail to make marketable quality.

Pythium root and stem base rot on rooted plants

On rooted plants, the effect of root rot is often first seen on above-ground parts, being expressed as poor growth, yellowing, wilting or even plant death. This is the result of a debilitated root system. Occasionally just the root tips or thin lateral roots are decayed but more often there is an extensive root rot affecting the whole root ball. Affected roots appear water-soaked, grey or brown and shrivelled. The outer cortex of the root sometimes falls away easily, leaving just the central vascular strand.

In non-woody species particularly, the fungus may invade the stem to cause a stem base or crown rot. Plants damaged in this manner include pelargonium and saintpaulia.

A wide range of host plants are susceptible to *Pythium* species. Examples of crops that are particularly susceptible are given in Table 1.

4 *Pythium* root rot on poinsettia – affected roots are grey coloured and fall away easily

5 Pelargonium showing *Pythium* stem base rot (black leg)

Table 1
Some bedding and pot plants particularly susceptible to *Pythium*

Bedding plants (seedlings)
Antirrhinum
Alyssum
Callistephus
Lobelia
Nemesia
Tagetes

Pot plants
Cyclamen
Fuchsia
Monstera
Pelargonium
Pilea
Poinsettia

Table 2
Some bedding and pot plants particularly susceptible to *Phytophthora* root rot

Bedding plants
Callistephus
Cineraria
Dianthus
Nemesia
Petunia
Tagetes
Viola
Matthiola
Salvia

Pot plants (foliage)
Dieffenbachia
Hedera
Peperonia
Spathiphyllum
Zantedeschia

Pot plants (flowering)
Bellis
Begonia
Calceolaria
Capsicum
Cineraria
Exacum
Fuchsia
Gerbera
Gloxinia (Sinningia)
Impatiens
Kalanchoe
Pelargonium
Peperonia
Poinsettia
Primula
Saintpaulia
Schlumbergera
Solanum

Phytophthora root and stem base rot

Phytophthora species most commonly attack mature plants, causing a root and 'foot' rot. Leaf yellowing and wilting symptoms on above-ground parts are very similar to those caused by *Pythium*. The disease symptoms on the roots are also similar to *Pythium.* The roots become water-soaked, brown or grey in colour, soft, and the cortex is easily removed. One difference between the two diseases, however, is the ability of *Phytophthora* to progress from roots to invade the stem base and cause a visible rot (eg solanum and poinsettia), more frequently than *Pythium*.

It is relatively uncommon during plant establishment, but there are instances where *Phytophthora* can cause severe damage eg rotting of saintpaulia and gloxinia leaf cuttings.

Comprehensive lists of susceptible species are available in text books; a summary of commonly grown susceptible crops is given in Table 2.

6 Primula brown core (*Phytophthora primulae*) – characteristic brown staining within roots (left) and resulting leaf yellowing (right)

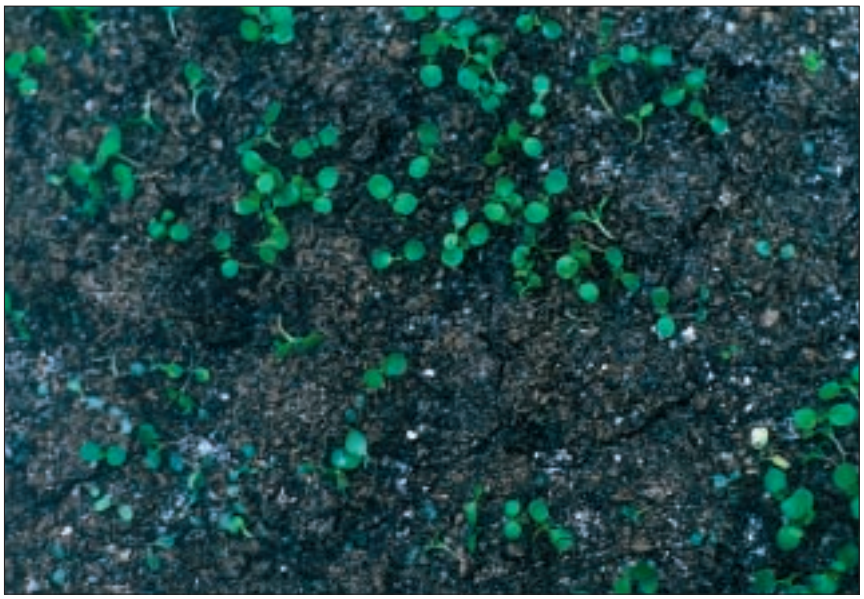
7 *Phytophthora* stem base rot of solanum – this visible rot is seen more frequently than with *Pythium* infections

Rhizoctonia root and stem base rot

Rhizoctonia solani is commonly found on many nurseries and affects a wide range of hosts. The fungus causes damping-off of seedlings, wire-stem, root rot, crown rot and occasionally a leaf and stem blight of cuttings. Generally, it causes a basal stem rot of cuttings and a crown rot of potted plants more often than a root rot.

Seedlings infected with *Rhizoctonia* tend to collapse in different directions, compared with *Pythium*, where the direction of collapse is more uniform. Aubretia, begonia and impatiens are particularly susceptible. If older seedlings become infected, damage usually occurs at soil level as a characteristic red-brown constriction on the stem (wire-stem). Seedling leaves touching the surface of infested growing media are rapidly invaded by *R. solani* and become water-soaked and rotten.

On cuttings and older plants, attack at the stem base or soil level results in a dry, light brown discolouration that is sometimes subsequently colonised by *Botrytis cinerea*. Cutting-raised fuchsia, geranium, poinsettia and New Guinea impatiens are all susceptible to *Rhizoctonia* basal stem rot during or after rooting. Saintpaulia and *Begonia rex* may also be affected during



8 Damping-off of aubretia seedlings due to *Rhizoctonia*; infection is often at compost level

propagation by leaf cuttings. Severely affected cuttings of poinsettia may fail to root or produce only a poorly developed root system.

On more mature plants, root rots caused by *R. solani* typically show as discrete brown lesions along the root length with rotting of the cortical tissues. New root growth can be inhibited.

Crown rot can result either from progression of the fungus from the roots, or from direct fungal attack of the crown tissue. Crown rots and/or stem base canker occur on begonia, saintpaulia, poinsettia and impatiens, for example. In the canker phase, on older plants, there is longitudinal cracking of the stem base and a dry appearance. Other symptoms include leaf yellowing, wilting, poor growth and plant death.

Under warm, humid conditions, the fungal strands of *R. solani* can sometimes be seen growing over the compost surface and occasionally as webbing over leaves.

Some ornamental species recorded as hosts of *R. solani* are shown in Table 3.

Table 3
Some bedding and pot plants particularly susceptible to *Rhizoctonia* root and basal stem rot

Bedding plants (seedlings)	Pot plants (flowering)	Pot plants (foliage)
Alyssum	Begonia	Cissus
Antirrhinum	Capsicum	Coleus
Aubretia	Cineraria	Ficus
Callistephus	Cyclamen	Nephrolepis
Cheiranthus	Fuchsia	Philodendron
Impatiens	Gloxinia	Syngonium
Matthiola	Lathyrus	Tradescantia
Nemesia	Pelargonium	
Salvia	Peperonia	
Tagetes	Poinsettia	
	Primula	
	Streptocarpus	

Disease sources and spread

Pythium* and *Phytophthora

The most common sources of *Pythium* and *Phytophthora* are infected crop debris, contaminated loam, peat, sand, dust, capillary matting, non-mains water supplies, water-holding tanks, dirty tools and unsterilised pots/trays. *Pythium* and *Phytophthora* are not seed-borne but they may be introduced to a nursery in infected cuttings or plug plants. Adult shore flies and sciarid flies can also provide a means of introducing and transmitting *Pythium.* Both pathogens produce resting spores that enable survival for long periods in the absence of a growing host.

The resting spores are stimulated to germinate by exudates produced by host plant seeds and roots. Once germinated, a mass of swimming spores are produced that are readily dispersed in flowing or splashing water during irrigation, or propagation under mist or in water films on benches or floors. Rapid spread can occur where production is on ebb and flood benches or floors. Aerial spread,

9 Water is often involved in the spread and/or development of root rots caused by species of *Phytophthora* and *Pythium*; note the *Phytophthora*-affected plants (purpling) at the edge of the flood-bench

other than by water-splash of contaminated material, does not normally occur.

Rhizoctonia

The most common sources of *Rhizoctonia* are: growing media containing unsterilised loam, pots stood directly on infested ground, contaminated peat and dirty containers. Cuttings may also have surface contamination of the fungus particularly if taken from the stock plant at compost level. *Rhizoctonia* can survive from one growing season to the next in soil and crop debris either as resting structures or as thickened fungal strands.

Under favourable conditions, *Rhizoctonia* can colonise growing media through extensive hyphal growth and may spread from an infected plant to healthy neighbouring plants by growth of hyphae between touching leaves or stems. The fungus only very rarely produces spores so aerial spread of the fungus is limited. Although water does not play as important a role in the transmission of *Rhizoctonia* as for *Pythium* and *Phytophthora*, water splash of contaminated material can occur.

Conditions conducive to disease development

Pythium* and *Phytophthora

Infection and spread are favoured by high moisture levels in the growing medium (moisture holding capacity greater than 70%). In general, infection can occur over a wide range of temperatures as long as free water is present. However, different species of *Pythium* and *Phytophthora* have widely ranging temperature optima. For example, some species of *Pythium* grow well at temperatures below 15°C, whereas others grow best at 25–30°C. For *Phytophthora*, there is negligible germination of resting spores below 10°C and most species tend to be most active in the 20–30°C range.

Pythium and *Phytophthora* are not strong competitors in soil, surviving mainly as dormant resting structures. These fungi tend to be more aggressive in sterilised soils or soilless media because of lack of competition from other micro-organisms. However, once dormant resting structures of *Pythium* and *Phytophthora* are stimulated by exudates from host plant roots or seeds, the rapid germination and fast growth rate of the fungus enable them to be successful invaders of plant roots.

Any cultural factors adversely affecting growth, such as over-watering, an excessively high conductivity level in the growing medium, high fertilisation rates or sub-optimal temperatures, can predispose plants to infection.

Rhizoctonia

Rhizoctonia can grow and cause infection under a wide range of environmental conditions, however it generally grows best in growing media that are evenly moist and warm. Research suggests that *Rhizoctonia* root rot increases at growing media temperatures of 17–26°C and when the growing media is dry.

Factors that delay plant establishment or maturation may facilitate *Rhizoctonia* attack. These include slow germination, sub-optimal temperatures, irregular watering, excessively high nutrient levels or incorrect pH.

10 High moisture levels in the growing medium favour the spread of *Phytophthora and Pythium.* Here *Phytophthora* root rot in kalanchoe has caused stunted growth, wilt and purpling of leaves (right)

11 *Rhizoctonia* stem base rot of campanula – evenly moist and warm growing media favours disease spread

Control strategy

Because of the ability of *Pythium*, *Phytophthora* and *Rhizoctonia* to survive for long periods in different areas of the glasshouse environment, effective disease management is unlikely to be achieved with a single control method. Use of healthy planting material and careful nursery hygiene, together with appropriate fungicide use, are key factors in the management of root rots on bedding and pot plants.

Healthy planting material

- Cuttings or plants from other nurseries should be inspected carefully for signs of disease. Plants with symptoms should be rejected.
- Where plants are being raised from cuttings, use only those with well-developed and healthy-looking root systems.
- Where seedlings are being transplanted, ensure that healthy seedlings are selected; avoid using seedlings from trays with poor emergence or other signs of damping-off.

Reducing sources of infection

- Only use new or thoroughly cleaned and sterilised pots and containers. Store them where they will not become contaminated with dust, water or debris. Segregate old and new pots and trays to prevent any potential disease cross-contamination.
- It is essential to use new growing media from a reliable source and to store it where it will not become contaminated. Growing media should be free-draining and not saturated with water.

Nursery hygiene

- Diseased plants and associated growing media should be removed and discarded into a covered skip or bin (this is particularly important with sub-irrigation systems).
- Sand from sand benches and should be regularly changed or disinfected (eg with Jet 5).
- Regularly change or disinfect capillary matting (eg with Jet 5). Discard old or contaminated matting.
- Regularly clean and disinfect the propagation, potting and production areas, including tools, equipment, machinery and benches. Danish trolleys, production troughs and floors should also be disinfected.
- Before disinfecting, remove as much plant debris, dirt, spent media and dust as possible from glasshouse benches, floors and propagation beds.
- Disinfectants with activity against *Pythium* and *Phytophthora* include Jet 5 and sodium hypochlorite. The latter also has activity against *Rhizoctonia*. Follow the manufacturers label and use at the recommended rate.

  Note: there is a risk of phytotoxicity to plants by root uptake if a hypochlorite residue remains in a sand bed or capillary matting, or on another treated surface, where new plants are placed.
- Eliminate standing water: treat leaks in roofs and find out why those niggling puddles are there and get rid of them. Check irrigation systems, especially overhead spray lines for leaks, drips or application irregularities.
- Encourage good crop hygiene in staff and pay particular attention to footwear, as *Pythium* inoculum is readily transferred from dirty to clean areas on the soles of shoes. If foot baths are employed at the entrance to sensitive areas of the nursery, ensure that the sterilant in them is regularly changed otherwise they may inadvertently become sources of disease themselves. And at all times there should definitely be no muddy boots.

12 Cuttings should be inspected carefully for signs of disease: *Phytophthora* stem and tuber rot of gloxinia leaf cutting, with rot progressing along leaf mid-rib

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 for contamination by *Pythium*. Water samples can be sent for laboratory testing to determine the presence of *Pythium* species.
- 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, install 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.

Pest control

- As potential disease vectors, the occurrence of shore flies and sciarid flies should be kept to a minimum. For control of shore flies, avoidance is the best strategy; use hygiene measures to reduce algal growth on substrates such as capillary matting, as this is the main food source. Routine control of sciarid flies is often necessary on susceptible hosts such as poinsettias and this can be achieved using biological control within an IPM programme (See HDC Factsheet 08/02 for options).

Cultural control during production

- Regular inspection of plant roots may provide advance detection of root rot problems.
- Avoid checking the growth of young plants – good growing conditions including correct growing medium nutrient levels and pH, will minimise the potential for these diseases to establish.
- The growing medium should be well drained, and irrigation should be applied only as needed to avoid prolonged periods of saturation, eg using well managed trickle or sub-irrigation.
- Fertilisers should be applied according to plant requirements for adequate growth.
- Plants, especially seedlings, should be grown at temperatures conducive to optimum growth and development.
- Manage the aerial environment to minimise surface wetness and periods of high humidity.
- With flood irrigation, accurate control of depth and duration of flooding, combined with disinfection of the empty floor or bench between crops, is important to reduce root disease risk.

Use of fungicides

- Where there is a significant disease risk, use a preventative fungicide programme.
- Alternate fungicides from different groups, and according to label instructions, in order to avoid the build up of resistant pathogen strains.

13 & 14 Adult sciarid fly (top) and shore fly (bottom) are potential vectors of disease and should be kept to a minimum

Fungicide use

Fungicide products with label approval for use on bedding and pot plants against *Pythium*, *Phytophthora* and *Rhizoctonia* are shown in Tables 4 and 5.

Fungicide application

Effective protection against *Pythium* and *Phytophthora* requires the fungicide to be thoroughly and evenly incorporated throughout the growing medium. This can be achieved either by thoroughly mixing an etridiazole product directly with the growing media just prior to use, or using this product or fosetyl aluminium or propamocarb hydrochloride, 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 applications will be required.

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, whilst Amistar and iprodione products are permitted as sprays. Note that application of Basilex is not permitted by hand-held equipment.

Fungicide resistance

Intensive use of certain fungicides increases the 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 that have been used in the past for controlling *Pythium* and *Phytophthora* on pot and bedding plants but which are no longer available (eg *Pythium* species resistant to furalaxyl, the active ingredient in Fongarid).

To minimise the development of resistant strains of the pathogen, select products from two or more different fungicide 'groups' for alternate sprays. Use no more than two sprays of the same fungicide, or fungicide 'group,' in sequence, then use a completely different fungicide group.

The fungicides currently approved and widely used for several years for controlling these pathogens (etridiazole in Terrazole 35WP, fosetyl aluminium in Aliette 80WG and propamocarb hydrochloride in Filex) have not to date given rise to a resistance problem.

Currently, effective fungicidal control of *Rhizoctonia* on pot and bedding plants in the UK is very largely

Table 4
Fungicide products with label approval for use on protected and outdoor bedding and pot plants and activity against *Phytophthora* and *Pythium*

Fungicide group	Active ingredient	Product	Level of disease control		Comment
			Phytophthora	*Pythium*	
Thiadiazole	Etridiazole	Standon Etridiazole 35	✓	✓	Label approval. Do not use on gloxinia or pansy.
		Terrazole 35 WP	✓	✓	Label approval. Do not use on gloxinia or pansy.
Phosphonate	Fosetyl-aluminium	Aliette 80 WG	✓	(✓)	Label approval.
		IT Fosetyl-AL	✓	(✓)	Label approval.
		Standon Fosetyl-AL 80 WG	✓	(✓)	Label approval.
Carbamate	Propamocarb hydrochloride	Filex	✓	✓	Label approval.
		Proplant	✓	✓	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 5
Fungicide products with approval for use on protected and outdoor bedding and pot plants and activity against *Rhizoctonia*

Fungicide group	Active ingredient	Product	Level of disease control	Comment
Benzimidazole (MBC)	Carbendazim	Cleancrop Curve	(✓)	SOLA 1213/04. Apply as a drench treatment.
		Delsene 50 Flo	(✓)	SOLA 1004/04. Apply as a drench treatment.
Dicarboximide	Iprodione	Rovral WP	(✓)	Extrapolation under LTAEU from various crops. Use as a foliar spray; not approved as a growing medium drench treatment.
		Cleancrop Gavotte WP	(✓)	As for Rovral WP.
		IT Iprodione	(✓)	As for Rovral WP.
		Ipromex 50% WP	(✓)	As for Rovral WP.
		Standon Iprodione 50 WP	(✓)	As for Rovral WP.
Organo-phosphorus	Tolclofos-methyl	Basilex	✓	Label approval. Apply as a drench treatment. Use by hand-held equipment is **not** permitted. Do **not** use on heathers. An organo-phosphorus pesticide.
Strobilurin (QoI)	Azoxystrobin	Amistar	✓	Permitted by LTAEU from various SOLAs (eg 1684/01 protected ornamentals or 1041/01, outdoor and protected celery. The latter allows up to 4 applications per crop). Use as a foliar spray needs to be high volume.

✓ **control**
(✓) **partial control**

- 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.
- 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 bedding and pot plants or how to correctly use them.
- Some products recently widely used for root disease control (eg 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 that can be safely treated. Where a product is to be used widely on a crop for the first time, test treat a few plants first to check for crop safety.

reliant on azoxystrobin (Amistar) and tolclofos-methyl (Basilex). The latter is not permitted by hand-held equipment. Instances of resistance to tolclofos-methyl have been very rare and none confirmed in the UK.

For further advice on strategies to minimise the risk of selecting resistant pathogen strains, see the FRAG-UK Technical leaflet: Fungicidal Resistance, which can be downloaded from www.pesticides.gov.uk.

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,* which may develop during composting or suppressive substances leached from bark such as phenolics. 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. HDC project HNS 125 is assessing the potential of compost teas for improving crop health and growth in hardy ornamentals.

Further information

Ball Field Guide to Diseases of Greenhouse Ornamentals by Margaret L Daughtrey and A R Chase (ISBN: 0-9626796-3-1). www.ballpublishing.com.

HDC project PC 97a, Ornamentals: Sources of *Pythium* inoculum, fungicide resistance and efficacy of surface sterilants, Final report May 2001.

HDC Diseases and Pests of Bedding Plants, Identification Cards.

Diseases of greenhouse plants by J T Fletcher (ISBN 0-582-44263-X). Longman.

Acknowledgements

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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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