Powdery Mildew

A myriad of nursery pathogens

Background

Powdery mildew is a widespread and important disease of many nursery plants and ornamentals. Conidia (spores), produced in great numbers on the surface of the host plant by the powdery mildew fungi, impart a white powdery appearance to affected tissue, hence the common name for the disease.

Powdery mildew fungi are obligate parasites, which means that they can only obtain nutrients from a living host plant. This is why powdery mildew rarely kills plants, but it can cause severe leaf distortion, defoliation, shoot dieback and reduction in growth. They may have little or no affect on some plants other than to reduce their aesthetic appeal.

A succinct and vivid description of powdery mildew is provided by Carefoot and Sprott (1967) in their book, *Famine on the Wind - Plant Diseases and Human History.* When describing a powdery mildew epidemic in French vineyards in 1848, the authors state:

"Each mildewed leaf spewed one hundred million spores into the air, and even the gentlest breeze spread these spores so that every grape leaf was touched by the deadly inoculum. Every animal, insect, bird and person became a potential vector of the Oidium of the grape. The matted mycelium pushed myriads of thumblike haustoria down into the epidermal cells, until the leaves withered and died."

Fig. 1. Powdery mildew on *Zinnia.*

Pathogens

Several genera cause the disease, symptoms of which are similar on many hosts. The most common powdery mildew fungi infecting ornamentals and nursery plants are, in the sexual stage, *Erysiphe*, *Leveillula*, *Podosphaera*, *Sphaerotheca*, and *Uncincula*, and in the asexual stage, members of the genus *Oidium.* Most species of these pathogens are host specific often infecting only a few related plant species. This means

that if powdery mildew is found on one crop in the nursery it does not mean that the other crops will be affected.

The powdery mildew fungi are obligate plant parasites; if the host dies so does the pathogen unless it is able to reproduce sexually and form resting structures known as cleistothecia. These survive adverse environmental conditions. It is common for powdery mildew fungi in more tropical areas not to reproduce sexually. They perpetuate themselves by conidia and survive adverse conditions as dormant mycelium in dormant buds, actively on other plant parts or on alternative hosts.

Powdery mildew forms a network of fungal filaments (hyphae) on the leaf surface which are securely anchored by numerous absorbing organs called haustoria that obtain nutrients for the fungus. They are the only part of the fungus which penetrates host tissues (99% of the fungus remains on the host surface).

A few days after the fungus has infected its host, the hyphae produce many long, hyaline, erect conidiophores, from which chains of spores (conidia) are produced. These spores are one-celled and vary somewhat from species to species. They are spread from infected plants by air currents.

When the production of these conidia slows down and eventually ceases, powdery mildew fungi with a sexual stage produce a resting structure called a cleistothecium on the white fungal strands (mycelium). These are first visible as small dark specks in the powdery mildew colony giving a pepper-specked appearance. Ascospores in asci are produced in the cleistothecium. When ascospores are mature they are released to begin a new infection. Refer to the downy mildew factsheet for a comparison of the two pathogens.

Symptoms

Symptoms vary depending upon host species, pathogen species, environmental conditions (temperature, relative humidity, light) and age of plant tissue when infection first occurs. In most hosts, young host tissues are most susceptible to infection. Powdery mildew fungi attack young foliage, stems, flowers, and fruit.

Small white powdery spots will be visible on the surface of the host tissues. These may remain as distinct colonies or the fungus may ramify completely across the plant organ affected. If the fungus has a sexual stage, cleistothecia may form on the affected plant tissue, which will be visible as tiny black specks on the fungal colony. Affected young leaves may turn pale green to yellow then necrotic giving the plant a scorched effect. Mildewed leaves may become crinkled and distorted. Young shoots with severe infection may wither, dieback and eventually die. Severe infection can also cause defoliation.

Spread

Mature conidia are released from conidiophores when there is a rapid decrease in relative humidity. The conidia are windborne and dispersed by air currents. Spores can also be spread by people (hands, clothing),

Fig. 2. Powdery mildew on a begonia flower (left) and gerbera leaves (right)

on equipment (pruning tools), and by introducing infected propagation material or plants from other nurseries. Ascospores are ejected into the air and carried by wind currents.

Epidemiology

When the windborne conidia land on a susceptible host they germinate to form hyphae which grow across the plant surface. Powdery fungi are unique in that they do not require a film of water on the leaf to germinate. Germination is actually inhibited by free water. They can germinate on dry surfaces when the relative humidity is low (as low as 20%). Infection of the host plant occurs within five to seven hours and a new generation of conidia are produced within five days of infection if conditions are favourable.

Disease development is favoured by warm, dry, and cloudy conditions. Cloudy weather limits damage to the fungus by ultra violet radiation. This means that plants growing in the shade are more prone to mildew than those growing in sunlight. Frequent periods of leaf wetness inhibit formation and dispersal of conidia.

In year-round mild climates powdery mildew fungi may remain active all year. In regions with a dormant season they overwinter as dormant mycelium in buds, or on shoot tips, and resume growth with the return of warm weather; or they survive as cleistothecia which liberate windborne ascospores to initiate new infections.

Management

Management of powdery mildew is reliant on regular monitoring; powdery mildew epidemics can develop very quickly from low level of infection. The following practices will reduce the likelihood of severe outbreaks of powdery mildew.

- Do not introduce infected propagation material or plants into the nursery. Isolate new introductions until you are certain that they are free from pests and diseases.
- Reduce relative humidity around foliage by allowing good air circulation.
- Adjust nutrition to avoid succulent growth.
- Since powdery mildew fungi survive in dormant buds and shoots, prune to remove heavily infected material prior to application of fungicides.
- Where possible grow cultivars resistant to the disease. Be aware that new races or strains may develop in response to using a host resistance gene for disease management.
- As most of the fungus is exposed on the plant surface powdery mildew is readily controlled with fungicides. Numerous fungicides are registered, some of which are protectants which prevent germination of conidia and ascospores, while others have curative or eradicant activity which act against existing powdery mildew colonies.

Fig. 2. Powdery mildew on rosemary (left—photo by B. Watts, University of Maine, bugwood.org) and poinsettia (right - photo by M. Daughtrey, Cornell University, bugwood.org).

Fungicide

There are two types of fungicides registered for use against powdery mildew species, those that have contact activity that suppress spore germination, but do not have post infection curative or eradicant properties, and those that have post infection curative or eradicant properties and are generally either translaminar or systemic. Most fungicides registered for use against powdery mildew relevant to production nurseries are listed in Table 1. Always ensure that you read the label and that it fits your exact situation; not all active ingredients listed in Table 1 are registered in all states or on all nursery plants. Refer to the nursery pesticide application best practice manual for more information.

Biosecurity

The international plant trade has great potential for the spread of new species and more damaging races of powdery mildew fungi. It is quite difficult to exclude powdery mildew fungi from world trade as it may be present as dormant mycelium in buds. Detection is not easy unless there is an extended quarantine period for plants. Exotic powdery mildews, such as citrus powdery mildew caused by *Oidium citri* and *Oidium tingitaninum,* which is present in Asia, can be a serious threat to Australian agriculture. If you see anything unusual your local agricultural department or call the Exotic Plant Health Hotline on 1800 084 881.

Table 1. Fungicides registered for use against powdery mildew relevant to production nurseries as at December 2015. It is recommended to read current labels for more up to date information. Mode of action P = protectant (and/or preventative), C = curative (and/or eradicant); Mobility in plant S = systemic, T = translaminar, CT = contact.

MoA group	Active ingredient	Example product	Registration details	Mode of action	Mobility in plant
3	Bitertanol	Baycor	PER30381 Begonia and Eucalyptus seedlings only	P,C	S
3	Hexaconazole	Synan	Grapes and apples only	P, C	S
3	Myclobutanil	Systhane	Apples and strawberries only	P, C	S
8	Bupirimate	Nimrod	PER12662 Non-food nursery stock	P, C	S
11	Azoxystrobin	Amistar	PER81491 Most non-food nursery stock and non -bearing fruit trees; labels vary and may include contact fungicides	P, C	S, T
11 + 7	Pyraclostrobin + boscalid	Pristine	PER81491 Most non-food nursery stock and non -bearing fruit trees	P, C	T, S
M	Hydrogen peroxide + peroxy acetic acid	Peratec plus	Grapes, brassicas, fruiting tomatoes, eggplant, peppers, cucurbits and alliums	P, C	CT
M1	Copper products	Copperguard	Brassicas, cucurbits, lettuce, onions, red beet, rhubarb, silver beet, spinach, ornamentals and grape; labels vary	P	CT
M2	Potassium bicarbonate	Eco-carb	Tomato, capsicum, cucumber, strawberry, zucchini, rose and grape; PER13793 hazelnut and herb and spice crops	P, C	CT
M2	Sulphur products	Lime sulphur, Thiovit Jet	Grapes, pawpaw, tomato, brassicas, cucurbits and vegetables (but not cucumber or rockmelon), leafy vegetables, mangosteen and pome fruit, rambutan, ornamentals (labels vary considerably)	P	CT
M3	Mancozeb and thiophanate-methyl	Zyban	Most ornamental plants	P, C	CT, S
M5	Chlorothalonil	Bravo	All ornamentals, cucurbits, peas, onions (not spring onions) and grapes	P	CT
U6	Cyflufenamid	Cyflamid	Grapevine and cucurbits only	P, C	S, T
U8	Metrafenone	Vivando	Cucurbits and grapes only	P, C	S
NA	Various oil products	Summer oil, Parafin oil	Pome fruits	P, C	CT

This document was prepared by Ken Pegg and Andrew Manners (Agri-science Queensland, Department of Agriculture, Fisheries (DAF), Ecosciences Precinct, GPO Box 267, Brisbane QLD 4001) as part of NY11001 Plant health biosecurity, risk management and capacity building for the nursery industry in 2015. Thanks go to Lindy Coates, John Duff and Tony Cooke for helpful comments on previous versions of this factsheet**.** Unless otherwise stated, photographs can be attributed to DAF (particularly Leif Forsberg).