

Managing downy mildew in NSW vineyards

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Photos in this section: P A Magarey

Downy mildew is 'driven' by warm, wet weather. In consequence, it occurs with different severity in different regions. For instance, in the Hunter Valley, warm, wet weather occurs often and regional crop loss from downy mildew is high. In dry, inland regions there are many seasons when the disease causes no damage at all.

No matter what region you are in, the best way to control downy mildew is to spray effectively when the risk is high and to withhold sprays when you are confident the risk is low. In wet seasons, this means many sprays may be needed but in dry seasons, no matter what region you are in, spraying for downy mildew is often not needed!

What does downy mildew look like?

Downy mildew is seen on younger leaves as typical, yellow oilspots. If the conditions have been suitable, white down then forms on the undersides of these spots (Figure 1). On older leaves, the symptoms are very different: a tapestry pattern develops when the smallest veinlets become resistant to infection producing small, angular patches of diseased cells. Young bunches are highly susceptible and when infected, turn brown and die quickly (Figure 2). Berries become resistant to infection 3–4 weeks after fruit set as the berries are reaching pea-size (E-L 31), but the berry stems remain susceptible.

Downy mildew is a 'green' disease: like powdery, it only infects green parts of the vine. Older tissue that has changed colour is no longer susceptible. So, for instance, green shoots can be infected whereas browned canes cannot.

Distinguish the two mildews on leaves by the distinctive circular oilspots of downy mildew and the fresh white down that forms in warm humid conditions on the underside of the spots. Contrast this with the more irregular-shaped yellow blotches of young powdery mildew on leaves and its grey-white fungal growth on both sides of the leaves, the foliage and fruit.

What 'drives' downy mildew?

Downy mildew is not actually a fungus. It is an algae. And, like most algae, it must have free water to infect the foliage. (In this case, free-water usually means enough rainfall to wet the leaves.)

To the contrary, **powdery mildew** mostly can grow without free water. While it does better at high rather than low humidity, in the main, it doesn't need rainfall. A helpful hint is to think of powdery as 'powdery-dry mildew' because it still grows in dry weather and, because water runs downhill, to think of downy mildew as 'down-hill mildew' – it needs water (rainfall with or without irrigation) to spread.

Downy mildew grows best at 20°C to 24°C but it can grow at other temperatures too. For example, if it rains with temperatures as low as 8 to 10°C, its spores in the soil can begin to germinate while, for the spores to form on leaves, warmer weather ie. a minimum temperature of 13°C, is needed.

The level of downy mildew that develops in your vineyard is the result of the complex interactions of temperature, rainfall, relative humidity and leafwetness with the downy mildew organism and how these factors vary over time. Various time intervals are needed for different aspects of downy's life cycle.



Figure 1: Typical symptoms of downy mildew on leaves. Left: Grape leaf showing oil spots caused by downy mildew. Right: Grape leaf showing sporulation on the underside of the oil spot in the morning. [© Western Australian Agricultural Authority].



Figure 2: Downy mildew rapidly kills highly susceptible young bunches (left), but berries are immune well before pea-size (E-L 31). Downy mildew is best controlled at or before primary infection because in suitably warm humid weather, the disease spreads rapidly in secondary infection.

Downy mildew life cycle

Downy mildew begins (or spreads) from two sources of inoculum (sources of disease). **The first:** downy mildew survives in the soil as resistant structures called *oospores*. Oospore inoculum leads to primary infection. Primary infection, the soil to foliage movement of the disease, leads to oilspots. The oilspots show up in the vineyard after a period of incubation: 4–6 days in warm conditions and up to 10–14 days in cool weather.

The second: downy mildew spreads from **oilspots**. Oilspots produce spores called sporangia. The sporangia lead to secondary infection, the leaf-to-leaf and leaf-to-bunch movement of the disease. Primary infection, of itself, does not cause crop loss but it produces a few oilspots that can trigger secondary infection. Secondary infection can lead to an explosive increase in disease producing many 1000s of new generation oilspots overnight. In early-season when bunches are very susceptible, secondary infection can be highly destructive.

Note: Pre-infection fungicides such as copper based products are cheaper than post-infection products such as Ridomil, but they need excellent spray coverage of the undersides of leaves to prevent infection by downy mildew.

Conditions for primary infection

The disease progresses if (and only if) the conditions are favourable. Those needed for primary and secondary infection differ. In former days, the rule of thumb 10:10:24 was used to summarise the conditions needed for primary infection. This referred to: ≥ 10 mm rain to wet the soil sufficiently to germinate the oospores and foster infection; $\geq 10^\circ\text{C}$ for sufficient warmth for this process to occur; and for at most 24 hours in which the processes needed to be completed.

This rule was better than a guess but it was only a guide. It did not describe the detailed interactions between the vineyard factors that combine to trigger an infection event. If the conditions are warm enough, wet enough for long enough oospores in soil leaf litter germinate to produce a second spore-type called macro-sporangia. These release another spore called zoospores which must be splashed into air currents to reach the foliage. To complete primary infection, the leaves need to be wet and warm enough for long enough. Zoospores, if carried to the undersides of the leaves, will germinate and infect through the stomates (breathing pores in green tissue) if the foliage remains wet for ≥ 45 degree-hours (0°C-hrs).

To calculate degree-hours, multiply temperature (0°C) by time (hrs) [$0^\circ\text{C} \times \text{hrs} = 0^\circ\text{C-hrs}$]. For example, if the temperature averages 23°C for 2 hrs, the degree-hours accumulated is $23^\circ\text{C} \times 2 \text{ hrs} = 46^\circ\text{C-hrs}$. This is $\geq 45^\circ\text{C-hrs}$ and is sufficient for infection.

Figure 3 illustrates some of the more detailed requirements for primary infection.

10:10:24 in detail

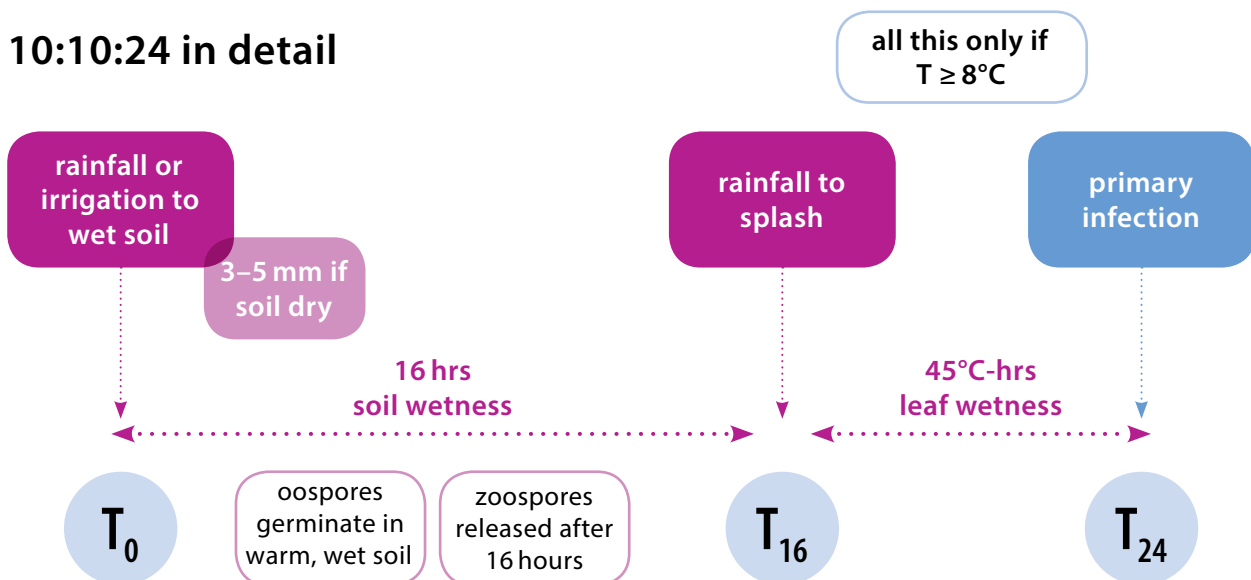


Figure 3: A very specific set of conditions is needed by downy mildew before primary infection will occur in your vineyard. Monitor weather events to determine the timing of disease events. From this, you can work out the best times to spray (or to confidently withhold sprays when not needed).

Conditions for secondary infection

To begin a secondary infection, an oilspot is needed and this needs primary infection. If primary infection has not occurred, secondary infection cannot occur. Secondary infection also needs warm, humid conditions at night. Humidity of $\geq 98\%$ is needed while temperatures are $\geq 13^\circ\text{C}$ for at least 4 hours at night. White down (sporangia) then develops on the undersides of the oilspots and the new spores (zoospores) will lead to secondary infection if the leaves are wet for $\geq 45^\circ\text{C}\text{-hrs}$ (the same as for primary infection) – that is 2 to 3 hours with temperatures around 20°C , or for longer if it is colder.

Managing downy mildew

It is critical to know when primary infection is likely. If you can prevent primary infection you prevent oilspots and if there are no oilspots in your vineyard you cannot have the dangerous secondary infection events. For best control, spray effectively when the risk of infection is high.

Determine the risk of infection by observing the weather. Check the forecasts to know when best to apply a pre-infection (preventative/ protectant) spray – that is to know if a primary (or a secondary) infection event might occur. A pre-infection fungicide is best applied as close as possible **before** the infection event. Monitor the resultant weather events as they pass over your vineyard to determine if the conditions favoured an infection. If your vines were unprotected against downy mildew at a critical time of the season, apply a post-infection (eradicant) fungicide as soon as possible **after** the infection event **and before** the new oilspots appear.

To best determine the risk of an infection event, seek assistance from regional disease alert services. These operate from a network of automatic weather station (AWS, Figure 4) that monitor temperature, rainfall, relative humidity, leaf wetness and daylight and dark at 10 (or 15) minute intervals.

Some systems such as **GrowCare**[®], use DModel, an Australian computerised, simulation model of downy mildew, to process vineyard weather data and provide an assessment of the risk of downy mildew. This allows specific advice on the optimum timing of sprays against primary and secondary infection events – critical to best control of disease with a minimum of sprays at minimum cost with maximum effectiveness.

Alternatively, you can use the following **GrowCare**[®] checklists in your vineyard as a guide to assess recent (or forecast) weather for risk of downy mildew infection events. Periods of high risk can be determined by monitoring the vineyard rainfall, relative humidity (RH) and leaf wetness and then using the relevant **GrowCare**[®] checklist as a guide to determine the optimum timing of sprays. In this way you can spray at the best time for maximum control or, you can confidently withhold sprays when they are not needed.



Figure 4: Automatic weather stations (AWS) monitor the vine canopy for leafwetness, rainfall, relative humidity (RH) and temperature. These are critical to the life cycle of downy mildew. An AWS, like this Australian designed and built Model T MetStation[®], is also a disease predictor. It processes the weather data it records and signals infection events by a series of red lights if infection is active. This provides a disease risk statement on-site in the vineyard or it can be relayed directly to your home computer. This information is often critical to refining optimum spray timing in your vineyard.

Note: Good timing of spray applications in relation to infection events, especially primary infection, is a major factor in effective spraying for downy mildew. Young bunches are highly susceptible so good control of primary infection will prevent the risk of secondary infection and reduce the need for more sprays.

GrowCare[®] check list for downy mildew primary infection

Only tick boxes if answer is 'Yes'.

Primary infection

- It has rained and your vines were not protected, i.e. they were not sprayed recently with a pre-infection fungicide. This time will vary depending on the stage of season you are in, e.g. for 5–7 days when vine growth is rapid and at flowering; or for 7–10 days until berries are pea-size.
- Rainfall was more than 3 mm if soil was wet before the rain, *or* at least 5 mm if soil was dry.
- Temperature was above 10°C .

If Yes, oospore germination has begun.

Soil was continuously wet to at least 2 cm depth for at least 16 hrs. This means the palm of your hand is wetted when placed on the soil surface.

- Soil did not dry for more than three consecutive hours.
- Temperature remained above 8°C .

If Yes, oospores have germinated.

- Some rain fell after the sixteenth hour and leaves were wetted.

Zoospores have splashed and drifted to the foliage.

- The leaves *then* remained wet for 45 °C-hrs. i.e. for at least 2 hrs 15 mins at 20 °C, or 3 hrs at 15 °C, or 4.5 hrs at 10 °C
- Are all boxes ticked Yes?

If Yes, then primary infection is likely (See note ¹ below).

Expect primary oilspots to appear in the next 5–7 days if the weather is warm (20 °C to 25 °C) or in 10–14 days if the weather is cooler or hotter.

- Is it at or near flowering and are berries less than pea-size?

If Yes, apply a post-infection fungicide (e.g. Ridomil) before the new oilspots appear.

These oilspots will be one or two every 50 m or so along the vineyard row – not easy to locate.

If you find any, tag the location to monitor this site for new events.

Secondary infection

Only tick boxes if answer is Yes.

- Active oilspots are present in my vineyard.
- The vines were unprotected i.e. not sprayed with a pre-infection fungicide in recent days.

This time will vary depending on the stage of season you are in: e.g. 5–7 days when growth is rapid and at flowering or 7–10 days until berries are pea-size.

- The conditions were warm and humid overnight and the leaves were wet in the morning.
- Temperature was above 13 °C and humidity was above 98% for at least four hours overnight.

Fresh white down will have appeared underneath active oilspots.

Check any oilspots present for fresh, white down. The spores drift in the wind to other places in the foliage.

- The leaves *then* remained wet for 45 °C-hrs, i.e. for at least 2 hr 15 min at 20 °C, or 3 hrs at 15 °C, or 4.5 hrs at 10 °C.
- Are all boxes ticked?

If Yes, then secondary infection is likely. (See note ¹ below).

Expect primary oilspots to appear in the next 5–7 days if the weather is warm (20 °C to 25 °C) or in 10–14 days if the weather is cooler or hotter.

- Is it at or near flowering and are berries less than pea-size?

If Yes, apply a post-infection fungicide (e.g. Ridomil) before the new oilspots appear. These oilspots will usually be several to many per leaf on many leaves often in clusters on either side of the vine row. If you find any oilspots, tag the location to monitor this site for new events.

¹ Please note: This checklist provides only a guide as to whether infection has occurred or not. It should not be relied upon when determining vineyard

management actions. If needed seek expert advice on the complex interactions between the vine, the weather, the downy mildew organism and any previous spray cover you may have applied. All these factors determine if infection actually occurred or not.

Further information

Nicholas, P.R., Magarey, P.A. and Wachtel, M.F. (Eds). (1994) *Diseases and Pests*, Vol. I. Grape Production Series, Winetitles, Adelaide, South Australia, 106 pp. See Downy mildew. Ch. 5, pp 5–11. ISBN 1-875130-15-2. This is an easy-read manual on vineyard diseases and pests and their control.

Magarey, P.A. et al. (1999) *The Australian and New Zealand Field Guide to Diseases, Pests and Disorders of Grapes*. This is 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.

Magarey, P.A. (March 2010) *Managing Downy Mildew, (Winning the war!)*. GWRDC Innovators Network Module INO904. Fact Sheet. 6 pp. www.gwrdc.com.au

See www.growcare.com.au for access to **GrowCare**® and for **Disease Diagnosis**® – the latter is an online module of the Field Guide (above). It allows you to diagnose vineyard symptoms from the tractor seat!

GrowCare® helps you:

- » grow clean, green crops
- » access timely weather and disease information
- » optimise timing of controls to maximise productivity.

GrowCare® currently provides you with quick access to weather data via an easy-to-read changeable graph. **GrowCare**® works well when operated with regional industry associations using their access to a network of automatic weather stations (AWS). It works equally well with you and your privately-owned AWS.

GrowCare® though still under construction, provides you with:

- » recent weather observations from your nearest AWS – by graph or by summary table
- » recent weather observations from the Bureau of Meteorology for the location of your choice – by graph or by table
- » the latest seven-day weather forecast from MetEye at the Bureau of Meteorology for your location of interest
- » a check list for you to use as a guide to downy mildew primary and secondary infection events depending on the weather near your vineyard.

If you access Model T MetStation data, **GrowCare**® also provides downy mildew infection alerts.

For access to **GrowCare**® as a service, contact Peter Magarey on mobile 0418 808 296 or email pmagarey@riverland.net.au