Downy Mildew in Production Nurseries

Downy mildews are obligate plant parasites that attack a wide range of plants. They are responsible for leaf spots and blights and can cause eventual plant collapse and death. They may cause considerable losses to the nursery production crops including many ornamental and vegetable seedlings, e.g roses, brassica crops, cucurbit crops, hellebore, lisianthus and many others. Symptoms can be confused with that caused by other pathogens, particularly when symptoms are mild. Management is best achieved using a range of cultural practices to prevent establishment and spread. In this factsheet, we will describe disease symptoms and provide cultural and fungicide management options.

Severe downy mildew infestation on impatiens.

SYMPTOMS AND IDENTIFICATION

On seedlings, symptoms occur on cotyledons, true leaves, hypocotyl and stems. In some plants when seedlings are infected, downy mildew becomes systemic and growth is stunted, malformed and discoloured and can eventually lead to plant collapse and death. Leaf symptoms are remarkably variable, making generalisations difficult. A common symptom is the downy growth and fruiting bodies that occur mostly on the lower leaf surface. Spores are usually white, lavender or grey. On some plants pale yellow to necrotic spots or black speckles appear on the upper leaf surface. Some spots are angular and delimited by veins. Severe infection can result in the death of large parts of the leaf. In perennial hosts, such as roses, it affects the young apical shoots causing distortion, stunting and stem cracking.

Downy mildews are very destructive pathogens, and it is important to be able to correctly identify early infections of the disease so that the correct remedial treatments can be applied. If you cannot see typical downy mildew growth

and sporulation on the lower leaf surface with a hand lens you may be treating the wrong disease. Sporulation can be encouraged by incubating leaves under high humidity in a plastic bag.

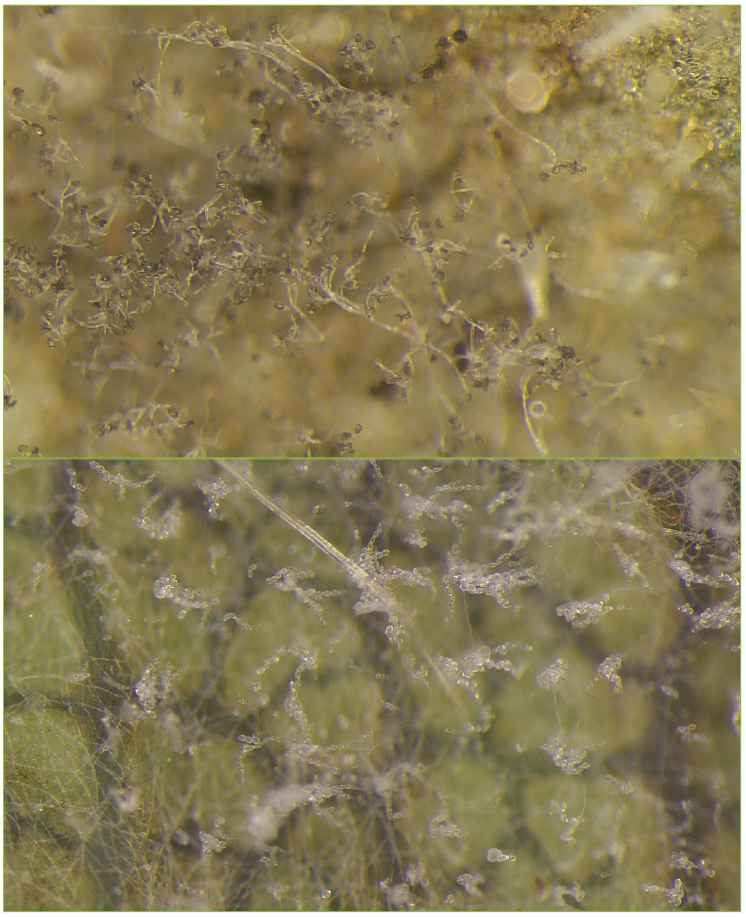
If in doubt send suspect plants or infected leaves to a reputable diagnostic laboratory. All production nurseries receive six free samples at the pest and disease diagnostic laboratory Grow Help Australia until the end of 2025. It is hoped that funding will continue for the production nursery in future years.

Downy mildew symptoms on hellebore (top) and stock (bottom).

DIFFERENTIATING DOWNY MILDEW FROM POWDERY MILDEW

The two diseases share the name “mildew” and are caused by obligate parasites that rely on living plants for nutrients. While they may sometimes appear superficially similar, they are very different. For more detailed information on powdery mildew refer to the factsheet on this disease.

DOWNY MILDEW	POWDERY MILDEW
Caused by water moulds (Oomycetes) that produce sporangia and oospore fruiting bodies, closely related to *Phytophthora*	Caused by Ascomycetes (true fungi) from different genera, forms conidia
Primarily observed on underside of leaves	Flour-like colonies can appear on both sides of leaf surface, mainly upper surface
Hyphae live internally in the host	Hyphae occur mostly on the leaf surface
Under a dissecting microscope, singular sporangia can be observed at the ends of branched hyphae, appearing tree-like	Under a dissecting microscope, spores can be observed in chains (end-on-end) often in upright strands that are not branching.
Leaves yellow and fall prematurely and can cause dieback	Leaves yellow but do not fall prematurely
Cool, humid, wet conditions preferred, with a film of water on the leaf for spore germination and infection	Warm, humid conditions preferred, with a dry leaf surface required for spore germination



Downy mildew sporangia (top) and powdery mildew conidiophores (bottom) at high magnification that can be seen under a dissecting microscope

HOST RANGE

Downy mildews are closely related to *Phytophthora*. Most downy mildews found in nurseries belong to the genera *Peronospora*, *Hyaloperonospora*, and *Pseudoperonospora*, however *Plasmopara* and *Bremia* are sometimes present. Downy mildews are host specific and tend to infect only one host family or only one host genus. For example, the rose downy mildew (*Peronospora sparsa*) also infects *Rubus*. Refer to Table 1 for a representative list of host plants affected by downy mildew species. Some downy mildew species have had various races described based on their ability to damage certain plant varieties. For example, there are several races of downy mildew that affect cucurbits, with some being more damaging to some crops than others.

Plant collapse of impatiens caused by downy mildew.

All downy mildew species are obligate parasites that can only grow in living host tissue. They cannot be cultured on artificial media in the laboratory.

TABLE 1. DOWNY MILDEW SPECIES ASSOCIATED WITH PLANTS RELEVANT TO NURSERY STOCK.

	HOST PLANT	DOWNY MILDEW
Amaranthaceae	Spinach	*Peronospora effusa*
	Beet	*P. schachtii*
Amaryllidaceae	Onion, shallot	*Peronospora destructor*
Asteraceae	Lettuce, *Helichrysum*	*Bremia lactucae*
	Helianthus	*Plasmopara halstedii*
Balsaminaceae	*Impatiens*	*Plasmopara obducens*
Brassicaceae	Broccoli, brussels sprouts, cabbage, cauliflower, kale	*Hyaloperonospora brassicae*
	Matthiola (stock), *Lobularia*	*H. parasitica*
Caprifoliaceae	*Scabiosa*	*Peronospora knautiae*
Caryophyllaceae	*Cerastium, Stellaria* *Dianthus*	*Peronospora alsinearum, P. conferta* *P. dianthi, P. dianthicola*
Cucurbitaceae	Cucumber, melon, squash, pumpkin, zucchini	*Pseudoperonospora cubensis*
Fabaceae	Pea	*Peronospora viciae*
	Jicama	*Peronospora trifoliorum*
Gentianaceae	*Eustoma*	*Peronospora chlorae*
Geraniaceae	*Geranium*	*Peronospora conglomerata*
Lamiaceae	Basil, *Coleus*	*Peronospora belbahrii*
	Salvia, Lamium	*Peronospora lamii*
Montiaceae	*Calandrinia caulescens*	*Peronospora calandriniae*
Papaveraceae	Poppy	*Peronospora arborescens, P. cristata, P. somniferi*
Plantaginaceae	Snapdragon	*Peronospora antirrhini*
	Hebe	*Peronospora grisea*
	Veronica	*Peronospora agrestis*
Polygonaceae	Rhubarb	*Peronospora jaapiana*
	Polygonum	*Peronospora polygoni, P. rumicis*
Primulaceae	*Primula*	*Peronospora oerteliana*
Ranunculaceae	*Ranunculus, Anemone*	*Peronospora anemones*
	Helleborus	*Peronospora pulveracea*
Rosaceae	*Rosa, Rubus, Geum chiloense*	*Peronospora sparsa, P. potentillae*
Solanaceae	*Nicotiana, Solanum*	*Peronospora hyoscyami, P. tabacum, P. tabacina*
Violaceae	*Viola*	*Peronospora violae, Bremia megasperma*
Vitaceae	*Vitis, Cissus*	*Plasmopara viticola*

LIFE CYCLE

Downy mildew spores germinate on wet leaf surfaces, penetrate the host and grow for five to seven days absorbing nutrients from plant cells. Downy mildew fruiting bodies typically grow on the undersurface of leaves during humid conditions at night. As the air dries out in the morning spores are released from the fruiting bodies and dispersed by air currents or water splash. As the host tissue dies the pathogen produces a different type of fruiting body (an oospore) that allows it to survive from one season to the next. These germinating oospores also form sporangiophores and sporangia that help it multiply. Downy mildew can also move systemically through the plant producing oospores in dead tissue.

Downy mildew requires around six hours of leaf wetness for spores to germinate and infect leaves and at least four hours of wetness to produce sporangia on infected leaves.

FAVOURABLE CONDITIONS AND SPREAD

Temperature and humidity are vital factors in the disease cycle. Downy mildew thrives under cool (15–23°C), moist conditions with a high relative humidity (85% or higher) at the leaf surface. Free water on the leaf surface is essential for infection and high humidity (› 90%) is needed for sporulation.

Spores can become airborne and travel long distances in moist air currents. They also spread short distances by water splash. In nurseries spores are disseminated by fans, air circulation and overhead irrigation. Downy mildew can be spread a long distance with contaminated cuttings and plants before symptoms become visible. Some downy mildews can be seedborne and produce systemically infected seedlings.

Rose downy mildew leaf and stem spots

DISEASE MANAGEMENT

Successful management of downy mildew relies on monitoring and identification of early symptoms. It is recommended to monitor susceptible seedling crops at least once to twice per week, particularly during high-risk periods, i.e. during cool, wet conditions. It is very important to correctly identify the pathogen before applying fungicides as the active ingredients for use against downy mildew are often different from those active against fungal pathogens. The following cultural practices are recommended for the management of downy mildew.

- Use seed and planting material from a reputable source.
- Monitor incoming stock, paying particular attention to high-risk stock.
- Quarantine incoming stock for a short period. The exact length depends upon the size of plants and risk of infection.
- Monitor highly susceptible plants regularly.
- Use resistant varieties if available.
- Remove and destroy infected plant material hygienically, preferably offsite by deep burial (most council waste services). Material that is discarded on site in a compost heap will increase risk of reinfection.
- Discard unsaleable plants hygienically.
- Do not hold over old stock as this can increase risk of infecting future crops.
- Water plants when leaf surfaces can dry quickly; do not water at night
- Do not overwater.
- If possible, avoid overhead irrigation. Capillary watering systems that do not wet the foliage can be very effective. If overhead irrigation is required schedule irrigation to reduce the period of time that leaves remain wet.
- Use fans to vent the growing area to reduce humidity and leaf wetness.
- Use protective cropping to avoid contact with rain.
- Space plants to allow good air circulation around foliage.
- Ensure appropriate disinfestation of pruning equipment to reduce spread.
- Plants with nutrient deficiencies are more susceptible, so maintain a balanced nutritional program.
- Apply appropriate fungicides.

FUNGICIDES

Fungicide products available against downy mildew in production nurseries include those with pre-infection (protectant) and post-infection (systemic or penetrant) modes of action. Protectant fungicides must be applied before infection occurs. During high-risk periods on high-risk crops, protectant products should be used regularly to protect plants. Systemic fungicides may kill downy mildew after infection has occurred. They should be applied as soon as possible after an infection event to help eradicate the infection and will also help protect healthy plants. Leaf damage caused by downy mildew will remain, but new growth should be healthy. During high-risk periods or when symptoms have appeared, rotate between curative and eradicant products and between mode of action groups when possible. Follow label directions, applying multiple sprays of the same active ingredient, then rotating to the next mode of action group.

Table 2 lists chemicals available for use against downy mildew in production nurseries. These include a range of new and old chemistries as well as a two biofungicides. Read the label or minor use permit prior to use. Many labels and permits have specific requirements that must be met, e.g. may not be used more than two applications per crop or may only be available for use in certain states. For more information on use of fungicides refer to the pesticide application best practice guidelines and the fungicide resistance management factsheet.

Viola downy mildew. Leaves may not always have symptoms on the upper side and must be turned over to observe downy mildew growth.

BIOSECURITY

Plant diseases caused by downy mildew remain an ever-increasing threat to the nursery industry. Some species and their variants are not known to occur in Australia. International trade in nursery plants and ornamentals is increasing and this increases the risk of these pathogens being introduced. Notable recent incursions are downy mildew of Impatiens (*Plasmopara obducens*) and basil (*Peronospora belbahrii*). Downy mildew of parsley, caused by *Plasmopara petroselini*, has not been reported in Australia. It occurs in Europe and can cause up to 100 percent crop loss.

Should any new downy mildew enter Australia, early detection will be essential for its eradication. For this reason, regular monitoring is essential in production nurseries. If unusual symptoms are found contact the nearest department of agriculture or call the Exotic Plant Hotline on 1800 084 081.

FURTHER READING

- Diseases of landscape plants: Downy Mildew
- Leaf spot disease management plan
- Preventing disease in production nursery propagation areas
- Managing disease transmission into production nurseries
- Fungicide resistance management
- Best practice manual for pesticide application
- Current nursery production minor use permits

TABLE 2. PRODUCTS CURRENTLY REGISTERED FOR USE AGAINST DOWNY MILDEW RELEVANT TO PRODUCTION NURSERIES (CURRENT AS AT 2025). READ THE LABEL AND MINOR USE PERMIT THOROUGHLY BEFORE USE.

MOA GROUP	ACTIVE INGREDIENT	EXAMPLE PRODUCT NAME	LABEL OR PERMIT COMMENTS	MODE OF ACTION[1]	MOBILITY IN PLANT[2]
M1	Copper products	Champ	Non-food nursery stock and ornamentals PER91754	P	C
M3	Propineb	Antracol	Cucurbits, lettuce, onion and grape	P	C
M3 + 4	Mancozeb + metalaxyl/M	Ridomil gold	Non-food nursery stock and ornamentals PER91756, garlic PER14008, PER14045 brassicas, rocket, chicory, endive, radicchio and beetroot, PER13673 silverbeet and spinach	P + E	C + S
M3 + 11	Metiram + pyraclostrobin	Aero	Non-food nursery stock and ornamentals PER91756	P + E	C + T
3 + 11	Tebuconazole + trifloxystrobin	Patriot	Ornamentals	P + E	S + T
11	Azoxystrobin	Amistar	Nursery stock (including non-food) and ornamentals	P E	S T
19	Polyoxin-D zinc salt	Intervene	Non-food nursery stock and ornamentals (PER94353)	P	T C
33	Phosphorous acid	Agri-Fos	PER14184 brassicas, PER13698 lettuce and allium, PER11951 brassicas and leafy vegetables	P E	S
40 + M3	Dimethomorph and/or mancozeb	Acrobat	Non-food nursery stock and ornamentals PER91756, PER14470 snow peas, PER14473 spring onions shallots and leeks, PER14958 brassicas and leafy vegetables	P + E	S + C
40	Mandipropamid	Revus	Various leafy vegetables PER91754	P E	S
40 + 45	Dimethomorph + ametoctradin	Zampro	Non-food nursery stock and ornamentals PER91754	P + E	S
44	*Bacillus amyloliquefaciens*	Serife	Non-food nursery stock (PER91754)	P	S C

[1] P= protectant (and/or preventative), E = eradicant (and/or curative)
[2] S = systemic, T = translaminar (local systemic), C = contact

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