

HNS and Herbaceous Perennials

Project No. HNS 79 and HNS 53

Control of downy mildew diseases on hardy nursery stock and herbaceous perennials

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Downy mildew diseases, although they tend to be sporadic, can seriously damage hebe, rose and several other major nursery stock and herbaceous perennial species. This factsheet provides guidance on how to minimise losses by: the use of clean stock plants; good nursery hygiene; avoiding environmental conditions favourable for disease development and by fungicide treatment.

Background

Downy mildews on hardy nursery stock and herbaceous perennial species are most common on crops

grown under protection and on plants grown in densely packed beds with overhead irrigation. Infection results in leaf spots (often angular), leaf distortion, premature leaf fall and

stunted growth. Outbreaks can be difficult to control even with a routine spray programme. Losses in hebe, for example, are estimated to exceed £200,000 annually.



1 *Buddleia* downy mildew (*Peronospora hariotii*) results in angular, yellow-green spots on the upper leaf surface (left); affected areas subsequently become necrotic and the leaves distorted (right)

Action points

- Be aware of which species and varieties are most susceptible to downy mildew. Check these regularly for first symptoms of the disease and to assess the efficacy of your control measures.
- Where the market allows, consider growing more resistant varieties.
- Take care not to confuse symptoms
 - rose downy mildew can sometimes be confused with black spot
 - buddleia downy mildew can appear similar to leaf and bud nematode damage.
- Ensure mother stock is, and remains, free of downy mildew.
- Be prepared - persistent leaf wetness (eg 84 hours accumulated over 10 days) indicates weather conducive for downy mildew development.
- Manage the crop so as to minimise prolonged leaf wetness
 - do not use overhead irrigation in the late evening or night
 - use sand beds where possible
 - grow high-value susceptible crops under protection in well-ventilated structures
 - use as wide a spacing as economically possible
 - use circulation fans to improve air movement in greenhouses.
- Act promptly when downy mildew is found. The disease cycle can be as short as five days under favourable conditions.
- Where practicable, trim off diseased shoots from lightly affected plants and treat with a suitable fungicide; promptly remove and dispose of severely affected plants.
- Treat susceptible species and varieties with a suitable protectant fungicide before downy mildew becomes established, normally in the spring.
- Use products from at least two different fungicide groups in a spray programme and alternate these to minimise the risk of selecting resistant strains of the fungus.
- Reduce the spray interval (eg to 7 days) when conditions are very favourable for disease development. Make sure that you are achieving good spray coverage throughout the plant canopy.

Symptoms

Crops commonly affected by downy mildew are listed in Table 1. It should be noted that many of the downy mildews are host-specific. For example, there is no risk of the downy mildew from rose affecting hebe, or vice versa. However, if conditions are favourable for development of downy mildew in one crop on a nursery, they may be equally favourable to development of a different downy mildew on another crop. Symptoms of

the more common diseases are described below.

Rose downy mildew (*Peronospora sparsa*)

A common disease of susceptible varieties of outdoor crops and of greenhouse crops eg 'Silver Jubilee' at certain times of the year. This fungus produces irregular, rounded, yellow-green or purplish spots on the upper side of leaves (Fig 2) and occasionally on the calyx, petals (Fig 3) and stems. Sometimes flowers or

flower buds are malformed.

Sporulation is often sparse but a whitish-grey, downy, fungal growth is sometimes seen on the undersides of leaves. Affected leaves may become necrotic and fall prematurely. If left uncontrolled, growth of plants (both height and stem diameter) is significantly reduced and plants may fail to reach marketable grade. Young shoots can become so heavily diseased that they die back. Cuttings that are deformed by downy mildew may fail to root.



2 Rose downy mildew (*Peronospora sparsa*) results in purplish spots on the upperside of leaves that may be mistaken for black spot (*Diplocarpon rosae*)



3 *Peronospora sparsa* may cause purplish marking on the stem, calyx and petals (above), as well as spotting on leaves

Hebe downy mildew
(*Peronospora grisea*)

A common disease affecting many varieties. Distorted leaves are usually the first sign of infection, especially on large leaf cultivars (eg 'Midsummer Beauty'). In humid weather, a felty, purple-grey mat of fungal growth develops on the underside of affected leaves. Irregular shaped necrotic areas may eventually develop within leaves which may fall prematurely. Leaf distortion is usually confined to young shoots (Fig 4).

Buddleia downy mildew
(*Peronospora hariotii*)

The variety 'Davidii' is particularly susceptible. The fungus causes angular, pale-yellow lesions on the upper surface of leaves (Fig 1) that subsequently turn brown and can be mistaken for leaf and bud nematode (*Aphelenchoides ritzemabosi*). Leaves become distorted. Sporulation of the fungus occurs on the underside but can be difficult to see because of leaf hairs.

Laurel downy mildew
(*Peronospora sparsa*)

An occasional disease on cherry laurel and Portugal laurel, caused by the same fungus that infects rose. Typically the disease appears as irregular necrotic blotches. The edges of blotches are often light green in colour. Sporulation is not commonly seen. As with some other foliar diseases of prunus species, affected areas may eventually drop out leaving a 'shot-hole'.

Digitalis downy mildew
(*Peronospora digitalis*)

The angular necrotic spots can be confused with those caused by leaf nematode.



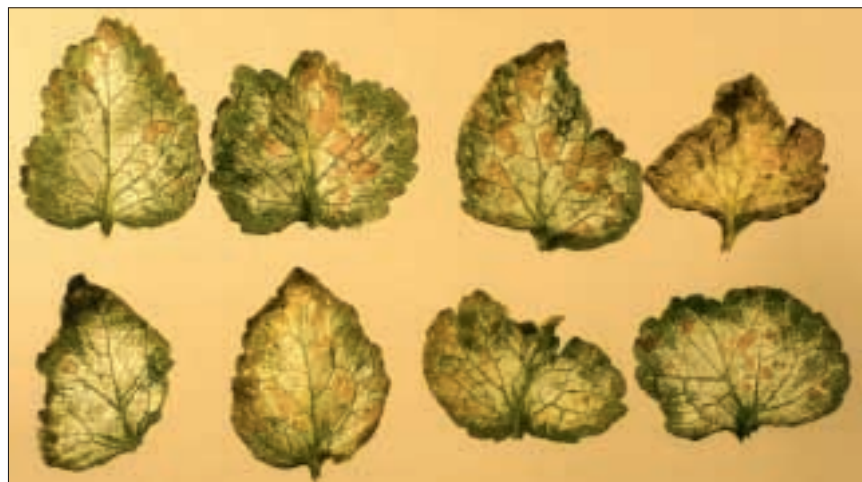
4 Hebe downy mildew (*Peronospora grisea*) is often found on young shoots where it causes leaf yellowing (top), distortion (bottom) and leaf necrosis

Table 1
Downy mildew diseases of hardy nursery stock and herbaceous perennials

Crop	Downy mildew	Symptoms and comments
Anemone	<i>Peronospora ficariae</i>	Soil-borne. Leaves dull, grey-yellow, down-curved
Buddleia	<i>Peronospora harti</i>	Angular, pale-yellow lesions, later turning brown; distorted leaves; common on the variety 'Davidii' (Fig 1)
Digitalis	<i>Peronospora digitalis</i>	Angular, necrotic spots
Gaillardia	<i>Bremia lactucae</i>	The same fungus affects lettuce. Distorted leaves; white mat of sporulation on the underside of leaves
Geranium	<i>Peronospora geranii</i>	Especially on cv. 'Johnson's Blue'. Brown blotches on upper surface that merge causing leaves to shrivel
Hebe	<i>Peronospora grisea</i>	Distorted leaves; purple-grey mat of sporulation on underside of leaves (Fig 4)
Helianthemum	<i>Peronospora leptoclada</i>	Yellow or brown angular lesions on upper leaf surface
Laburnum	<i>Peronospora cytisi</i>	Leaf distortion and necrosis (Fig 5)
Lamium	<i>Peronospora lamii</i>	Purple spots on the upper surface, developing into brown necrotic areas
Laurel	<i>Peronospora sparsa</i>	Irregular necrotic blotches with light green edges; affected areas may fall out leaving a 'shot-hole'. Sporulation rarely seen
Meconopsis	<i>Peronospora arborescens</i>	Furry, grey sporulation on underside of leaves, flower stalks and seed pods
Rose	<i>Peronospora sparsa</i>	Irregular, yellow-green/purplish spots on upperside of leaves and sometimes on calyx, petals and stem (Figs 2 and 3)
Salvia	<i>Peronospora lamii</i>	Angular yellow or pale-green leaf spots



5 Laburnum downy mildew (*Peronospora cytisi*) can cause considerable leaf necrosis and distortion



6 Lamium downy mildew (*Peronospora lamii*) causes purple spots on the upper leaf surface that often develop into angular, necrotic areas, as here on cv. 'Beacon Silver'

Disease sources and spread

The life cycles of these diseases are not fully understood. Rose downy mildew caused by the fungus *P. sparsa* is the most studied and is summarised here. It is likely that other downy mildews behave in a similar way.

Air-borne spores produced on the underside of leaves are the most important means of spread. These

spores are short-lived, surviving just a few days. Under moist conditions, they germinate quickly and infect leaves or other plant parts.

The fungus can survive between seasons in a dormant state as fungal strands, both in the wood of rooted plants and in cuttings, or as resting spores inside infected host tissue (such as leaves). The role of resting spores in disease spread is uncertain; no method of their transmission from leaf debris to fresh leaves resulting in

infection has been described. It has also been suggested that for some species the fungus is occasionally spread in seeds.

Recent studies have confirmed the occurrence of *P. sparsa* within the stem cortex, crown and root tissues of plants showing symptoms, supporting the occurrence of long term infections within rose. It is likely that root and stem infections may also occur with no obvious symptoms.

Conditions favouring disease development

Detailed information on conditions favouring disease development is not available for all hosts. Rose downy mildew is described here and other downy mildews are likely to be favoured by broadly similar environmental conditions.

Outbreaks of rose downy mildew occur only sporadically suggesting the disease is limited by environmental conditions. Various studies have shown a dependence on temperature and leaf wetness, with isolates from different geographic locations differing slightly in their

response to temperature. Spore germination and infection occurs over a broad range of temperatures from 5 to 25°C, with occasional isolates germinating as low as 2°C. Spores may survive low temperatures even if they do not germinate. The optimum temperature for infection is between 15-20°C. At this temperature, as little as 4 hours leaf wetness is sufficient for infection to take place. Whereas, at temperatures around 10°C, at least 8-h leaf wetness is required for significant levels of infection. A recent study on rose downy mildew in California identified a critical leaf wetness duration of 84-h accumulated over 10 days, to discriminate between wet periods that are conducive to downy mildew and

those that are not. Prolonged periods of high relative humidity, when condensation may occur, are also likely to favour development of downy mildew diseases.

The period between infection and appearance of first symptoms can be as short as 4 days (at 20-25°C) with sporulation occurring one day later. When the temperature is in the range 10-20°C, symptoms can still appear in 4-7 days. This very rapid disease cycle is not uncommon for downy mildews and helps to explain the difficulty in achieving effective control.

Control strategy

Successful control of downy mildew is achieved by adopting a range of control measures starting at the propagation stage.

Healthy mother stock

Careful selection of mother stock from which cuttings are to be taken is vital. Plants should be carefully examined to ensure freedom from visible downy mildew. Young, actively growing crops are best because juvenile cuttings are less likely to be infected and they root faster than older cuttings from woody plants. A programme of preventative fungicide sprays (see below) together with care in irrigation to avoid leaf wetness (eg use drip-irrigation or sub-irrigation) will minimise the risk of downy mildew on stock plants.

Treatment of cuttings

As noted above, dormant roses may carry latent infection of *P. sparsa* within stems, crowns and roots. Pre-planting dip treatments that reduce the number of persisting infections may delay the start of an outbreak or reduce its severity. In trials in the USA, a 10 minute pre-plant dip of a susceptible variety in a fungicide was found to reduce subsequent disease in the field as did a hot-water dip treatment (44°C for 15 mins). Further work is needed to determine the usefulness and crop-safety of such treatments.

Crop management: avoid conditions favourable to downy mildew

Leaf wetness is the most important factor that encourages downy mildew disease. If leaf wetness duration can be kept to less than 4 hours on most days the risk of significant levels of

downy mildew occurring on rose, and probably other species also, is low. Consider adopting the following measures:

- Avoid overhead watering during the evening or night.
- Use capillary sand-beds and drained beds, where overhead irrigation will be required less frequently.
- Grow high-value susceptible crops on sand-beds under protection; this both avoids rainfall and precludes the need for frequent overhead irrigation, and can provide very effective control of downy mildew (see results from a trial on micro-propagated rubus (HDC project SF 39).
- Consider using drip-irrigation for stock plants.

- Space plants as much as possible so as to allow good air circulation and rapid drying conditions.
- Ventilate greenhouses to increase airflow across the crop.
- Use fans to move air in areas where natural ventilation is limited and air may be stagnant.
- Avoid placing downy mildew susceptible crops in areas where there is little natural air-movement.

Nursery hygiene

Where practicable, cut off and carefully dispose of affected shoots. If mother stock is affected, dispose of the whole plant. After an attack, rake or vacuum up fallen leaves, to help prevent disease spread; this may also reduce carryover to the following season. If a crop becomes severely affected, remove and dispose of the plants and carefully remove all debris. Consider treating the standing area with a disinfectant (eg Jet 5, Panacide M) after a severe outbreak.

Resistant varieties

Observations suggest varieties of rose, hebe and buddleia can differ significantly in their susceptibility to downy mildew. For example, *Rosa* 'Silver Jubilee' is noted to be very susceptible, as is *Buddleia* 'Davidii'. Many larger leaf hebe varieties are susceptible (eg 'Midsummer Beauty', x 'Franciscana Variegata') but so also are some of the smaller leaf varieties including *H. albicans*, *H. rakiensis*, *H. 'Youngii'* syn. 'Carl Teschner'. *H. ochracea* 'James Stirling' appears to have some natural tolerance to the disease.

Fungicides

Foliar sprays of fungicides remain the cornerstone of downy mildew control for most growers. A wide range of fungicides is available (Table 2). For effective control, it is important that:

- Programmes commence before the disease becomes established.
- Fungicides from at least two different 'groups' (see opposite) are used, where both products are active against downy mildew.
- Products from different fungicide groups are used alternately, or in



7 Susceptible crops such as buddleia are most at risk from damaging attacks of downy mildew if grown in densely-packed beds with frequent overhead irrigation



8 A trial evaluating fungicide treatments for control of hebe downy mildew on a polythene tunnel crop of x 'Franciscana Variegata'. Note that the rows of plants at the outer edge of plots (left hand side), where air movement is better, are considerably less affected than those in the centre of the tunnel

mixtures (where allowed); some example programmes are shown overleaf.

- The spray interval is reduced (eg from 14 to 7 days or less) when conditions favour downy mildew (eg leaf wetness of 84 hours is accumulated within the previous 10 days).
- Spray application achieves good coverage of leaves throughout the crop canopy (eg adjust nozzle type and arrangement, spray pressure and water volume, as necessary).
- Fungicides are used in combination with other control strategies, especially crop management to avoid prolonged leaf wetness (see above)

- Protect the rapid extension growth that occurs in hot conditions where overhead irrigation is used.

- Once a crop becomes infected, it is difficult to eradicate the disease by fungicide sprays; however, it is possible to reduce infection of new extension growth by trimming off affected shoots and following with a fungicide programme.

Crop safety

Many of the fungicides listed in Table 2 with potential for control of downy mildew do not have specific label recommendations for use on an individual nursery stock or perennial herbaceous crop species. Off-label use is permitted, at growers' own risk,

Table 2
Fungicides with activity against downy mildew diseases and currently permitted for use on ornamental crops

Fungicide group and products	Permitted on crops		Approval status and comment
	Outdoor	Protected	
Carbamate			
Filex	✓	✓	Label approvals for use on ornamentals. Filex used safely on hebe and rose in HDC trials
Propeller	✓	✓	
Proplant	✓	✓	Extrapolation from on-label use on lettuce
Dithiocarbamate + carbamate			
Tatoo	✓	X	Extrapolation from on-label use on potato. Used safely on rose in unreplicated experiment (HNS 53)
Dithiocarbamate + cinnamic acid derivative			
Invader	✓	X	Extrapolation from on-label use on potato. Used safely on rose in unreplicated experiment (HNS 53)
Dithiocarbamate + cyanoacetamide			
Curzate M68	✓	X	Extrapolation from on-label use on potato
Dithiocarbamate + phenylamide			
Fubol Gold WG	✓	✓	Extrapolation from SOLA 2142/03 on lettuce
Phthalonitrile			
Bravo 500 (and other formulations)	✓	✓	Label approved for use on protected ornamentals; extrapolation from on-label uses (eg potato) to outdoor ornamentals
Phthalonitrile + phenylamide			
Folio Gold	✓	X	Extrapolation from on-label uses on vegetable crops
Phosphonate			
Aliette 80 WG	✓	✓	Label approval for use on protected pot plants; extrapolation from on label use (eg field lettuce) to outdoor ornamentals. Do not mix with other products. Aliette 80 WG used safely on hebe and rose in HDC trials
Standon Fosetyl-AL 80 WG	✓	✓	
Strobilurin			
Amistar	✓	✓	Extrapolation from SOLAs eg from 1684/01 on protected chrysanthemum and from 1465/01 on outdoor lettuce. Leaf tip damage sometimes reported on some hebe varieties.
Barclay ZX	✓	X	
Me2 Azoxystrobin	✓	X	
Standon Azoxystrobin	✓	X	
Stroby WG	✓	✓	Label approved for use on outdoor and protected roses
Sulphamide			
Elvaron Multi	✓	X	Extrapolation from on label use

Regular changes occur in the approval status of pesticides arising from changes in the pesticides legislation or for other reasons. For the latest information, please check with a professional supplier or with the Information Office at the

Pesticides Safety Directorate (PSD) Tel: 01904 455775; www.pesticides.gov.uk.

- Always read the label or Specific Off-Label (SOLA) notice of approval.
- Use pesticides safely.
- Check with suppliers for full details of any side effects on biological control agents.

via the Long Term Arrangements for Extension of Use (2002). Before use, you must obtain a copy of the product label and SOLA notice of approval (if relevant) and comply with the conditions stated. It is strongly recommended that, when a fungicide is used for the first time on a new crop or variety, it be first tested on a small number of plants to ensure there is no phytotoxic risk. Grower experience suggests spray damage is most likely to occur:

- On young plants.
- Soft growth of older plants.
- When several pesticides are used on a crop over a short period.
- When several pesticides are used in mixture, or additional wetter/spreaders are added.
- During very hot or bright weather.

Some fungicides recently used for control of downy mildew on nursery stock are no longer marketed or permitted, including Elvaron WG, Favour 600 SC, Fongarid, Ripost Pepite and Trustan WDG. Other fungicides registered for use on potatoes may give control of downy mildew diseases, and are permitted on outdoor crops at growers' own risk, but may not have been tested for safety on ornamental crops.

Fungicide programmes

There are many programmes alternating fungicides from different

groups that could be devised, based on the information in Table 1. Some have been tested in HDC trials on hebe (HNS 79) and on rose (HNS 53) and showed good, though not complete control. For example:

- Aliette / Amistar / Aliette / Amistar (one spray every 14 days)
- Aliette / Elvaron / Aliette / Bravo 500 (one spray every 7 days)

If a general spray programme includes Bravo 500 or Elvaron Multi (outdoor crops only), as in the second example above, use of these products interspersed between more specific downy mildew products provides additional protection against downy mildew.

Similar programmes that gave good control of downy mildew on a cut flower crop (lisianthus) were:

- Fubol Gold WG/ Amistar / Aliette 80 WG / Filex / Amistar / Aliette 80 WG / Filex (one spray every 14 days until downy mildew is seen, then spray interval reduced to 7 days).

Fungicide resistance

The development of fungicide resistance is a real risk in downy mildew species, especially when fungicides are used intensively. Although not confirmed in any of the species listed, fungicide resistance has resulted in loss of control in related downy mildew fungi that affect lettuce (*Bremia lactucae*) and cucumber (*Pseudoperonospora cubensis*). The phenylamide eg Folio Gold, Fubol Gold WG and strobilurin eg Amistar, Stroby WG groups appear

to be most at risk. In order to minimise the risk of selecting resistant strains of the fungus, it is recommended that you:

- Use fungicides according to the programmes shown, or similar programmes that have been designed to avoid resistance development.
- Use no more than two sprays of the same fungicide, or fungicide group, in sequence, then use a completely different fungicide group.
- For strobilurin fungicides, use no more than 50% of the total sprays of this type of fungicide per crop.
- Follow the label recommendations carefully and keep to the manufacturer's recommended dose rate.
- Do not rely on fungicides alone for disease control; follow the cultural control measures detailed in this factsheet, especially regarding leaf wetness.
- For further advice on strategies to minimise the risk of selecting resistant strains, see the FRAG-UK Technical leaflet: Fungicide Resistance, published in August 2001, which can be downloaded from: www.pesticides.gov.uk.

Further information

Reports on HDC-funded trials on control of downy mildew on hebe

(HNS 79), rose (HNS 53), lisianthus (PC 179) and blackberry (SF 39) are available from the HDC office on 01732 848383.

Kim Green of ADAS is gratefully acknowledged for help in reviewing the text.

Further information: A full copy of the final reports for HDC projects HNS 79, HNS 53, PC 179 and SF 39 are available from the HDC office (01732 848383).

March 2004

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