Managing Powdery Mildew

(Doing it better!)

Innovators Network Module INO906

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Introduction

Powdery mildew is driven by the amount of inoculum (spores) inherited from last season. In much of Australian viticulture, the disease progresses more or less independent of the weather, though in cool climates, temperature may be limiting at times.

Powdery mildew is common across Australian vineyards. With a better knowledge of disease epidemiology (ie how the disease spreads), of the need to time sprays appropriately and, with improved spray technology and an excellent array of fungicides, direct crop loss from powdery is minimal. Main costs are from fungicide spraying critical to good control because wineries may reject whole crops if powdery mildew levels exceed 3%.

The Disease

Powdery mildew is insidious - it 'sneaks' along inside the canopy until it 'suddenly' appears, potentially causing problems, anxiety and cost!

It is caused by the fungus *Erysiphe necator* (formerly *Uncinula necator*) which arrived in Australia in the 1860's. Grapevines were grown since the First Fleet in 1788, so Australia was powdery-free for 70-80 years.

It is a 'dry weather but high humidity disease' favoured by mild cloudy weather. It could be called 'powdery-dry mildew because it develops in the absence of free-water, in contrast to down-hill mildew which needs free water for infection.

Many vineyards are sprayed 6-7 times/season for powdery but there is opportunity for improved control of powdery with fewer applications.

Symptoms

Identify powdery by the characteristic grey-white mildew that develops on any infected tissue (Figure 1). Main symptoms on leaves are irregular yellow blotches best seen on the upper surfaces and, on varieties like Chardonnay, with associated browning of the smallest (tertiary) veinlets on the under sides. The blotches soon show the typical white mildew as spots expand and merge across both surfaces of leaves. Eventually the whole surface is covered.

To see young mildew spots clearly, angle the leaf into the light; this makes the fungal sporulation more visible.

Source of Inoculum

Powdery mildew develops from two sources of inoculum:
1) Infected buds carry the disease from last season when they are infected in the first 2-3 weeks of their exposure on last season's shoots. This season, the mature buds emerge, producing diseased shoots called 'flag shoots' (*Figure 1*). The fungus on these produce spores (conidia) that spread disease to adjacent foliage; and
2) Cleistothecia form late last season. If, this season, ≥ 2.5mm precipitation occurs while the temperature is >10°C, they release ascospores like seeds from an apple, and these sometimes also spread disease (*Figure 2*).

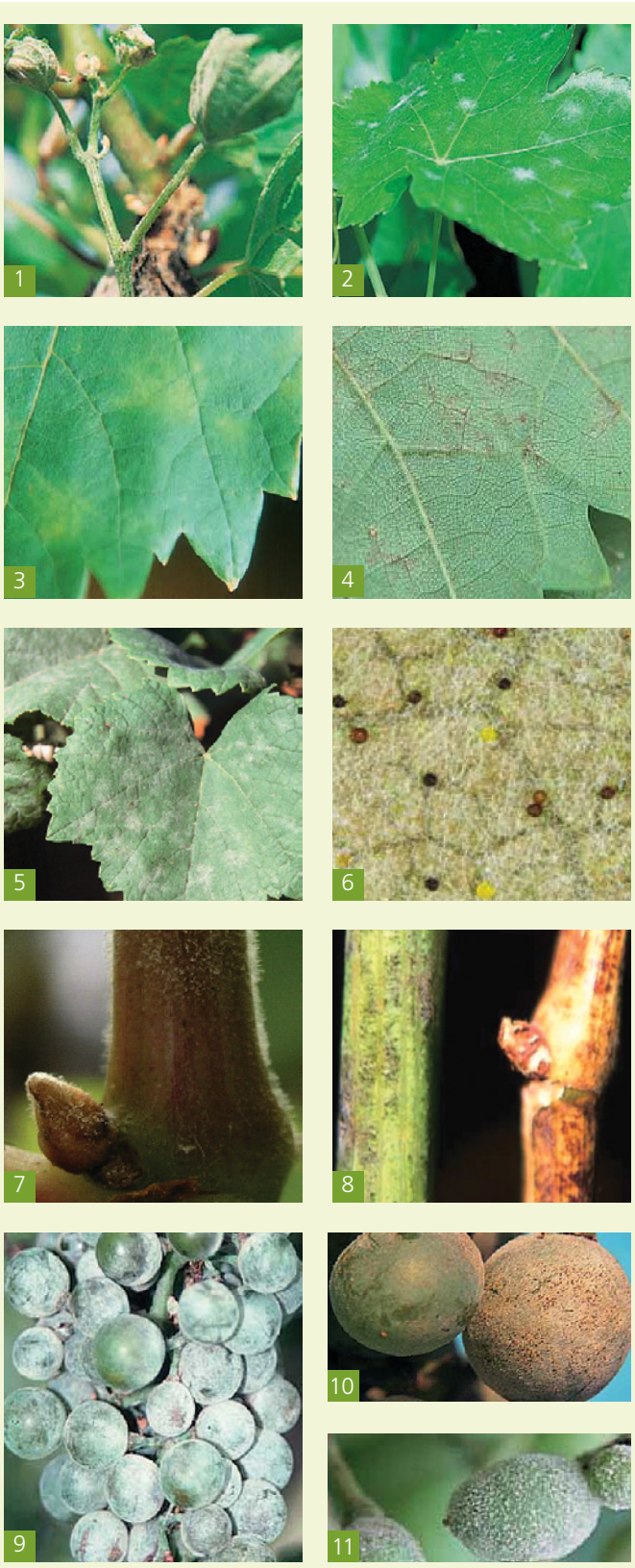

Figure 1: Powdery mildew shows as grey-white 'mildew' on any green tissue. **(1)** Flagshoots show as stunted shoots with up-curled leaves covered in part with the mildew. **(2)** Leaf spots develop scattered on the leaf which **(3)** may show yellow leaf blotches and **(4)** browning of the veinlets underneath. **(5)** Whole leaves may be covered where **(6)** yellow and black cleistothecia develop on mature 'mildew mats'. **(7)** Buds are infected when young and show the white mildew growth **(8)** leading to greasy blotches on shoots, and reddish blotches on canes and mature buds some of which carry powdery inside. Bunches and berries show typical mildew growth **(9-11)**.

Disease Cycle

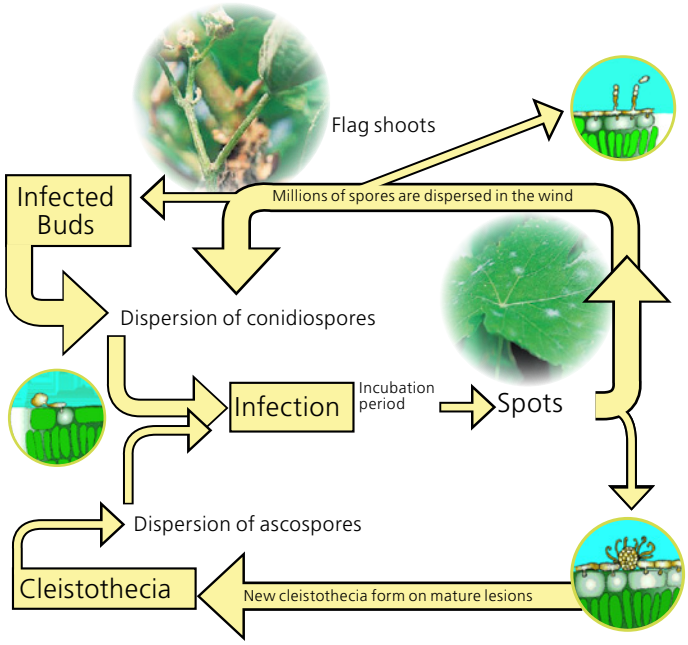

Figure 2. In most of Australian viticulture, powdery mildew develops from infected buds and sometimes, also from cleistothecia. Both lead to the production of new infection sites in the canopy from where the disease spreads steadily.

Spores that spread disease from overwintering inoculum (flagshoots and cleistothecia) lead to new leaf spots and disease on foliage and bunch every 7-10 days after infection *(Figure 2)*. Powdery has considerable capacity to multiply. It spreads slowly and steadily, increasing disease incidence and severity even in dry conditions and often unnoticed in shaded parts of the canopy. Optimum temperature for growth is 20-28°C. Although powdery is thought to be retarded by temperatures >40°C, in practice, it thrives in the optimum night temperatures that follow hot days, bringing more hours with favourable than unfavourable temperature.

Powdery mildew produces about twice as many spores at relative humidity (RH) >40% than at lesser RH and is killed by exposure UV light. Canopies open to airflow and UV light therefore have less risk of disease while dense, shaded canopies provide a favourable microclimate.

Epi-Seasons. Diseased buds and cleistothecia develop in Season 1, the first of two growing seasons in the 'season of the epidemic', called the 'epi-season'. Most infected buds are diseased early in Season 1 and produce flag shoots in Season 2. Cleistothecia are produced late in Season 1 and discharge ascospores sometime either prior to or early in Season 2. They do not carry over to Season 3. Thus, the powdery mildew epi-season covers a rolling window of two growing seasons *(Figure 3)*.

Legacy/inheritance. Consequently, in Season 1, powdery mildew produces inoculum that survives over winter as a legacy, inherited by Season 2 where it triggers infection. The 'legacy/inheritance' factor from within a vineyard is the main factor influencing initial levels of disease and thus the level of difficulty to achieve good control of powdery mildew each season.

Season of an epidemic

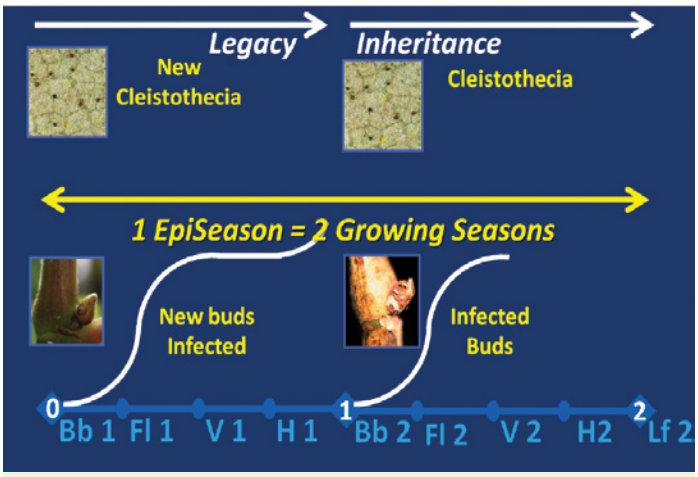

Figure 3. Diagram illustrating an epi-season (season of an epidemic) which, for grapevine powdery mildew, encompasses two growing seasons. The factors that influence the development of an epidemic are presented where Bb=budburst, Fl=flowering, V= veraison, H=harvest and Lf=leaf fall, in Seasons 1 and 2 respectively. The white graph lines for each season are simplistic disease progress curves for an unsprayed vineyard. The 'legacy/inheritance factor' for over-wintering inoculum determines initial levels of disease and so, the level of difficulty in managing powdery mildew in the second growing season.

Powdery mildew increase and severyity in unsprayed Australian vineyard

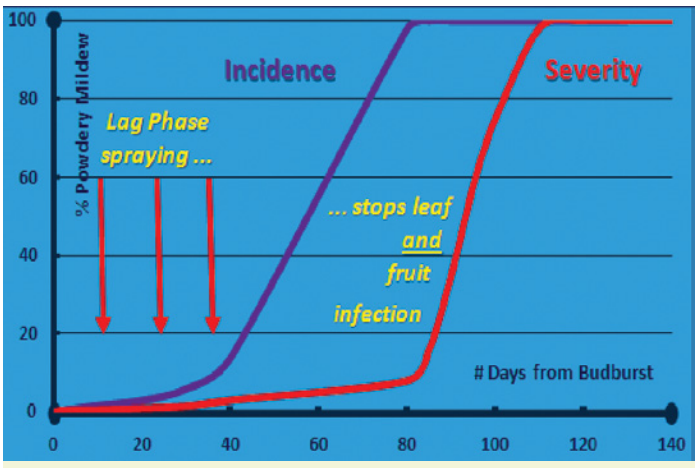

Figure 4. Graph illustrating the increase in incidence and severity of grapevine powdery mildew in a typical unsprayed inland Australian vineyard. Disease incidence increases significantly at around Day 40 from budburst at Day 0, and severity increases at about Day 80. The principle of 'lag phase control' is to apply fungicides while initial inoculum levels are low and more manageable, and sufficiently early in the epi-season to prevent the development of over-wintering inoculum for Season 2.

Managing the Disease

A simple sequence of events occurs in unsprayed vineyards: fruit infection comes from leaf inoculum; leaf inoculum comes mostly from flag shoots and flag shoot inoculum comes from bud infection. So, if you control bud infection (and cleistothecia), you also control fruit infection.

Inoculum for powdery comes from conidia and ascospores (see above) but these only come from other grapevines and not the mildew from roses, cucumbers, melons etc. Also, in early-season, inoculum moves usually much less than 200-300m which means that the spores that most influence your vineyard in early-season, come from your vineyard... and you can control these. The level of powdery that you inherit in Season 2 depends on how much disease you allow to develop in Season 1.

To control the disease effectively, use:
Lag Phase control; and
knowledge of Epi-Seasons:

This approach is best for powdery because it means controlling the disease when spore loads are lowest, during the slower, early season, 'lag phase' in disease development *(Figure 4)*.

The rule of thumb - the Three T's of good spray application: Type, Timing and Technique. Like three links in a chain, ensure each factor in spraying is of good quality for good management.

Fungicide Type: All fungicides registered against powdery mildew work well. There are about 15 different active ingredients (~65 products) registered in Australia for control of powdery. The main product types and groupings are shown below. A recent change to the classification system for fungicides has revised the classifications. The previous classifications are shown in brackets:

sulphur	M2 (Y6)
DMI	3 (C)
amines (eg Prosper®)	5 (E)
strobilurins	11 (K)
phenoxyquinoline (eg Legend®)	13 (M)
[copper	M1 (Y2)]

Note: Copper has lesser efficacy than those above.

For further details, see the AVCARE website: www.avcare.org.au

Sulphur: is Man's oldest fungicide. To date, no fungicide resistance has developed despite centuries of use! Sulphur is cheaper than most other fungicides and works well if sprayed well. It is best used at the high rate 600 g/100L. It has both direct contact and volatile action – a significant advantage. Because powdery grows on the surface of grapevine tissue, it is killed readily by any contact fungicide active against the pathogen. As a result, sulphur has post- and pre-infection activity; that is, it both kills the pathogen (post-infection activity) and protects the new foliage.

Sulphur has effective volatile (fumigant) activity at temperatures >20°C. In cooler temperatures, eg <15°C this activity is limited. The contact activity occurs at any temperature but for this, good spray coverage of upper and lower surfaces is needed. This means that in cool climates, ensure good spray coverage and sulphur can still work well.

Sulphur may cause phytotoxicity at high temperatures if RH >75%. Sulphur in solution is weakly acidic and burns the foliage if, over a long period, the spray solution does not dry. Drying rates are slower at high RH.

The best time to apply sulphur may be on a calm evening after a hot day, allowing maximum volatile action of the fungicide as it permeates the sprayed canopy at warm temperatures. A single application with good spray coverage can restrict powdery on that sprayed surface for 40 days.

DMI's: were developed in the late 1980's and include Bayfidan®, Mycloss® and Topas®. These demethylation inhibitors have 'translaminar activity', that is, they move across and/or within the leaf and are partly systemic. However, they do not move in the vine's 'plumbing' in sufficient concentration to be effective beyond the sprayed zone. Topas® has a limited volatile action but is the most effective fumigant of the DMI's. Optimum temperature for this is >20˚C.

The DMI's are single-site fungicides, acting at only one point of the mildew's biology. As a result, they are at risk of the fungus developing resistance, making the product ineffective. The DMI's are excellent pre- and post-infection fungicides for powdery mildew. They protect the vine and kill the fungus, and have potential for use in early season when the young buds are most at risk from powdery. The DMI's are also valuable tools where spray coverage is limited but they are more expensive than sulphur. Resistance management strategies recommend that the DMI's not be used more than three times in a season.

Strobilurins: These fungicides were developed in the early 1990's and include Amistar®, Flint® and Cabrio®. Like the DMI's, they have 'translaminar activity' and move across and/or within the leaf and are partly systemic but they need to be applied with good coverage and dose, to compensate for the loss of active ingredient as it moves within the leaf. Like the DMI's, the strobilurins are also single-site fungicides prone to resistance though, as an added advantage, the strobilurins also control downy mildew.

Spray Timing. As discussed above, sprays timed in the lag phase reduce the number of infected buds this year and so reduce the number of flag shoots to spread disease next season. Prevent disease build-up this season to prevent production of cleistothecia that survive to next season.

Over a five year period, well-timed sprays reduce the reservoir of inoculum in the vineyard and reduce the number of sprays needed for effective and efficient control, and so have potential to reduce vineyard inputs while achieving more effective control of disease.

Spray Technique, includes spray coverage and dose critical to success of fungicide applications for powdery mildew.

Further Reading

Emmett, RW et al. 2006. Improved management of grapevine powdery mildew. GWRDC Project Number: DNR 02/06, Adelaide, South Australia, 61 pp. See http://www.gwrdc.com.au/webdata/resources/project/DNR0206.pdf

Emmett, RW. et al. (2006) Grape diseases and vineyard protection. Ch 11, pp 232-278, in Viticulture Volume 2 Practices, Coombe, BG and Dry, PR. (Eds), Winetitles, Adelaide, South Australia. 376pp. – for a detailed scientific review of the disease.

Emmett, R.W. et al. (1994) Powdery mildew. pp 12-16 in 'Diseases and Pests', Vol. I. Grape Production Series, Nicholas, P.R., Magarey, P.A. and Wachtel, M.F. (Eds). Winetitles, Adelaide, South Australia. 106 pp. ISBN 1-875130-15-2 – for an easy to read manual on the disease and its control.

Magarey, P.A. et al. (1999). The Australian and New Zealand Field Guide to Diseases, Pests and Disorders of Grapes. A companion to 'Diseases and Pests', Grape Production Series No.1., Winetitles, Adelaide, South Australia. 108 pp. ISBN 1 875130 33 0. (634.82) – to help you correctly diagnose the symptoms of disease.

See www.CropWatchOnline.com for access to details on CropWatch and Disease Diagnosis® an online module to diagnose disease from the tractor seat.

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