Managing Downy Mildew

(Winning the war!)

Innovators Network Module INO904

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Introduction

Downy mildew is driven by the weather. The disease can devastate individual vineyards and in some seasons, affect production from regions. It occurs sporadically according to the suitability of conditions for infection so that, in inland regions, severe disease occurs once in 9-10 years while in regions like the Hunter Valley, it is more frequent.

Previously considered a fungus, the downy mildew pathogen *Plasmopara viticola*, is now classified an algae.

To reduce the losses downy causes, reduce the number of unnecessary sprays in dry conditions and refine the timing of sprays during conditions that favour the disease. This fact sheet provides an overview of the disease, the conditions that favour each phase of its development and best management options to lessen the impact of this disease.

The Disease

Downy mildew needs warmth and water. As for most algae, in most stages of its life cycle, take away water and it will die. As a reminder of its dependence on free-water and because water runs downhill, think of downy as 'down-hill mildew'! In contrast, we may call the other mildew 'powdery-dry' mildew because it grows in the absence of free water.

Periods of high risk from downy can be determined by monitoring the vineyard microclimate for factors such as temperature, rainfall, relative humidity (RH) and leaf wetness. This allows optimum timing of control actions when they are needed, and gives confidence to withhold sprays when not.

Symptoms

Downy mildew is best recognised by its typical, circular, yellow oilspots on the younger leaves and, if the conditions have been suitable, the white down 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 – this confines the disease to small, angular, interveinal patches of diseased cells. When infected, highly susceptible young bunches turn brown and die quickly (*Figure 2*). Later, 3-4 weeks after fruit set, berries gain resistance to infection. By pea-size (E-L 31), they are immune though the stems remain susceptible.

Like powdery, downy is a 'green' disease in that matured tissue that has changed colour is no longer susceptible – for instance, green shoots are able to be infected whereas browned canes are not. Distinguish the two mildews by the distinctive circular oilspots of downy mildew on leaves and the fresh white down that forms in warm humid conditions on the underside of the spots. Contrast this with the more irregular yellow blotches of young powdery mildew on leaves and its grey-white fungal growth on both sides of the leaves, the foliage and fruit.

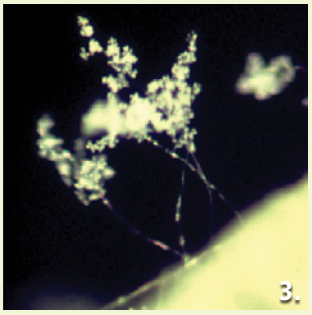

Figure 1: Typical symptoms of downy mildew on leaves:
1) oilspots are circular and light yellow when young;
2) older oilspots are dark yellow with or without the white down on the undersides;
3) & 4). close-up of the fresh down (sporulation) that provides inoculum (sporangia) for spread of disease.

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

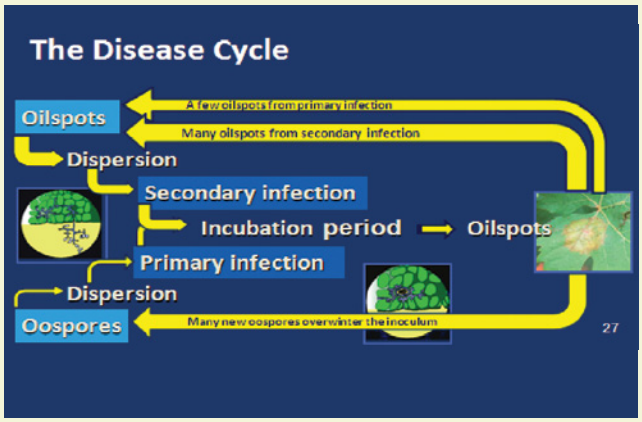

Figure 3. Downy mildew has two sources of inoculum that trigger disease if conditions are favourable: oospore inoculum leads to primary infection; while oilspots produce sporangia which cause secondary infection. Primary infection does not cause crop loss but sets the scene for potentially devastating secondary infection events.

Source of Inoculum

Downy has two sources of inoculum (i.e. the spores that spread disease) (*Figure 3*).

Oospores: These are survival spores that live for (we suppose) 7-10 years in leaf litter in the soil. They develop within oilspots on leaves diseased in preceding season(s). If the conditions are warm enough, wet enough, for long enough (see later), the oospores produce a second spore type called macro-sporangia. These release a third type of spore called zoospores which need to be splashed to the foliage to trigger primary infection.

Oilspots: These produce sporangia in the foliage if specific conditions occur at night (see later). The sporangia are in the white 'down' of downy mildew on the underside of oilspots and are spread in wind and rain. Like the macro-sporangia, if the conditions are warm enough, wet enough, for long enough, they produce zoospores which trigger secondary infection.

Disease Cycle

Primary infection: This involves the soil to foliage movement of inoculum. The rule of thumb 10:10:24 gives a guide to the conditions in which infection might occur, i.e. at least 10mm rainfall is needed while temperatures are at least 10°C during a 24 hour period. If 10:10:24 does not occur, the conditions will not suit primary infection. However, if 10:10:24 does occur, the conditions still might not suit infection. More specifically, for primary infection processes to begin, oospores in the upper 1-2 cm of soil need to be wetted for ≥ 16 hours at temperature ≥ 8°C (*Figure 4*). Like most stages in downy's life cycle, the optimum temperature is 20-24°C.

If conditions remain suitable, macro-sporangia, then zoospores, are released. The latter are then ready to be splashed to the undersides of the leaves where they germinate and infect through the stomates if the foliage remains wet for 45 degree-hours (0°C-hrs). To calculate degree-hours, multiply temperature (0°C) by time (hrs) [0°C x hrs = 0°C-hrs]. For example, if the temperature averages 23°C for 2 hrs, the degree-hours accumulated i.e. 23°C x 2hrs = 46°C-hrs. This is ≥ 45°C-hrs, sufficient for infection.

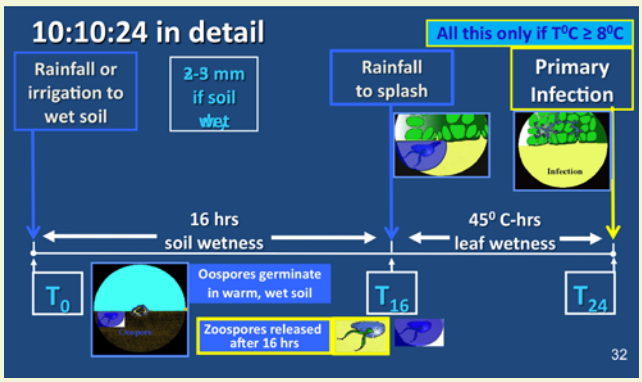

Figure 4. Determining if primary infection has occurred early-season, is critical for good control. The 10:10:24 rule of thumb summarises a very specific set of conditions needed by downy before primary infection will occur. Monitor weather events to determine the timing of disease events and, as a result, work out the best times to spray.

Incubation: Once infection has occurred, there is a temperature controlled delay of 5-17 days before the oilspots are seen. During this period of incubation, the mildew pathogen grows inside the infected tissue disrupting cell function. Eventually the leaf tissue turns yellow and the oilspots appear. Primary infection produces only ~1-2 oilspots every 50 metres of vine row but these are important in establishing the disease in the canopy. Oilspot numbers could explode if conditions were then to favour secondary spread. As a result, if the vines are unprotected before a primary infection in early season, be sure to control the disease before the oilspots appear.

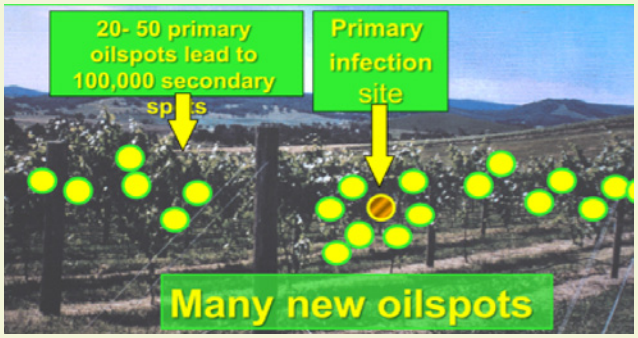

Figure 5. Secondary infection can be explosive, producing many 1000's of new generation infection sites overnight. Early season, when the bunches are very susceptible, this phase of the disease can be rapidly destructive.

Secondary Infection: This involves the leaf to leaf and leaf to bunch movement of inoculum. This requires oilspots in the foliage and a warm humid night. Sporulation (the production of sporangia on the undersides of oilspots) occurs if relative humidity (RH) is ≥ 98% at temperatures ≥ 13°C during at least 4 hrs of darkness. The sporangia will germinate and release zoospores which are spread to other leaves and bunches in wind and rain (*Figure 3*). If they land in a drop of water, they will cause infection if the leaves remain wet for 45°C-hrs, as is required at the same stage for primary infection. Many 1000's of sporangia are produced from each oilspot. As a result, one oilspot can trigger a huge multiplication of disease overnight - an initial 20-50 primary oilspots can produce 100,000 new oilspots after the second incubation period *(Figure 5)*.

Managing the Disease

The Three T's. A useful rule of thumb is the Three T's of good spray application: Type, Timing and Technique. Like three links in a chain, each of the T's must be of good quality for good management of disease. We discuss the first two here. The third, Technique, includes spray coverage and dose.

Fungicide Types: The two main types of downy mildew fungicide are classified according to their timing in relation to infection events. They are best applied when they are most effective, that is either pre- or post-infection.

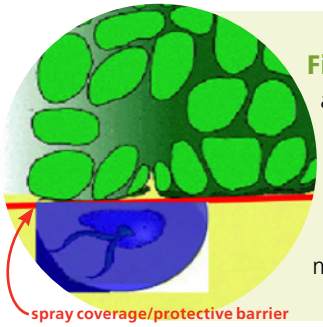

Figure 6: Pre-infection fungicides such as copper based products are cheaper than post-infection products such as Ridomil, but they need excellent **spray coverage** of the undersides of leaves to prevent infection by downy mildew's zoospores.

Pre-infection fungicides (protectants): These protect the vine by preventing infection. Many belong to the Group M (formerly Group Y) fungicides and are not systemic (phosphorous acid and fungicides in Groups 11 and 40 are exceptions). The non-systemic (or contact) fungicides provide a **protective barrier** on the surface of the foliage where they stop the spores germinating (*Figure 6*). Since downy invades through the stomates, apply contact fungicides to cover the undersides of leaves – the most difficult place to spray. They must be re-applied prior to an infection event if there is sufficient growth of leaves or of developing berries. Apply the sprays as close as possible before infection. Access to forecasts of downy mildew events will help time these sprays best.

The pre-infection fungicides include:

Group Name	(formerly)
copper-based	M1 (Y)
dithiocarbamates (eg mancozeb, thiram, ziram)	M3 (Y)
phthalimide (eg captan)	M4 (Y)
chlorophenyl (eg Bravo®)	M5 (Y)
quinone (eg Delan®)	M9 (Y)
strobilurin (eg Amistar®, Flint® and Cabrio®)	11 (K)
cinnamic acid (Acrobat®)	40 (X)

Post-infection fungicides (eradicants): These are sometimes known as systemics - but note: some pre-infection fungicides are also systemic. The post-infection fungicides kill the pathogen inside infected tissue if they are applied at the right time. They do not eradicate the disease from the vineyard but, being systemic, they are quickly absorbed into the sprayed foliage and are rain fast within 2-3 hrs of spraying. Because Ridomil is usually mixed with mancozeb it simultaneously provides a protective shield against new infection. The post-infection fungicides are more expensive than their pre-infection counter-parts but, like a surgeon, they are able to 'remove the bullet' i.e. the downy pathogen, from within infected tissue. Consequently, apply these fungicides only when needed and then, as soon as possible after an infection and before oilspots appear i.e. in warm conditions, within 5 days post-infection. Like all fungicides, good coverage is important.

The post-infection fungicides include Ridomil Gold® (a Group D fungicide) and phosphonate eg Foli-R-Fos® (Group 33 – formerly Y1). Because resistance to Ridomil has been reported overseas, Australian management strategies recommended only 1-2 applications/year.

Phosphonate (phosphorous acid) is not currently (2010/11) accepted for use on grapes for export wines, though it is widely used in Europe to control downy. Because it is the world's only fully systemic fungicide, moving easily up and down in the vascular fluid, it rapidly moves away from sprayed tissue. Since it is very effective in post- and not pre-infection activity, tank mix it with protectants.

Figure 7. 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.

Figure 8. Automatic weather stations (AWS) monitor the vine canopy for leafwetness, rainfall, relative humidity (RH) and temperature, critical to the life cycle of downy mildew. Some AWS, like this Model T MetStation®, signal infection events and help refine optimum spray timing.

Spray Timing

Because warm wet weather drives downy mildew, for optimum control, apply sprays in relation to primary and secondary infection events. Where possible, access weather forecasts and predicted times of high disease risk and spray before the disease develops. Monitor and interpret the weather that followed to determine if infection occurred and adjust spray type and timing accordingly. If available, seek assistance from regional disease alert services.

You may have access to an automatic weather station (AWS) that monitors temperature, rainfall, relative humidity, leaf wetness and daylight and dark at 10 (or 15) minute intervals. If so, you may process the above data through DModel, an Australian simulation model of downy mildew, for specific advice on the timing of primary and secondary infection events critical to best control of disease. In some regions, industry-based services such as CropWatch and CropWatchOnline.com use a network of AWS to provide region-wide advice of disease risk in different localities. These services provide a weekly e-mail and fax-out advisory service and have helped minimise the number of sprays needed for effective control of downy mildew, especially in dry seasons.

6. Further Reading

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.

Magarey, P.A. et al. (1994) Downy mildew. pp 5-11 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.

Magarey, P.A., et. al. (2000) Reduced chemical usage and improved control of grapevine downy mildew using a simulator of disease. Project No. DAS 9GW / DAS 9. Final Report to Grape and Wine Research and Development Corporation, Magill, SA. July 31 2000. 43 pp. – for a detailed report on the development of the downy mildew simulator and its use.

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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