Factsheet 24/02

Grey mould (*Botrytis cinerea*)

Project No. PC/HNS 121

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Control of grey mould (*Botrytis cinerea*) in container-grown ornamentals: heated glasshouse crops

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This factsheet describes the symptoms, sources and development of botrytis in pot and bedding plants. It details an integrated approach to control the disease in heated glasshouses based on good nursery hygiene, environmental control and appropriate fungicide use.

Details of how to control the glasshouse environment to prevent prolonged periods of high humidity can be found in factsheet 25/02: Controlling humidity to minimise incidence of grey mould in container-grown ornamentals: heated glasshouse crops.

Summary of action points

Reducing sources of infection

- Inspect plants arriving on the nursery for botrytis, if disease is discovered, reject plants or quarantine and treat.
- Remove plant debris and thoroughly disinfect between crops.

Maintaining healthy plants

- Maintain stock plants free of botrytis and never take cuttings from diseased plants.
- Handle plants carefully to avoid damaging tissues; be particularly careful with soft, fleshy tissues.
- Minimise plant stress by ensuring appropriate air-filled porosity of the growing medium and optimum fertiliser levels.

Irrigation

- Reduce misting of cuttings as soon as possible after rooting begins.
- To minimise leaf wetness,time watering to allow foliage to dry before nightfall.
- Use sub and drip irrigation where possible to reduce leaf wetness, but ensure that plants are not over-watered.

1 Fleshy leaves and petioles, as in cyclamen, are particularly susceptible to attack by botrytis

Ventilation and humidity control

- Where space is available, separate plants so that air can circulate between them.
- Use fans to keep air moving over the plant surface.
- Keep the humidity as low as possible. Expel moist air at nightfall (see factsheet 25/02 for guidance on humidity measurement and control).

Use of fungicides

- Apply protectant fungicides sprays to the most susceptible species immediately after potting.
- Alternate fungicides from different groups, and according to label instructions, in order to avoid the build up of resistant strains.

Symptoms of botrytis

Initially, botrytis appears as a white growth but soon darkens to grey as dispersal spores (conidia) are formed (Fig 2). Occasionally, black resting bodies (sclerotia) develop in affected tissues and in this form the fungus can persist for many months in the absence of plants.

Flowers and leaves are often the first tissues affected and flower petals may show a water-soaked spotting where spores infect. Leaf rotting may progress down petioles to cause stem rot such as in fuchsia (Fig 3). Woody branches and stems affected by botrytis are often discoloured but do not always develop the typical grey-brown spore mass.

Botrytis is capable of attacking any plant part at almost any stage of growth including whilst in cold storage or after dispatch, especially if high humidity or condensation occurs. Botrytis can attack crops throughout the year but is most common in cool, humid conditions, usually in the autumn and winter.

Grey mould on pot and bedding plants commonly starts around the stem base, in the centre of dense plants, on foliage in contact with the growing medium (Fig 4) or on dead flowers. Necrotic and yellowing leaves, fading flowers and damaged succulent plant parts such as cyclamen flower stalks are particularly susceptible. On cuttings (eg fuchsia, geranium) botrytis rot often develops from the cut end. On stock plants, dieback may develop on the branches where cuttings were taken.

2 Dying flowers showing characteristic white and grey fungal growth of botrytis disease

3 Fuchsia – stem base rot arising from botrytis leaf infection

4 Foliage in contact with the growing medium is a common starting point for botrytis infection

Sources, spread and infection

Sources

The main sources of grey mould are diseased plants and crop debris (Fig 5). Infections can remain in a 'latent' (symptomless) state for several weeks and cuttings taken from apparently healthy stock plants may be infected.

Spread

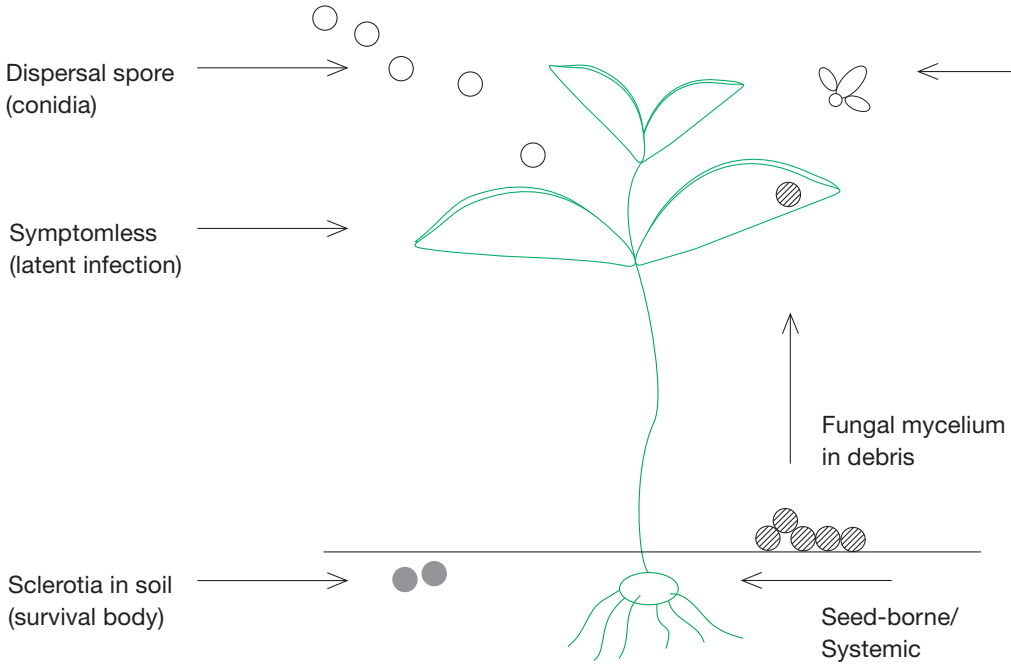
Dispersal spores for botrytis are known as conidia and are produced in massive numbers on affected tissues. These spores are spread by air currents or splashing water. Human activity within the glasshouse or sudden fluctuations in relative humidity (RH) will result in a release of spores. Long distance spread between glasshouses and different nurseries occurs through the transport of infected plants and cuttings.

Infection cycle

The spores can germinate and invade plant tissue immediately, or may remain dormant on plant surfaces for up to 3 weeks. High humidity (greater than 95%) favours rapid germination and infection. Germination can occur over very wide range of temperatures (5–25 °C). A complete infection cycle, through symptom development to fresh spore production, can be as short as a few days.

5 Plant debris is important source of botrytis - remove it from the glasshouse

Diagram 1
Sources and spread of botrytis infection



Latent infection
When infection has occurred, symptoms may develop within hours, or the infection may remain as a dormant, symptomless relationship that changes into an active one, days or even weeks later ('latent' infection).

Alternative infection routes
In addition to spores, infections may arise from fungal strands (hyphae) growing from either dead plant parts or from debris in contact with the host. This inoculum in dead tissue is a potent source of infection, important both in establishing infections and localised disease spread. *B. cinerea* has also been found on, or associated with, the seed of many species, including primula.

Integrated disease management

Botrytis has proven to be a persistent, adaptable fungus that can cause crop damage under a wide range of conditions and via a number of different infection routes. A single disease management tool, such as fungicide application, is unlikely to be effective under all conditions and against all infection routes. A combination of treatments, that each act by different means, is more likely to provide effective and durable disease control than any single measure.

Cultural control

Implementation of good nursery hygiene, crop cultural practices and the prevention of prolonged high humidity are key to avoiding serious outbreaks of botrytis. The components identified below have been demonstrated to have a significant impact on the control of botrytis.

Glasshouse and crop hygiene

- Inspect plants arriving on the nursery for botrytis, if disease is discovered, reject plants or quarantine and treat.
- Plants may carry latent infection for several weeks, so continue to monitor apparently disease-free plants for this time, checking foliage in contact with the growing medium surface and in the centre of dense plants. Pay particular attention where air-movement is poor, and to any batches that have been kept past their optimum stage for spacing or dispatch. Separate new plants and dispose of severely diseased plants.
- Infected plant debris such as dead or dying leaves and flower petals is a potent source of infection so remove it from plants, glasshouse benches, floors and propagation beds and place in covered bins or skips outside the glasshouse. Thoroughly disinfect the glasshouse structure between crops.
- In recent trials, 'picking-over' on cyclamen at 2–3 week intervals (approximately 5 times during cropping) to remove dead leaves at the plant base was shown to be as effective as a full fungicide programme. However, this approach is labour demanding and consequently may not be economic.

- Do not take cuttings from affected plants, keep stock plants well spaced and regularly monitor for botrytis infection.

Crop management

- Many factors are known to predispose plants to botrytis. Avoiding these conditions can markedly reduce the risk of botrytis developing. Common factors are listed in panel 1 opposite.

- Wounding predisposes plants to infection; handle plants carefully during potting, spacing and at dispatch.

- Potting of plug plants too deeply results in deterioration of lower leaves that become covered in damp compost; pot to the correct level.

- Where space is available, separate plants so that leaves do not touch and good air circulation is possible. Adequate spacing of plants can also reduce losses due to contact spread of the disease between adjacent plants such as with cyclamen and primula (Fig 6).

- Overhead irrigation should only be done when there is time for foliage to dry before nightfall. Overhead

Panel 1
Factors predisposing plants to botrytis

Predisposing factor	Example
Damaged tissue (especially at potting, spacing, dispatch)	Cracked leaves, broken stalks
Leaf age – young tissue	Seedlings (eg lobelia)
– mature tissue	Poinsettia bracts, primula leaves
Fallen flower parts; pollen	Cyclamen, geranium, primula
Secondary to other diseases	Tissue damaged by *Alternaria*, mildew or rust
Fertiliser scorch	
Pesticide scorch	
Nutrient deficiency	Low nitrogen, calcium or potassium
Nutrient excess	Nitrogen
Soft growth	New growth on cuttings
	New growth on mature plants after a period of poor light/high humidity
Physiological damage	Bract edge damage on poinsettia
Plant debris	Fallen or dead leaves; trimmings
Trimming stubs	On stock plants (eg fuchsia, osteospermum, poinsettia)
Yellowing (shaded) leaves	Dense crop (eg pelargonium)
Plant spacing	During production, at dispatch and receipt of plants (eg material left on Danish trolleys too long)
Sheltered site	Prolonged high humidity – see factsheet 25/02
Leaking vents and gutters	
Low glasshouse	
Overhead irrigation	
Poorly-managed sub-irrigation	
Poor ventilation/air-movement	

6 Spacing plants minimises plant to plant spread of botrytis

irrigation encourages the development of botrytis by spreading spores, creating leaf wetness and moving plant debris on to healthy plant tissues.

- If using drip and sub-irrigation avoid overwatering and persistently wet compost as this creates an environment favourable to botrytis around the stem base.

7 Botrytis stem base rot of poinsettia; check that plants are not over-watered

Environmental control

Experiments with cyclamen leaves have shown that high humidity levels, greater than 95% for a period of more than 3 hours, *is the critical threshold* for the germination of botrytis spores. Once this period is exceeded spore germination will continue even if the humidity is reduced to 80% or less. However, where high humidity periods are controlled to 3 hours or less, trials have shown there should be little germination or disease development, even after 14 days of fluctuating high and low humidity periods.

Experiments with primula leaves have shown that leaf wetness is important for the expression of botrytis symptoms with disease severity increasing with leaf wetness duration. Therefore humidity is the controlling factor for spore germination whereas leaf wetness encourages disease expression once the plant has been infected.

The key objective, therefore, is to prevent moisture lying on plant tissues for several hours, or an atmosphere of still, very humid air persisting around plants. Even lowering the humidity slightly can have a significant effect on botrytis. Various techniques can be used to reduce the humidity within and around crops.

- Details on humidity measurement and guidance on humidity control to prevent botrytis are included in factsheet 25/02.

Fungicide control

Fungicide sprays are important for botrytis control and regular, preventative spray programmes are most effective. Once botrytis becomes established in a crop, fungicide applications may not be able to control the disease.

Key points to follow when devising a spray programme are:

- Choose products you have found to be safe to use on the crops you grow. Test treat a small batch of plants/cuttings before large-scale application if using a fungicide for the first time.

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

- Start your fungicide programme early before botrytis is established; apply two initial sprays soon after potting/sticking. Where new leaves form and lay directly over older leaves (eg primula) it is important to treat leaves when they are young with a persistent fungicide.

- A spray interval of 10–14 days is often adequate; it can be extended to 21–28 days when conditions do not favour the disease (warm, dry weather or very cold weather) or other effective control measures against botrytis are in operation, providing one or two early protectant sprays have been applied.

- Ensure good coverage of leaves close to, or in contact with, the growing medium surface. For species with a dense canopy, treatment using a single nozzle, pushed into the centre of each plant, may be needed.

- Routine preventative spray programmes are particularly important for stock plants from which cuttings are taken.

- If you are not satisfied with the level of disease control achieved, consider having the fungus (at least 10 samples) tested for fungicide resistance. Consult a Plant Pathologist to investigate your overall disease management strategy.

Crop safety

Relatively few products carry a label of recommendation for use on protected ornamental crops. However, several fungicides are permitted under the Revised Long Term Arrangements for Extension of Use (2002) (LTAEU) or under a Specific Off-Label Approval (SOLA). Such use is entirely at grower's own risk.

As a general guide, crop damage is more likely to result:

- On young plants and soft growth

- When treated during or immediately after a period of high humidity

- In hot, sunny weather

- Where products are used in mixture with an additional wetter or other adjuvant (modern pesticides are usually pre-formulated with wetters/spreaders)

- Where several spray treatments are applied to a crop in close succession.

A summary of the fungicides commonly used against botrytis and approved for use on protected ornamentals is given in Table 1.

Table 1
Fungicide with activity against *Botrytis cinerea* and permitted on glasshouse ornamental crops

Fungicide group and product	Active ingredient	Activity			Standard spray rate (product)	Approval status	Comments
		Protectant	Curative	Sporulation suppression			
1 Anilinopyrimidine							
Frupica	Mepanipyrim	✓	✓	x	0.8 g/l	LTAEU[a] extension from label	A visible spray deposit can occur
Scala	Pyrimethanil	✓	x	x	1.0–2.0 ml/l	LTAEU[a] extension from SOLA (3411/02)	Flower colour fade on cyclamen and small brown/necrotic flecks at leaf margins of various species noted
2 Dicarboximide							
Rovral WP	Iprodione	✓	✓	✓	1.0 g/l	Label recommendation	Resistance confirmed in *B. cinerea*
3 Dithiocarbamate							
Unicrop Thianosan DG	Thiram	n/t	n/t	n/t	4.0 g/l	Label recommendation	
4 DMI							
Octave	Prochloraz	n/t	n/t	n/t	1.0 g/l	Label recommendation	
5 MBC							
Bavistin DF	Carbendazim	✓	✓	✓	1.0 g/l	SOLA 0009/99	Resistance confirmed in *B. cinerea*
6 Phthalonitrile							
Bravo 500[b]	Chlorothalonil	✓	✓	✓	2.2 ml/l	Label recommendation	A visible spray deposit is likely
7 QoI							
Amistar	Azoxystrobin	✓	✓	x	1.0 ml/l	LTAEU[a] extension from SOLA (1684/01)	
Stroby WG	Kresoxim-methyl	n/t	n/t	n/t	0.3 kg/ha	LTAEU[a] extension from label	
8 Sulphamide							
Elvaron WG	Dichlofluanid	✓	✓	✓	1.0 g/l	SOLA 0167/93	Do not use on soft growth in spring and summer. Damage has been noted on fuchsia and bedding plant seedlings

*** Demonstrated on strawberry leaves in HDC-funded trial (SF 37)**
[a] Permitted under the PSD Long Term Arrangements for Extension of Use 2002 (LTAEU)
[b] Similar products are available
n/t – not tested

Regular changes occur in the approval status of pesticides, so growers should check with a professional supplier or with the Information Office at the Pesticides Safety Directorate (PSD). (Tel: 01904 462 500, or www.pesticides.gov.uk/raid_info/rep-fp.cfm; e-mail: p.s.d.information@psd.defra.gsi.gov.uk

- **Off-label use (SOLA and LTAEU) is at grower's own risk. The conditions relating to off-label use are statutory and must be compiled with. The conditions of use for SOLAs are listed on the SOLA document, a copy of which must be obtained before the product is used.**
- **Always read the product labels before applying pesticides. Use pesticides safely.**
- **Check with suppliers for full details of any side affects on biological control agents.**

Example fungicide spray programmes

Fungicide programmes designed to investigate the efficacy of new products and the importance of sprays applied at different growth stages were tested in several trials. Up to 70% improvement in botrytis control was achieved with the use of novel fungicides such as Scala and Elvaron Multi compared with the industry standard, Rovral WP. In addition, the number of fungicide sprays required to achieve botrytis control on cyclamen was reduced from 10–12 sprays to 4–5.

The spray programmes found to be effective on cyclamen are shown below (Table 2). Programmes were also tested on primula, although no significant disease developed (Table 3). Numerous other programmes could be devised that would probably result in equivalent control, based on the products permitted on protected ornamentals (Table 1). Example spray programmes for container grown nursery stock are detailed in HDC factsheet 23/02.

Table 2
Example fungicide spray programmes for control of botrytis on cyclamen

Spray timing	Spray programme				
	1	2	3	4	5
Within 7 d of potting (13 July)	Rovral	Amistar	Scala	–	Scala
21 d later	Elvaron Multi	Elvaron Multi	Elvaron Multi	Elvaron Multi	Elvaron Multi
Full leaf canopy	Rovral	Amistar	Scala	Scala	Scala
21 d later	Elvaron Multi	Elvaron Multi	Elvaron Multi	Elvaron Multi	Elvaron Multi
Flower buds present	Rovral	Amistar	Scala	Scala	–
Reduction in disease severity	✓	✓	✓✓✓✓	✓✓✓	✓✓✓✓

Disease severity reduced by: ✓1–20%, ✓✓21–40%, ✓✓✓41–60%, ✓✓✓✓61–80%, ✓✓✓✓✓81–100%

Note
Elvaron Multi (tolyfluanid) is not currently permitted for use on protected ornamentals, use Elvaron WG (dichlofluanid) or Bravo 500 (chlorothalonil) as an alternative; the product Frupica was not available when these experiments were conducted.

Table 3
Example fungicide spray programmes for control of botrytis on primula

Spray timing	Spray programme		
	1	2	3
Within 7 days of potting	Scala	Scala	Scala
Complete whorl of leaves on pot surface	Bravo 500	Amistar	Rovral WP
Flower buds just visible	Scala	Scala	Scala
Colour visible in buds	Bravo 500	Amistar	Rovral WP

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

PSD has recently issued changes to the Statutory Conditions of Use and Labelling of Fungicides containing QoI active ingredients such as Amistar and Stroby. Please see: www.pesticides.gov.uk for further information.

Integrated control works best

Integrated fungicide and crop management programmes were evaluated on commercial nurseries growing cyclamen crops in Autumn 2001 (Table 4). Crops were grown in paired glasshouse blocks with and without a humidity influenced heat boost. In addition fungicide treatments were applied and the crop was picked over to remove dead flowers and leaves once at spacing. The effect of picking over five times during crop production was tested in a separate trial. The trials demonstrated that the best control of botrytis was achieved where a 6-spray fungicide programme was combined with using a routine heat boost treatment at night. Fungicide treatment was notably less effective where no environmental control was applied.

Table 4
Effectivness of separate and combined treatments for control of cyclamen grey mould
(trial results: 1998–2001). Heat-boost/vent was applied nightly for 3 hours from 02:00h

	No heat boost or ventilation	**Heat-boost + ventilation**
No fungicides or picking over	–	✓✓
Picking over (once at spacing)	✓	✓✓✓✓
Picking over (5 times during production)	✓✓✓✓	–
Fungicides (one spray at spacing)	✓	✓✓✓
Fungicides (5–6 sprays applied as per Table 2)	✓	✓✓✓✓✓

Disease severity reduced by: ✓0–20%, ✓✓21–40%, ✓✓✓41–60%, ✓✓✓✓61–80%, ✓✓✓✓✓81–100%

Further information

The information in this factsheet was obtained in part from a series of experiments and glasshouse trials conducted between 1997–2002 under Horticulture LINK Project 25 (HDC Project PC/HNS121 and DEFRA Project HL0107). A summary report (August 2002) and five annual reports, available from the HDC, provide detailed results. Information on strategies for managing botrytis on container-grown ornamentals in unheated glasshouses is given in HDC factsheet 23/02.

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Further information: A full copy of the final report for HDC project PC/HNS 121 is available from the HDC office (01732 848383).

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