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GWRDC pest and disease debrief sessions: What we learnt from the 2010-11 season

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Introduction

This document captures the information from the 2010–11 grapegrowing season.

The season was unusually wet in south-eastern Australia, which led to higher than usual disease pressures in vineyards.

The aim of this report is to summarise the problems faced and the ideas learnt, to foster more efficient pest and disease management by Australian grapegrowers in future seasons, be they wet or dry.

The season

The wet 2010–11 season had been 'coming' for a long time. The law of averages through the history of Australian viticulture had been 'predicting' a major wet season for some years despite the advent of a series of drought years prior to season 2009–10. This long drought had interrupted the historical cycle that extended across south-eastern Australia of one very wet season every nine years. At least in the inland districts of Riverland/Sunraysia this had held true, except for the 'miss' in 2001–02, in the middle of the drought. Then, interestingly, just nine years later again, came 2010–11, the next in the series of seasons favouring high levels of the foliage diseases of grapes across south-eastern Australia.

In recent memory, the years with high disease pressure across south eastern Australia similar to 2010–11 were 1973–74 and 1974–75, 1983–84 and 1992–93. Prior to that, the wet seasons of 1917 (when downy first appeared in Australia), of 1931, 1954–55 and 1955–56 stand above the other seasons. So, in the 75-year period to 1992–93 since downy mildew was first observed in Australia, at least eight years – or one year in nine - were prominent from the amount of rain and the copious damage caused by the foliage diseases in vineyards.

However, climate averages mean little. The extreme weather of 2010–11 may not have been new, but it was destructive. Arguably, it was one of the most destructive of all in south-eastern Australian viticulture. Though 1992–93 had followed a drought, the most recent 'big dry' was more prolonged and it was economically more debilitating. Moreover, the recent wet season coincided with international events like the high exchange rate for the Australian dollar that took the profit away from Aussie wines on export markets. These factors depleted the financial reserves vital for grapegrowers to apply the additional protective and curative sprays needed in defence of diseases and pests of their vineyards.

So, what did we learn from season 2010–11? How did Australian grapegrowers react to the disease pressure with its waves of assault on the canopy of vines, on the economy of their vineyard and on their personal resilience? What approaches were tried in managing the disease events? What worked and what didn't? And, how should we best prepare for an approach disease control in subsequent seasons?

Disease overview

Season 2010–11 began with downy mildew. In some locations, such as the Riverland, the disease began just after budburst before progressing rapidly and, where uncontrolled, killed all bunches by mid- to late-November 2010. Then powdery mildew came to the fore. Having progressed steadily since budburst, disease levels increased dramatically in some regions causing severe loss by early December 2010. Finally, bunch rots caused their devastation toward the end of the season.

During the season, many problems arose, questions were asked and ideas expressed on how best to manage the disease and pest pressures.

The Grape and Wine Research and Development Corporation (GWRDC) thought that it was important to capture how growers managed the pest and disease pressures and what worked best. This information will help foster more efficient disease and pest management in future seasons, be they wet or dry.

Capturing the information

There were four primary sources of information:

1) Problems recognised and questions asked in one-to-one contact during the 2010–11 season.
2) Growers' answers to a detailed questionnaire sent via email to members of the GWRDC's Innovators' Network and through the AWRI's e-bulletin distribution list.
3) Presentations and discussions at five full-day GWRDC pest and disease workshops. At each workshop, technical specialists made short presentations on the major diseases *viz.* downy mildew, powdery mildew, Botrytis and other bunch rots, and other pests. Each presentation was followed by a facilitated free-flowing question and answer sessions, which gave good insights to the ins and outs of disease control experienced by growers. The sessions concluded with a discussion of best management practices.
4) Numerous other season review workshops and seminars were held across south-eastern Australia.

What follows came from comments received and from observations made by growers and technical personnel involved in the production of grapes during season 2010–11.

Discussion

There were three major assaults on the production of grapes in south-eastern Australia during season 2010–11. First came downy mildew with the most conducive weather conditions in nearly 20 years. Then came powdery mildew, normally a challenge every season, but more so in 2010–11. Next came the bunch rots. Not only Botrytis, but also an array of other fungi and organisms that thrived in the extreme wetness of the season.

Downy mildew

Key issues identified in the GWRDC pest and disease survey

- **Drought before the storm.** The large increase in the number of sprays used for downy mildew in season 2010–11 (to well above average levels) reflects the very favourable weather conditions for downy mildew in that season. The abundant rains changed canopy microclimate from the dry of recent times to ‘frequently wet’ in season 2010–11 across south-eastern Australia.

  Table 2 illustrates this with data from Sunraysia. The table shows that an ‘average season’ usually has only one or at best, two or three downy mildew primary infection periods but in season 2010–11, there were no less than seven events.

  Table 2: Differences between the three seasons to 2010–11 in relation to downy mildew and powdery mildew of grapes.
  [Data are for September to February inclusive from the Mildura Bureau of Met*, and from observations of disease at Mildura in the Sunraysia by Dr Bob Emmett**, DPI, Mildura, Vic.]

Factor	2008/09	2009/10	2010–11
Days max. temp > 35 ºC*	33	54	16
Total rainfall (mm)*	83	148	710
Total rain days (≥ 2.5 mm)*	8	15	32
Downy mildew primary infection periods**	0	1	7
Powdery mildew severity**	low	average	high

  In the drought years that preceded 2010–11, many growers were monitoring for the risk of downy mildew infection through their own observations or through disease advisory services like CropWatch™. Accordingly, they were spraying less. Vineyards in some regions had no primary infection periods in one or more seasons of the drought. As a result, the trend was away from ‘calendar spraying’ and applying pre-infection fungicides ‘just in case’, to spraying as needed. Nevertheless, the wet season changed that, prompting the significant increases observed as growers sprayed more often in response to the dynamics of the season as it unfolded.

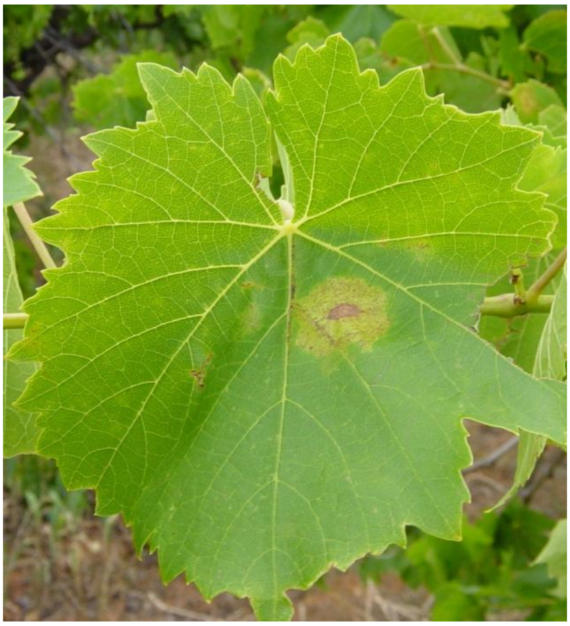
- **Number of sprays**: In a ‘normal’ season, the survey tells us that 68% of growers (as measured by the number of respondents) apply between 1–6 sprays for downy. Only 19% apply more than this, while 13% apply none. Contrast this with season 2010–11: 42% applied between 1–6 sprays and 56% sprayed more often. These extreme conditions drove 30% of growers to apply 10 or more sprays! From observations across the regions, a significant number sprayed vines 13–16 times, most of which included some downy mildew fungicide.

- **Spray strategies**: The survey indicated many growers used pre-infection and/or post-infection strategies for downy mildew and that ‘calendar’ spraying according to some regular schedule, was also common. The blend of the different strategies in an individual vineyard in the same season probably reflects the progression in disease severity as the season unfolded and the need to tank mix with the regularly scheduled sprays for powdery mildew and occasionally for other diseases and pests as well. Powdery control needs focussed spray schedules whereas downy is best controlled according to the prevailing weather when the risk of infection is high. This varies with the wetness of the conditions.

In the complexity of season 2010–11, with frequent long periods of rain and humidity favouring downy and bunch rot, a difference between the pre- and post-infection strategies was effectively lost in the overlapping demands both to spray for these weather-driven diseases and in the regular schedule needed for powdery mildew.

- **Pressure from Downy mildew**: As indicated, this season was extreme in terms of rainfall, not least, in terms of pressure from downy mildew. In the survey, growers were asked to rate this disease pressure on a scale from low to extreme. As expected, a majority (77%) found this pressure high or extreme. The good news was that despite this, 81% believed they were able to control the disease sufficiently. This was an exceptional achievement given the stress of the season and the difficulties growers faced.

- **Controlling primary and secondary infection**: A vast majority of growers (91%) believed they achieved success against primary infection (though this success must not have been complete or the disease would have caused no further trouble). A similar majority believed that, by vintage, they had blunted the impact of secondary infection. Again, this was a major achievement given the interrupted supplies of fungicides etc (see later point on this).



Downy mildew primary infection usually causes only a single oilspot on a leaf 'here and there' (left). This enables the disease to spread and in ideal conditions as occurred frequently in 2010–11, secondary infection caused the disease to explode with many new oilspots appearing in unsprayed foliage nearby (right). (Photos: A. Weeks, CCW (left); P.A. Magarey, MPP (right).

- **Fungicide supplies**: The frequent spraying of vineyards required by the high disease pressure demanded a supply of fungicides that the chemical industry could not match. The lack of product brought stress to seek both alternative sources and alternative products to control downy. Despite this, most growers (80%) were happy with the amount of product they were able to obtain in the finish though 20% were left disappointed and felt at least partly thwarted in getting the supplies and therefore the control they wanted.

- **National shortages**: The fungicides in short supply included copper, most pre-infection fungicides and the post-infection fungicide Ridomil. This lack of stock applied not only to products for downy but was part of an Australia-wide shortage of chemicals for powdery and bunch rots. This was heightened by the extreme conditions increasing the demand for fungicides to control disease in pulse and cereal crops and a wide array of others. It is worth noting that all this had happened before in the last big wet season, 1992–93.

- **Phosphorous Acid in supply**: As a result of disease pressure from downy in 1992–93, many growers still had a good store of phosphorous acid in the shed, but they felt frustrated because its use was not permitted for wines to certain export markets. While in a welcomed step, temporary permits were obtained to allow market access to some additional countries (for example Canada), additional permits (when MRLs are established) would relieve this matter for future seasons. This process is underway but, like most international trade negotiations, may take some time.

- **Different products and difficulties**: Necessity is the mother of invention and shortages of product for downy mildew meant that a wider than usual array of product types were sought and tried. Some 17 different registered product types, incorporating a large array of registered trade names, were used. While a number of registered products were thought to be ineffective by some, there was a wide array of factors that might have led to a lack of control after a supposedly well-timed spray had been applied with good coverage. Caution is needed to interpret the supposed failure of any registered product applied under the extremities of the season.

- **The *Three Ts***: Attention to the ***Three Ts*** of good control is needed for a fungicide spray to be effective *viz.* the right ***Treatment*** (selection of fungicide) must be applied with the right ***Timing*** and with the right ***Technique*** (spray technology for optimum spray rate and coverage). At times during the rigours of 2010–11, it became almost impossible to achieve this goal. As a result, it was almost impossible to control downy mildew and the other foliage diseases effectively so, the 'failure' of a product to control downy might rightly be attributed to any one of the issues included in the ***Three Ts***.

- **Vine growth**: An illustration of one of the factors associated with ***Timing*** was evident when a pre-infection spray of copper was applied three days before a downy infection event. Normally this would be good spray timing, especially near flowering when rapid vine growth and capfall quickly reduced effective coverage. However, this season, with good soil water, a lack of temperature extremes, and excellent conditions for vine growth for a longer period, shoot elongation and leaf expansion continued for longer than normal and was more extensive, reducing the effectiveness of the coverage within just three days.

- **Spray coverage**: The spray timing in the above example was less than best because spray coverage failed in that circumstance. To explain this, suppose at that time, a leaf 1 cm in diameter was well sprayed with copper achieving 100% coverage 3 days prior to the infection event. The rapid leaf expansion that occurred since spraying meant that the leaf area more than doubled in that time (see Downy mildew Q6 later in the document for more detail) and the leaf area protected by copper would have halved. The newly expanded leaf surface was unprotected and now exposed to infection. Accordingly, downy mildew oilspots showed up about 10 days later, despite the fact that the right treatment had been applied with the right technique.

  The absence of effective control was not a failure of the fungicide nor was it the amount of product that washed off the leaf in the rains that brought the downy. Nor was the lack of effective control a matter of resistance developing to copper or to any other failure of the fungicide. It was linked to the high and prolonged rate of vine growth and this led to the unexpected loss of effective spray cover.

Effective disease control requires effective spray coverage. This is achieved by well-designed spray machinery, properly configured to the canopy dimensions and carefully calibrated to delivery accurate dose of fungicides. The multi-head machine pictured delivers airflow from above and beneath the canopy. The converging airflow adds turbulence in the canopy that improves spray coverage.
(Photo: P.A. Magarey, MPP.)

- **Canopy management**: Such prolonged growth provided additional difficulty through the extra density of foliage and length of shoots. These combined to make spray penetration into the canopy much more difficult. The survey indicated that many approaches were tried in an attempt to increase spray coverage inside the canopy and into the bunch zone and, as a result, to improve the control of downy. These attempts included adjusting foliage training wires, shoot training and leaf removal and also using higher water rates and slower ground speeds. Some growers sprayed once in one direction and then back again, down the row from the opposite direction. But most often, the attempts to improve spray coverage centred on some form of shoot trimming including hedging and skirting of vines.

  However, sometimes this practice triggered an additional problem. As shoot growth continued unseasonably, so did the growth of secondary shoots and new leaves formed at the point of trimming. These increased the density of the external parts of the canopy and thus increased the shielding of the inner foliage. This reduced the exposure of the bunches and inner leaves to the needed fungicide activity. None-the-less, as the survey indicated, many growers hedged vines twice, three and even four times. Nearly always though, some welcome improvement in spray coverage was achieved despite the repetition and the difficulties. In the final analysis, most growers, especially in the Riverland, Murray Valley and Riverina regions with the bigger canopies, felt the trimming was well worth the cost and effort.

Questions and answers

[For additional information on downy mildew, refer to '*Downy Mildew: Questions and answers*' *(GWRDC website)* and see Further reading, below:]

The disease begins in the soil

Q 1: Oospores over winter the downy mildew fungus. How long do they survive in the soil?

- These overwintering fruiting bodies developed in oilspots on leaves last season and fall with the foliage to the ground in autumn. There the hardy, resistant oospores survive for many years spreading in any movement of soil and leaf litter. No chemical treatment can control them. Although they seem able to last 7–10 years in the soil and there is no lack in their supply from year to year, the increased levels of downy mildew last season will have refreshed the population of oospores in most vineyards. This is ready to initiate downy mildew primary infection in 2011–12 and in the seasons ahead.

Q 2: Can I stop the zoospores from splashing to the vine?

- If the soil has been wet for 16hrs while temperatures are above 8°C, the oospores release into soil water at the surface causing another spore type called zoospores. For primary infection to occur, these need to be splashed to the foliage. Attempts to use mulch or dense grass swards on the vineyard floor to block their movement to the vine have not worked. Perhaps only one or two zoospores may escape here and there, moving past the mulch or the tall grass and this seems to be enough for the zoospores, once splashed into the air currents, to be carried in tiny aerosols to the foliage and cause primary infection.

It is triggered in primary infection?

Q 3: If you have 10:10:24 conditions, does that mean that you will get downy?

- You might and then you might not! Let's explain. If you **don't** get 10:10:24, you are **very unlikely** to get downy. The rule of thumb indicates that primary infection needs ≥10mm rain while temperatures are ≥10°C during a 24 hr period. But, downy actually needs enough rain (or irrigation) to wet the soil for ≥16 hrs (see Downy mildew Q2 above). It then needs more rain to splash zoospores and then enough rain for leaves to stay wet for 45°C-hrs (see Downy mildew Q5 below). You **can** get these conditions if you have had 10:10:24, but you **may not**. Suppose all the rain fell in the first two hours and the soil dried up – the rule would have said 'yes' for downy but the soil dried out too quickly for downy to start. The rule of thumb is just a guide – see Downy mildew Q17 further on.

Q 4: Season 2010–11 had many long periods where leaves stayed wet. Why was this good for infection from downy?

- There were numerous occasions when leaves stayed wet for 36-48 consecutive hours. In these conditions, 'fungi' like downy produce millions of spores and these cause lots of infection, even if it is cool at the time. For example, downy mildew infection first needs zoospores, either from primary infection processes splashed from the ground (see Downy mildew Q2 above), or from secondary infection processes from the white down on oilspots or berries. Downy then needs these zoospores to invade (the lower sides of) unprotected green vine tissue. This will occur if leaves remain wet for 45°C-hrs (see Downy mildew Q5 below). Often, leaves were wet for much longer than this, favouring infection not only from downy but also from a wide array of the bunch rotting organisms – see later.

Q 5: So, how do you calculate degree-hours?

- It sounds complex but it is in fact, quite straight forward. Suppose it has rained, the leaves are wet and the temperature is 10°C. If these conditions persist for one hour, you will have accumulated (10 x 1)°C-hours = 10°C-hrs leaf wetness. Suppose it was 20°C and leaves were wet for 2¼ hours, then (20 x 2.25) = 45°C-hrs leafwetness. This is enough warmth and leaf wetness for downy mildew infection to occur (see Downy mildew Q3 above). Suppose the temperature had stayed at 10°C; we would need 4½ hrs leaf wetness (10 x 4.5) = 45°C-hrs. The persistent high humidity and leaf wetness after the rains in season 2010–11 were very favourable for downy infection and spread.

Strategies to control downy

Q 6: I followed a preventative strategy last season, but I still got downy mildew. What went wrong?

- I suppose by 'preventative strategy' you mean that you applied a pre-infection (protectant) fungicide as close as possible **before** an infection event. To be successful with this approach in last season's very wet conditions, you will have needed accurate weather forecasts for your region and been able to have sprayed your vineyard quickly. Any slack in spraying **close** to the infection event will have meant that the foliage will have elongated and leaves expanded significantly, exposing the leaves and bunches to infection (see 'Spray Coverage' section above). A simple preventative program was very unlikely to succeed last season.

So often the vineyard was too wet (or flooded!) to get on the ground when needed; or it was too windy, or maybe the canopy was too dense to get good spray penetration into the bunch zone. The barrage of successively wet days meant that often the canopy was not well covered and downy mildew got away. A post-infection strategy was then needed to 'retrieve' the situation.

Q 7: My neighbour tried to use a post-infection strategy but he failed too. What are we supposed to do in this situation?

- A good post-infection strategy needs close attention to weather data from a station near you. Some regions have a weather monitoring and warning system like *GrowCare* or *CropWatch* (see GrowCare.com.au) that provide detailed advice as to when infection events have **just** occurred. This is very helpful as it allows precise timing of high-cost post-infection sprays like Ridomil to be applied **as soon as possible** after the infection event and **before** the oilspots appeared. But last season, the succession of rain days, flooded vineyards, warm moist conditions and dense canopies put a post-infection spray strategy under a lot of strain. The only effective solution was an amalgam of the two strategies, spraying when the gap in the weather presented itself and then with the best spray coverage applied to recently trimmed or hedged canopies.

Monitoring for growth and for disease

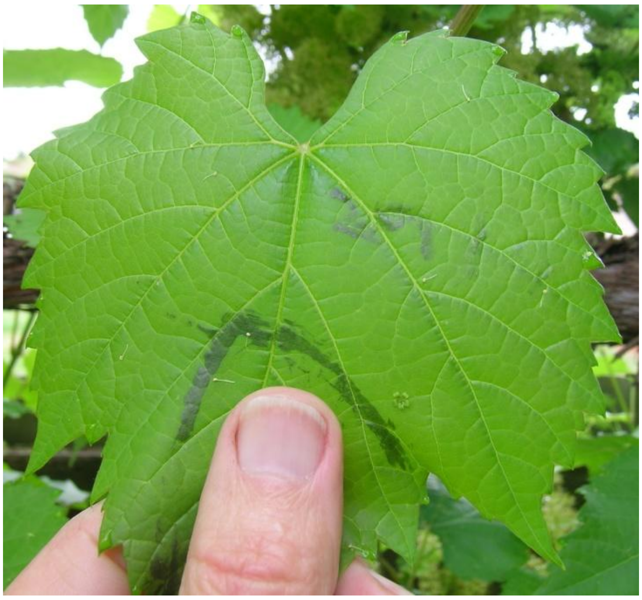
Q 8: In mid-season, many oilspots appeared suddenly on the upper shoots at the top of the canopy. What happened there?

- Several things coincided. First, shoots elongated quickly in the good growing conditions (see Downy mildew Q6 above). This lead to an increase in the amount of soft young foliage very susceptible to infection. Second, unless control had been excellent, in the wet conditions millions of downy spores were produced within the canopy; and third, very few spray machines were capable of spraying that high in the canopy to protect the high shoots at the tops of vines. Perhaps the monitoring of spray coverage for oilspots may have been lacking but a combination of the above three factors meant that the many spores which had escaped control after a 'ripper' of an infection period would have caused high levels of disease on the very susceptible foliage. It caught many people by surprise.

Q 9: So how could I have avoided this?

- A little monitoring of the vines works wonders. Check how much **new shoot growth** has occurred by looping a plastic clip from a bread bag over the petiole (leaf stem) of the youngest fully expanded leaf. Gauge how much longer the shoot has grown since your last spray by counting how many new leaves have opened above the clip. Also, check how far existing **leaves have expanded** by holding the thumb of one hand on an upper leaf on a developing shoot, then use a marking pen to draw an outline of your thumb on that leaf. [You can draw around any object that you carry daily with you – e.g. a 10c piece.]

  To assess how much the leaf has expanded, come back 3, may be 5, or 7 days later and compare your thumb with the outline you drew. These two procedures will show you how many new leaves developed since last spraying and how much the existing sprayed leaves have expanded. That new foliage is unsprayed and unprotected.



To check how far leaves have expanded since spraying, hold the thumb of one hand on an upper leaf of a shoot tip just before spraying. Then use a marking pen to draw an outline of your thumb on the leaf. This photo was taken seven days after the marking. See how much the 'thumb print' had nearly doubled in size in that time as newly expanded, unsprayed, tissue had developed. Diseases like downy and powdery mildew developed rapidly in this unprotected tissue. (Photo: P.A. Magarey, MPP.)

Q 10: This sounds simple enough, is there anything else I can do?

- Yes, you can check for new disease. Monitor the canopy regularly and look for two things. First, check if existing oilspots have sporulated: look for **fresh** white down (new spores) beneath the oilspots. If present, downy may have spread and a new generation of oilspots is probably on its way. Secondly, look for the new generation of oilspots, distinguishing young oilspots by the presence of a chocolate halo until they are 5–7 days old. Access to weather data and to a downy mildew advisory service, e.g. GrowCare.com.au (see Downy mildew Q7 above), will help you monitor for downy events. Combined with the foliage checks (see Downy mildew Q9 above), there should not be any surprises in terms of downy mildew from now on!

Q 11: In the wet conditions, I often ended up spraying with copper or other pre-infection fungicides just before it rained buckets. Is it correct that 50% of these sprays get washed off in a 25mm rain?

- There is a lack of data on this but, if the spray has dried before the rain begins, it is likely that more fungicide sticks than is commonly thought. While some fungicide content will wash (strip) from the leaf after rainfall, some of the spray deposit will also be re-distributed across the leaf. This will improve the effectiveness of the spray coverage. Nevertheless, more often the critical factor is the amount of new growth that occurred since the rain (see Downy mildew Q6 above). Despite the concern about the loss of fungicide following rainfall, often the more important issue is the gain in new foliage area exposed to new infection.

Q 12: Do copper sprays at flowering pose a problem?

- In Australian conditions: No, or at least, hardly ever. The issue arises if there are long periods when the foliage remains wet. When the copper stays in solution for a long period, it can be phytotoxic burning the foliage and/or the soft, young flower-parts. For this to occur, the wetness must persist for 24–30 hours and this is rare in Australia. Only in seasons like 2010–11 is it different but, for all the wetness last season, there were very few reports if any, of damage from copper sprays at flowering.

Q 13: Downy infected some of my bunches, they turned brown then black when they died but some berries turned purple. What was this?

- It was downy mildew. Few other diseases turn berries purple. Downy mildew only invades berries when they are less than pea-size (6–7mm, E-L 31) but sometimes, a berry may be infected just **before** pea-size. As the berry grows bigger, downy grows inside, soon turning the berry purple. This is a characteristic symptom for downy mildew.

Downy mildew infection near flowering can be devastating to the crop. The young flowers and developing fruit are very susceptible and are killed rapidly if infected. In this case, the infection was halted by well-timed applications of a post-infection fungicide like Ridomil.

Automatic weather stations provide help in timing sprays for downy mildew with precision. (Photo: P.A. Magarey, MPP.)

Q 14: The conditions last season favoured downy mildew more than in most recent seasons? How good were the conditions for the disease?

- The answer depends on where your vineyard was but generally, across south-eastern Australia, season 2010–11 was the worst in terms of crop loss and the struggle to control the disease since the wet season of 1992–93. In some unsprayed vineyards in inland Australia, downy had killed 90–100% of bunches by late November (E-L 29-30). In 2010–11, if you managed to protect your crop from downy mildew till veraison (E-L 35), you did well.

Q 15: How far do downy mildew spores travel? Some people are blaming disease in their vineyard on the abandoned block next door?

- This may be correct in some places but often, spores from unsprayed vineyards next door, were of little consequence. You might well exclaim, '*Why not?*' Well, previous investigations have shown that abundant sporulation (spore production) as occur beneath 100s of oilspots on vines at one edge of an unsprayed vineyard, will mostly move only 30(–50) metres down the row. Yes, in favourable weather, a few spores will go further; one or two might even go 200–300m, but most of the inoculum that you will need to be concerned about will come from infection in your vineyard. Rare is the time when conditions favour downy mildew that you won't need to have sprayed your vines anyway, no matter the condition of your neighbour's vines.

Q 16: Last season, by the time many people spotted downy mildew, it was secondary not primary infection.

- Yes, primary infection produces only 2–3 oilspots in a little group here and there about 50m apart down the vineyard row. These are hard to spot unless you are monitoring closely. It is much easier to spot secondary infections because the clusters of oilspots are larger in number and often in groups spaced across half to one metre of canopy or more. But downy mildew is best controlled by preventing or killing primary infection (see Downy mildew Q6, Q7 and Q17).

Q 17: In 2010–11, I was caught out – primary infection started earlier than I thought. How can I best monitor the conditions for disease?

- You will need to know the micro-climatic conditions in your vineyard canopy (see Downy mildew Q3 above). An automatic weather station (AWS) can monitor the temperature, RH (relative humidity), rainfall and leaf wetness on a 10 (or 15) minute interval. With a trained eye, a study of these conditions will allow you to determine whether or not primary or secondary infection had occurred and whether oilspots are expected in any unprotected parts of your vineyard. This, coupled with close observations of detailed weather forecasts, will give you a guide to your best spray options through the season. You can spray with good timing when needed and confidently withhold sprays when sprays are not needed.

Q 18: That's all very well, but what if I don't have time to do all that; and anyway, I'd rather be outside than trying to work that out on my computer?

- Some regions have access to advisory services that download weather data, process these for risk of downy mildew and, on a regular basis, provide emails or other forms of message with disease management options for growers. You might have a service near you or maybe you can be part of a service beginning in your region (see Downy mildew Q7, Q10 above, go to www.GrowCare.com.au or see other regional weather monitoring/warning services).

Q 19: Some of my neighbours are confused. Should they apply another cover spray after a rain event and prior to the next, or do they need to use an eradicant?

- Let's suppose there were oilspots in the vineyard (primary infection had occurred and was missed), and let's suppose a pre-infection fungicide (e.g. copper) was applied just before a rain that was good for a secondary infection. What is best from here? If it was at or near flowering (and so the crop was very susceptible to infection) and if there was any indecision about the effectiveness of the copper spray (because of new vine growth, see Downy mildew Q6 and Q9 above), then it is best to take no chances and apply a post-infection fungicide such as Ridomil. However, if it was later in the season (and berries were greater than pea-size (and resistant), **or** if the protective spray was well-timed and applied with good coverage, then a protective cover applied as close as possible before the next rain event, would probably be just as effective and cheaper!

Q 20: I saw no sign of infection on my Merlot leaves but shortly after, I had devastating berry loss.

- This is tragic. What probably happened is that downy mildew was present but unseen on leaves inside the canopy. While there was no downy mildew on the new shoot growth on the outside of the canopy a primary infection had probably occurred when the shoots were young and the rapid new growth had hidden the oilspots from view. Conditions must have then have favoured a strong secondary infection so that new spores were spread to the young and very susceptible (and presumably, unsprayed) berries and to any unsprayed new shoot growth. The berries would have been killed shortly after but sometime later, especially in cool weather, you should have noticed new downy mildew oilspots showing on the foliage.

Downy mildew infection of the very susceptible flowers leads to rapid spread of disease. Note the white sporulation (spores) on the young bunch. In warm, humid conditions, these spores can spread the disease unseen, inside the canopy. (Photo: Warren Burgess, vbh supplies.)

Q 21: Later in the season, I hedged my canopy strongly to cut off infected foliage before my next spray. I did this to remove oilspots from the canopy and reduce the amount of inoculum that could spread infection. It did reduce symptoms, but did not eliminate them?

- Your approach was excellent. By hedging your canopy, you not only removed the susceptible growing tips, but you reduced a significant number of the latest, largest and youngest oilspots (on the susceptible shoot tips) and so, reduced the pressure on the fungicide that followed. Another good thing was that you opened the canopy to allow better spray access to the bunches and to better aerate allowing leaves and bunches to dry more quickly and be less at risk from downy mildew and bunch rots (see later).

Best practice approach to managing downy mildew

Key elements pre-season:

- **Fungicides**: Check your resources this season to secure an appropriate supply of fungicide and other products for your vineyard. Allow flexibility to handle the wettest season.

- **Calibrate vineyard spray equipment**: Check spray nozzles and calibration to ensure best possible spray coverage is achieved with least loss from off-target residues, especially in early season. Remember that downy mildew invades through the lower leaf surface; these are the most difficult to spray effectively. Be ready to adjust spray volumes as the canopy develops during the season.

- **Spray strategy**: Decide on your preferred approach to managing downy mildew in your vineyard. Prepare for one of the following:
    - pre-infection (preventative) strategy, post-infection (curative) strategy or a combination of both.
    - For the **pre-infection strategy** you will need:
        1) ready access to detailed weather forecasts that enable you to decide if a weather event will bring suitably wet conditions; and;
        2) capacity to spray individual vineyard blocks at short time intervals **as close as possible before** that event, even if a succession of rain events follow.
    - For the **post-infection strategy** you will need:
        1) ready access to interpretations of vineyard weather data to know if a rain event has just past, and will it have induced an infection event; and;
        2) capacity to access and spray your vineyard **as soon as possible after** the rain event and **before** oilspots appear. This is easiest on sandy soils.

- **Know your 'enemy'**: Be familiar with the symptoms of downy mildew and the conditions that favour infection and the spread of the disease. Be alert to primary infection events (the 'triggers' of disease) and ensure you take the best action to prevent or kill the disease as it begins. This will prevent the likelihood of explosive secondary infections that risk causing crop loss. Do this by:
    - **Monitoring your vines**:
    - do this yourself or employ a specialist in the field;
    - regularly check for vine growth and for occurrence of disease symptoms;
    - **Monitoring vineyard weather**:
    - For future events: be attentive to local weather forecasts; For current events: use your own AWS (automatic weather station), or access one nearby, be it a neighbour's or a local industry networked AWS, or;
    - employ a specialist disease advisory service to daily monitor current and forecast weather data, assess risk of downy mildew infection events, determine expected dates for oilspots to appear and provide you with regular updates on disease management options.

Key elements within-season:

- Observe for budburst in each vineyard/variety block. Remember, any green tissue is susceptible to downy mildew
- Look at local weather forecasts and/or use disease advisory services, to monitor for incoming weather conducive to primary infection events and to advise of high risk weather events as and when they occur
- Spray at appropriate times when the risk of disease is high
- From budburst (E-L 5-7) till berries reach pea-size (E-L 31) (critical, high risk stage): be vigilant in inspecting vine and weather data and monitoring spray effectiveness
- From pea-size (E-L 31) till harvest (E-L 38) (cautionary, moderate risk stage): if there is little downy mildew infection present by this time, maintain careful inspection of vine and weather data and monitor spray effectiveness and withholding periods
- From harvest (E-L 38) till leaf fall (low risk phase): if no infection is present, maintain a watching brief of vine and weather data and of spray effectiveness as necessary.

Powdery mildew

Key issues identified in the GWRDC pest and disease survey

- **Characteristics of the season**: Season 2010–11 not only suited downy mildew, a wet weather disease, but it also suited powdery mildew, a dry weather disease. While powdery mildew does not normally require rainfall to spread and infect a vineyard it thrives better in overcast cloudy conditions with moderate temperatures and few periods of extreme temperature. It also likes long periods of high relative humidity. These conditions occurred frequently in 2010–11.

- **Prelude to pressure**: In contrast to downy mildew which in frequent wet conditions, builds up with speed, powdery mildew progresses slowly, steadily increasing disease pressure. Its highest infection rate occurs at RH 65–85% and the frequency of these conditions last season greatly assisted its growth within unsprayed canopies.

- **Comparing recent seasons**: To illustrate this point, Dr Bob Emmett, Vic DPI, Mildura, collected season data from Sunraysia (Table 2, page 8). They reflect in general terms, the conditions that occurred across south-eastern Australia, especially the differences in season 2010–11. It was cooler and had many fewer days >35°C and rainfall total was extreme. In the Riverland, there was rain every four days compared to the usual every nine days in an 'average' growing season. That fact that powdery mildew levels were scored high in 2010–11 tells of the favourable conditions for the disease.

- **Canopy growth**: Not only were the conditions in 2010–11 more favourable for powdery mildew but there was an abundance of new and highly susceptible shoot growth which continued longer and matured more slowly in the moderate temperatures. In addition, the denser and more shaded canopies in most vineyards and the resultant less exposure to ultraviolet light which inhibits powdery, added to the impact of the higher the humidity. Powdery mildew thrived.

Powdery mildew will develop on unsprayed bunches especially inside shaded canopies. Note the grey-white fungal growth on the stems even though the berries are mostly free of disease. This suggests that controls were good until late in the season, after the berries but not the bunch stalks, had developed some resistance to the disease. (Photo Andrew Weeks, CCW.)

- **Overwintering inoculums**: Powdery mildew has two sources of overwintering inoculum (spores). The first and most frequent is diseased buds which were infected in a preceding season. These buds led to the development of shoots 'diseased from birth' (flagshoots). In unprotected vineyards, powdery mildew spreads from the expanding diseased tissue (leaves and stems) on the flagshoots to infect adjacent healthy new growth. In favourable conditions as occurred in 2010–11, the disease cycled once every 5–7–10 days with each spore stem (conidiophore) producing a new spore every day. In this way, the disease increases unhindered, little by little, slowly, steadily, surely.

The second overwintering source for powdery mildew is a resistant spore called cleistothecia. These are formed late in the previous season and are dislodged from the leaves and foliage to be caught up in the bark of the cordons and trunk of vines. The cleistothecia release another spore called an ascospore when there is a little rain (≥2.5mm) above 10°C (see Powdery mildew Q11). While a few cleistothecia may have survived until budburst 2010, during the wet conditions that prevailed in August 2010 in most regions, in the absence of green shoot tissue, the majority would have discharged and fallen to the ground, adding little or nothing to the inoculum from bud-infection. (A similar event is likely to be occurring in late winter 2011.)

- **Number of sprays**: During 2010–11, because of the increased disease pressure from powdery mildew, most growers applied quite a few more sprays than normal for that disease. A majority of growers (79%) applied 7–10 or more, sprays contrasting a 'normal' season in which a similar majority (75%) apply only 4–9 sprays. As previously reported, in 2010–11, a number of growers applied 13–16 sprays, often adding to their spray for powdery mildew a tank mix with products for downy mildew and bunch rots. One grower reported spraying for powdery mildew on 22 occasions. In this instance, the spray interval for powdery mildew products was probably reduced to fit in with the need to apply a pre-infection spray for downy when more rain was forecast. In a 'normal' season, with drier atmospheres, 15% of growers apply only 1–3 sprays, apparently successfully. (Note: It seems worthwhile to investigate how these growers can achieve success with so few sprays. They must be doing something right.)

- **First symptoms seen**: While the disease began spreading either at or just after budburst, some growers noted first signs of powdery mildew (on leaves), soon after, when shoots were 10cm (E-L 12). On the other hand, most only saw it first when berries were pea size (E-L 31) and then mostly on leaves and/or berries. Powdery mildew developed on all *V. vinifera* varieties though more disease was reported on Chardonnay than on other varieties and less was seen on Cabernet Sauvignon than other varieties. Of the recently planted varieties, Viognier and Tempranillo were often found highly diseased (see Powdery Mildew Q21).

- **Strategies**: Both in normal seasons and in season 2010–11, two main strategies are used in spraying for powdery mildew. In the so-called '2, 4, 6 week' strategy, regular spraying starts early season at the three to five-leaf stage (E-L 9 to 12) with aim to reduce initial and long-term inoculum loads and to focus disease control when spore loads are least, reducing the risk of fungicide resistance. In this approach, sprays are applied at 2, 4 and 6 weeks after budburst (or three before flowering), then others follow according to the results from monitoring the canopy of disease. Early-season sprays reduce the risk of bud infection and inhibit the build up in the severity of disease which leads to the development of cleistothecia. In the so-called 'calendar strategy' vines are sprayed on a rote calendar basis at regular intervals (e.g. every 10, 12 or 14 days) but often beginning relatively later in the season. This strategy aims to knock down inoculum loads in early-mid season and to control disease on the developing crop. In contrast to the 2, 4, 6 strategy, it lacks the strategic aim to reduce inoculum loads over the longer-term.

Severe levels of powdery mildew like this on leaves means that the disease has been progressing for some time. The best strategy is to apply control measures well before powdery develops to this level. The white spots are little clusters of disease that each are producing thousands of new spores each day. These spores are spread to nearby foliage in the wind. (**Photo: P.A. Magarey, MPP.)**

- **Success despite pressure**: Most surveyed growers achieved good to very good control of powdery mildew during 2010–11 having little or no crop loss from the disease. Most (91%) reported that in a normal season, powdery mildew was at worst, only seen at moderate pressure but in 2010–11, disease pressure was higher and most (71%), considered disease pressure was moderate to extreme. Even so, only 16% reported suffering losses of any consequence. Like for downy mildew, this was a significant achievement in 2010–11.

High levels of powdery mildew on berries. These were infected sometime soon after flowering. Favourable conditions during 2010–11 led to widespread disease in shaded, dense canopies that were not sprayed well from early-season. (**Photo: P.A. Magarey, MPP.)**

- **Fungicides used**: Most applications of fungicide for powdery mildew were intended in a protective approach, ie before infection was seen, many using the 2, 4, 6 strategy (see above). And, a large majority of growers (87%) used sulphur during the season. However, as we know, powdery mildew usually starts just after budburst (from flagshoot inoculum). Therefore, most sprays are applied to foliage in two disease categories 1) healthy and 2) diseased. So, when fungicides such as sulphur are applied, they serve as 1) a protectant on healthy foliage, and 2) perhaps unintended, as a 'curative' of existent infection on diseased foliage. Though a few growers (7%) were aware of the 'curative' capacity of sulphur, most apparently do not recognise that it has this action (see Powdery mildew Q16). Powdery mildew is a surface growing fungus, and sulphur, at good spray dose and with good spray coverage, is effective post-infection. There is possibility that better use of this knowledge may lead to improved spray strategies in some vineyards. Likewise, Ecocarb® (potassium bicarbonate) was used in a post-infection capacity by some (19%) growers and Mycloss® (myclobutanil) by a similar proportion (11%).

Even so, a wide range of products apart from sulphur were used at some time during 2010–11 as a protectant to control powdery mildew. Particularly Cabrio® (pyraclostrobin)[1], Prosper® (spiroxamine) and Topas® (penconazole)[2] but also Mycloss® (myclobutanil)[2], Folicur® (tebuconazole)[2] and Legend® (quinoxyfen). Most of these belong to the Strobilurin[1] and DMI[2] groups of fungicide and are susceptible to the development of resistance. Due care is needed in using the 'at risk' fungicides (see Powdery mildew Q18).

- **Fungicide supplies**: Most growers were able to obtain fungicides when required except sometimes sulphur and Cabrio® were limited. Despite this, most growers were satisfied with the performance of the fungicides they had and good control was achieved (see above).

- **Canopy management**: Many respondents, when finding difficulty in controlling powdery mildew, considered the reasons to include the variety of grape and maybe its higher level of powdery mildew infection last season, the restricted airflow of bigger canopies and the more dense canopies of some blocks. It was well acknowledged that dense canopies increased disease pressure (see above), reduced airflow and inhibited spray coverage. In consequence, many growers used canopy management practices to obtain/regain the control they needed. The growers used these practices to assist spray penetration and reduce disease incidence by adjusting foliage wires and trimming shoots or by skirting or hedging the canopy. A number of growers also adjusted spray application practice for larger canopies by reducing tractor speed and/or applying higher spray volumes. Together, a large majority (96%) of growers considered these actions were at least moderately effective. A significant number (62%), thought the actions were very effective.

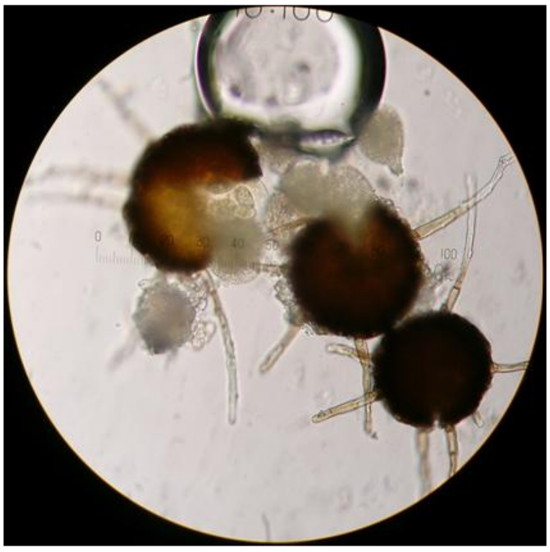
Questions and answers

[For additional Q&A on powdery mildew, refer to '*Powdery Mildew. Questions and Answers.* (GWRDC website) and see Further Reading, below:]

The disease begins in the vine

Q 1: I know that flagshoots come from diseased buds, but when were these buds infected?

- Diseased buds carry the powdery mildew inoculum in the form of fungal strands growing on the internal scales of a bud infected the previous season. In a spur-pruned vine, the buds that carry through on the spur are formed very early last season, at the base of the then fresh young, green shoot. The young buds were most susceptible to infection at that time but only remained so for 3–4 weeks. That means that if you protect the buds early in their life this season, you will reduce the overwintering inoculum and reduce the number of flagshoots for next season.



The second source of over-wintering powdery mildew is resistant spores called cleistothecia. They are seen here under low-powered microscopy. The orange-black spherical bodies are the cleistothecia which produce light coloured ascospores. In the vineyard, the ascospores are discharged and infect grapevine foliage near cordons and spurs. (Photo: PA Magarey, MPP.)

Q 2: I am concerned about cleistothecia, the fungal fruiting bodies, adding to disease levels in my vineyard. Can I kill them by spraying before they spread disease in my vines?

- No, cleistothecia once matured, are very resistant to sprays. Like oospores, their counterpart in downy mildew, no spray is effective in controlling them.

Q 3: I know they attach to the bark and hang on the cordons and trunk, but what about the millions that fall to the ground on leaf litter?

- No problems. The cleistothecia on the cordons have the highest risk of causing infection. There are at least three reasons for this. First, most of the cleistothecia that fall to the ground are biologically consumed and decayed by the dynamic of active microbes in the soil. Second, if some cleistothecia on the ground do survive, they will discharge their ascospores whenever adequate moisture and temperature prevail. This is likely to occur more often in that environment than for those cleistothecia on the vine trunk and cordon and importantly it will often be before budburst and so, before there was any susceptible tissue in the canopy. Third, any ascospores released during the growing season will need to travel 1–1.5metres to reach the foliage, much further than ascospores discharged from cleistothecia on the bark. The risk of these relatively heavy spores travelling more than 20 cm to reaching the foliage is low.

Q 4: You mentioned that in some seasons, cleistothecia discharge before budburst. I have never seen a flagshoot in my region, so how does the powdery mildew begin in my vineyard? [see also Q10 in Q&A Powdery mildew, Dec 2010 on GWRDC website.]

- Good question. Some people are convinced that there are no flagshoots in their area. This may be the case but, globally, infected buds are only killed by extreme cold e.g. in North America and as experienced only sometimes in Europe, where temperatures drop at least below -7°C. Most Australian regions do not approach this level of freeze necessary to kill infected buds. So, it is most likely that you will have infected buds in your vineyard. Here's a challenge: Cleistothecia were only first found in Australia (by Dr Trevor Wicks, SARDI) in 1984. All evidence pointed to them being the result of a recent introduction of a second mating type of the powdery mildew fungus needed for the cleistothecia to form. If your region had powdery mildew prior to then, it must have had infected buds and flagshoots.

  So, maybe you have never seen the flagshoots but they are not easy to find, especially if you are spraying to control the disease! Why not have a close look this season? If you can access an unsprayed canopy about 6–8 weeks after budburst, this will help. Look for scattered groups of powdery mildew affected shoots with disease on the leaves, then use these as a guide to search in detail for a highly diseased shoot, a flagshoot, somewhere within that diseased zone. Look for upward curled, powdery affected leaves with the typical ash-grey spore growth on the stems of shoots. Keep looking till you find them; they will be there!

Fungicides for powdery

Q 5: If, coming up to harvest, I have moderate levels of powdery, is there any fungicide that will knock the powdery mildew out?

- No, not completely but there are several products that are quite effective. Surface acting fungicides like sulphur and several oil-based sprays have shown value in reducing powdery mildew on the foliage. Positive reports during 2010–11 affirmed the value of full-rates of sulphur. Similarly good reports followed trial work and field use of several oil-based products like Biopest Paraffinic Oil® which has recently been included in the AWRI's Dog Book (see Further Reading).

  Some users also found EcoCarb® (potassium bicarbonate) helpful as a knockdown (but not knockout!) near harvest. All these products need good spray coverage to be effective.

Q 6: Do the knockdowns include the so-called disinfectants?

- Peratec®, a per-oxy product was reported by some growers to work as a knockdown against powdery mildew (note: it is not registered for this purpose) but like EcoCarb®, it is short lived (4–5hours) and washes off the foliage easily. Products like Sulphur and Biopest Paraffinic Oil® stick better. All these products (see Powdery mildew Q5 above) disrupt the surface of the fungal strands and kill the pathogen in contrast with the DMIs and the strobilurins which, with translaminar activity, kill the fungus from the inside out.

It is a difficult time to control powdery mildew at or near harvest. Recent trials with 'knock-down' fungicides like food grade oils or high rates of sulphur have worked well. The leaf with the red tag was not treated; it shows high levels of powdery mildew in contrast to the foliage sprayed with Biopest Oil®. Excellent spray coverage is essential for the powdery mildew 'contact' fungicides to be effective. **(Photo: PA Magarey, MPP.)**

Q 7: If a DMI were applied to young growth, would it go into the bud and kill infection?

- Another good question, but the answer is 'No', at least not in enough concentration to kill the infection. However, several years ago, some trial work assessed a combination of products with partial systemic activity. The trials showed encouraging success with potential for use. Wouldn't it be good if this work were continued? An early-season spray that killed the powdery mildew inside buds would have potential to 1) reduce the number of flagshoots; and 2) restrict the number of diseased buds for next season. If effective, this could reduce/remove the need to spray canopies in long schedules comprising 7–10–14 applications/season!

Q 8: The emphasis in strategic spray programs is to reduce the number of buds that are infected in early-season, but are buds also infected after harvest?

- Yes. Any newly exposed bud, whenever it grows, is susceptible to infection for up to 3–4 weeks. So, if the shoots in your canopy put on new leaf growth after harvest, the buds at the base of the new petioles (the leaf stems) will be at risk of infection. Because the vines are often more or less neglected after harvest, this is a time when powdery mildew gets least attention so the disease often spreads unnoticed. The result, newly formed buds may be diseased (but see Powdery mildew Q9 below).

Q 9: So, are post-harvest sprays needed to control bud infection?

- A question to ask first is, 'Will the newly formed buds (see Powdery mildew Q8 above) be removed during pruning?' If 'Yes', then there is no risk from these buds. If 'No', then you will need to protect these buds by a post-harvest spray **before** they are infected. Note: Any buds older than 3–4 weeks will be resistant to infection so that no amount of spraying will change the condition of these buds.

Q 10: Are post-harvest sprays then also needed to control cleistothecia? [see also Q16 in Q&A Powdery mildew Dec 2010 on the GWRDC website.]

- Only in some situations. If control of powdery has been excellent, there should be no need to spray again post-harvest (depending on the timing of leaf fall) because there will be no disease to spread. To achieve this, follow the ***Three Ts*** closely (see section 5.1.1 in this document on Downy mildew.). If on the other hand, control has been poor, there will already be an abundance of powdery by harvest and, as a result, many cleistothecia. The risk of new cleistothecia forming post-harvest arises only if powdery is at low incidence at harvest and if the disease can increase in severity sufficiently to produce the fruiting bodies. If so, a spray post-harvest is worth considering. Aim to prevent a low disease incidence increasing to high severity (see also Powdery mildew Q9 above).

Q 11: Suppose that cleistothecia have already developed on my vines late season, what can I do?

- Remember: 1) that no spray will kill any existing cleistothecia (see Powdery mildew Q2 above); 2) late winter rains with temperatures ≥10°C deplete most of the reserves of cleistothecia (see Overwintering inoculum page 17) and so nullify their potential to trigger disease; and 3) early-season sprays are needed for best control of bud-infection. So, if cleistothecia discharge ascospores in early season (see section 5.2.1 on Overwintering inoculum), the 2, 4, 6 spray strategy will likely take care of this inoculum. It is only when a dry winter is followed by a dry spring that vines are at significant risk from ascospore inoculum and then only after rainfall. Your monitoring of the conditions will alert you to the need to spray at this time.

Cleistothecia of powdery mildew on a grapevine leaf, showing the young (yellow), maturing (brown) and mature (black) fruiting bodies of the fungus. Once the fungus has reached this stage, no amount of spraying will kill these resistant spores. Effective control of cleistothecia starts by preventing an increase in disease severity on the foliage in early- mid-season. **(Photo: P.A. Magarey, MPP.)**

Q 12: I am told powdery mildew is hydrophobic. What does that mean?

- 'Hydro' water; 'phobic' repelling. The powdery mildew fungus on the foliage can grow in a dense mass that is hydrophobic, that is, it repels water and is hard to wet. This is one of the reasons that powdery is hard to control because existing infection requires high spray volumes to flood the surface of the foliage with sufficient fungicide.

Q 13: Does the quality of sulphur products make a difference in controlling powdery?

- It used to more so than now. Most recent formulations work well having a uniform particle size well formulated for effective activity. Previously, some crudely formulated products had quite variable particle size with some big and some very fine particles. These greatly reduced the activity of the product and caused problems in their use.

Q 14: My father used lime sulphur for powdery. Are the wettable sulphur formulations any better?

- In former days, there was only one form: dusting sulphur. It worked well but washed off easily. Because dusting coverage was often poor, its action was mostly through vapour activity. Next came lime sulphur; the lime made it the sulphur stick. But, while lime sulphur works brilliantly, it smells, costs a lot, was phytotoxic and had negative impact on predators. Then came wettable sulphur also with the capacity to stick well but it was cheaper. So, use lime sulphur if you wish but wettable sulphur at high rates (600gm/100L) with water volume matched to the canopy size does an excellent job at lower cost.

Q 15: I don't like using sulphur in cooler conditions.

- Why not? Sulphur is often blamed for not working in cool climates or at temperatures below 15–17°C. This is because at these temperatures, its volatile action is restricted **but** the direct contact action is not affected. If you are not getting good control with high rates of wettable sulphur in cooler conditions, this is a significant wakeup call that you probably have less than the best spray coverage. It is time to look closely at calibrating your sprayer and comparing spray volume with the size of your canopy.

Q 16: Well then, just how effective is sulphur in controlling powdery mildew?

- It is as good as the best! If it is sprayed at the right dose, with the right coverage, it works very well as both a protectant **and** a 'curative' (see Powdery mildew 'Fungicides used'). In trials with sulphur, a single spray of 600gm/100L, to fully opened leaves (no longer expanding) covered in a dense layer of powdery mildew fungus that gave off a strong musty smell in the vineyard, a single spray of sulphur stopped the powdery mildew in its tracks for 50 days. You got it, for 50 days, and that was with a rain fall of 10mm about 10 days after spraying. Get the ***Three Ts*** in order and sulphur works well.

Q 17: What of the newer types of fungicide, like the DMIs and strobilurins?

- These work well too and, having 'translaminar' action, they move inside the sprayed tissue killing off the fungal feeding structures called haustoria. These structures are like oil wells, allowing the fungus to feed on the cell's sap contents. *Trans laminar* means '*across leaf*' referring to the fungicide spread across but not beyond the leaf. This compensates a little if spray coverage is poor. However, as the cell contents increase, the cell expands, blowing up like a balloon diluting the concentration of fungicide within each cell. As a result, the fungicide becomes less active.

  Both the DMIs and the strobilurins attack a specific part of fungal metabolism and are susceptible to resistance developing within the powdery mildew fungus.

Q 18: I've heard that there is resistance showing up to the DMIs and 'strobis'.

- Yes, in nearly every other country resistance has developed to these products. Australia has done well to have effective control from these for so long, thanks to so many users following the Anti-resistance Management Strategies, alternating sprays with different chemistry. However, one trial location in the Adelaide Hills has recently shown resistance to Cabrio®, a 'strobi', but at this site, the strobilurins were sprayed excessively (beyond recommended anti-resistance strategies) during developmental tests (Dr Trevor Wicks, SARDI, Adelaide, SA, *unpublished data*). There is also likely to be some resistance to the DMIs (seen as reduced efficacy) in regions where these products have been sprayed frequently. To the contrary, there has been no record of any resistance to sulphur which has been used overseas for more than 150 years and in Australia since the 1860s.

Q 19: What then is the advantage of using a strobi like Cabrio®?

- Sulphur costs about $28–30/ha while at around $45–50/ha, the strobis are more expensive but the advantage of Cabrio® is that it provides long lasting effective protective action against both powdery and downy mildew. Being translaminar, it is absorbed and distributed within the sprayed cells while sulphur is a contact fungicide and, though it controls mites, it does nothing to downy mildew. Cabrio® showed its excellence during the succession of downy mildew infection periods late season 2010–11.

Q 20: What about the usefulness of softer products such as milk and whey?

- These may have a place in vineyards registered for 'organic' production but they are about 40% as effective as sulphur and need more frequent spraying than the other mainstream products for powdery mildew. Further refinement of their active component may prove of value for future use of the milk-based products.

Q 21: Many people I know first saw powdery mildew when berries were pea-size (E-L 31) and then, only on bunches. Why was that?

- In a sprayed canopy, powdery mildew develops slowly. Its symptoms on the foliage are masked by the control achieved. Symptoms will be hard to see on mature, sprayed leaves since the spots, if present, will be small and few will produce spores. It is the sporulation (spore production) that helps the eye to detect the presence of powdery mildew. In contrast, it is harder to maintain effective spray coverage on the rapidly expanding young berries inside the shaded canopy where conditions are more suited for sporulation, and protected from sprays. As a result, powdery mildew is often first seen on the young berries even though the disease began on the leaves!

Q 22: Are berries after pea size resistant to powdery mildew? I ask because I have seen bigger berries get infected?

- Indeed, you will see berries bigger than pea-size covered in the ash-grey white spores of powdery mildew. But, these were infected **before** the berries reached the critical size for new infections.

Q 23: When is the best time to control powdery mildew in my vineyard?

- If you are aiming for the best long-term control of disease, it is best to apply sprays as soon as possible after budburst. Spores to infect the fruit come from a build up of the disease on the foliage, and spores to infect the foliage come from the release of spores from overwintering inoculum and, these are released early season. So, control the overwintering inoculum and you stop (or greatly reduce) the infection of the foliage. Stop foliage infection and you will stop (or greatly reduce) infection of the fruit. It is a very simple strategy, harder to achieve than it is to say, but it is none-the-less achievable for sustainable long-term control of what is currently, Australia's worst foliage disease of grapes. Start early, work effectively and in a few year's time, we will reduce the losses caused by powdery mildew and we can reduce the number of sprays needed to achieve that outcome.

  It's as simple as *'2,4,6 ...'* ... begin spraying at 2, 4 and 6 weeks after budburst or three sprays before flowering in cooler districts, and you are off to a good start.

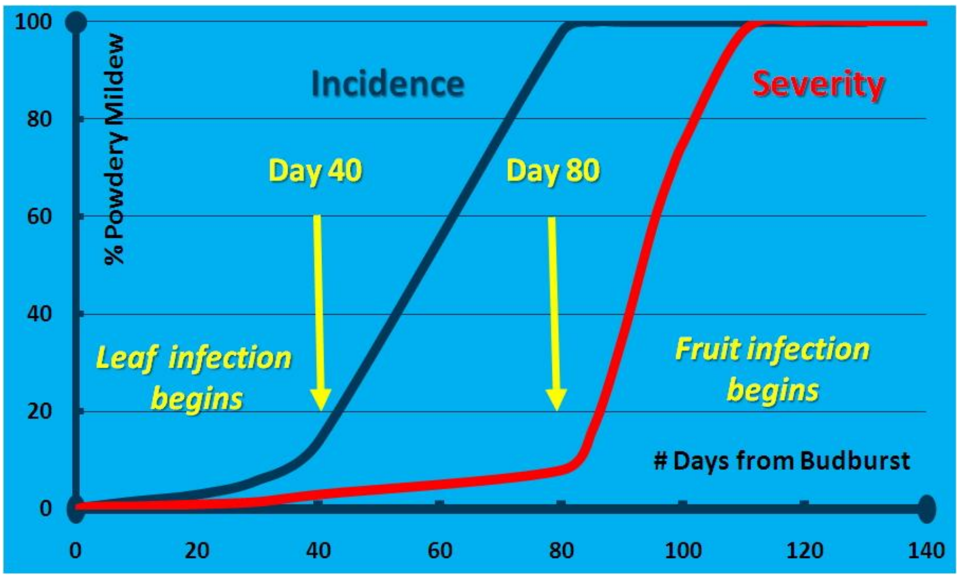
Best practice approach to managing Powdery mildew

Key elements pre-season:

- **Fungicides**: As for downy mildew, check your access to this season's supply of fungicide for powdery mildew.
- **Calibrate vineyard spray equipment**: Effective spray coverage is even more critical for powdery mildew control than downy mildew. Ensure best possible spray coverage with least loss from off-target residues by checking spray pump outputs and spray head/nozzle configurations. This is especially relevant for early season sprays.
- **Spray strategy**: Choose the ground you want to fight for. Decide if you want to spray many times each season for powdery mildew. If not, take the first opportunity this season to attack powdery mildew in your vineyard. This gives you the best chance to reduce inoculum loads with fewest sprays so that you can 'do it better' next season.
- **Not your neighbour**: Remember that you inherit the inoculum you allowed to develop in your vineyard last season. Infected buds that develop flag shoots early this season were diseased early last season(s). Cleistothecia developed where you allowed disease severity to increase on the foliage mid to late last season. You bred your own inoculum. So, the good news is that you have the responsibility for your own inoculum, it's not your neighbour's fault. As a result, the blessing is that you have opportunity to control powdery well, no matter what your neighbour does. This is because the powdery mildew spores don't travel more than 60–80 metres from an unsprayed vineyard in the first 80 days. Choose your spraying strategy to ensure your own success!
- **Know your 'enemy'**: Be familiar with powdery mildew symptoms and the conditions that favour infection and spread. Powdery mildew is a 'dry' weather disease that begins early season and spreads slowly. It increases insidiously, surprising many by its apparent sudden appearance early in the new calendar year – but it has been developing since bud burst.

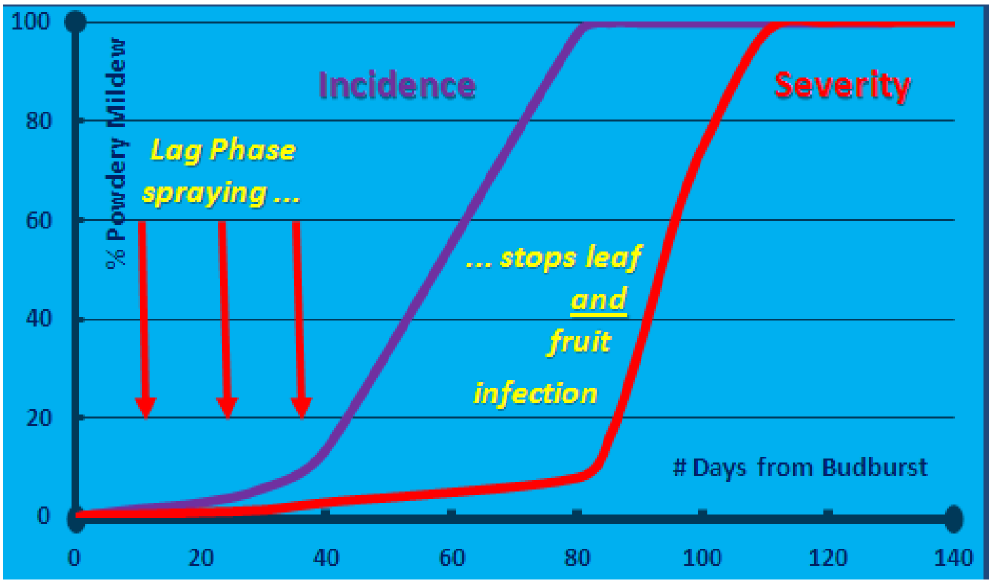
  It is a disease of shaded canopies with poor penetration of light (UV kills powdery mildew), poor air flow (double the number of spores are produced at high humidity) and inefficient spray coverage (it is difficult to adequately spray the foliage inside dense canopies).
- **Build on the 'epi-season' concept**: Since the epidemic season of the powdery mildew fungus develops over two growing seasons, apply fungicides early this season both to control the disease this season <u>and</u> reduce carry-over inoculum (infected buds and cleistothecia) for the next. Reducing inoculum loads means fewer sprays are necessary for successful control next season.

  Control the disease early season on the foliage for more successful control of the disease on fruit.



Key elements within-season:

- Begin spraying soon after budburst, as soon as shoots are big enough to spray economically with your sprayer
- Spray at least three times in the '*lag phase*' of disease development – that is, within the first 40 days from budburst. This is before spore numbers begin to increase dramatically (in the '*log phase*' of disease severity), 80 days from budburst
- If spraying with sulphur, use 600g/100L as your standard rate
- Look for early signs of disease. Do this by monitoring your vines. If needed, employ a crop monitoring specialist. Regularly check for new vine growth and for disease symptoms. Keep spraying accordingly
- Spray thoroughly according to the rate of new vine growth and to disease risk. Alternate with a selection of fungicides with different chemistry, unless spraying with sulphur
- Use canopy management when required to improve spray penetration, increase air flow and reduce shading
- If it is cold (maxima less than 20°C), the foliage is not growing quickly but neither is the fungus. Powdery will grow slowly but remain low in spore numbers. This is a good time to drive home your advantage! Use your sprays to apply good coverage of susceptible green tissue and reduce the disease before it multiplies rapidly. If you wait for warmer weather and for the shoots to expand, you risk the fungus needlessly getting the upper hand
- From budburst (E-L stage 5–7) untill pre-flowering (E-L stage 12–15) (critical, high risk stage): be vigilant; inspect vines and monitor spray effectiveness to eradicate/prevent disease increase on the foliage
- From pre-flowering (E-L stage 12–15) till berries pea-size (E-L stage 31) (high risk stage): monitor closely and spray if necessary to protect the fruit as it forms and expands
- From berries peas-size (E-L stage 31) to veraison (E-L stage 35) (cautionary, moderate risk stage): continue monitoring closely, spray if needed to ensure spore loads are low prior to pre-harvest withholding periods begin
- Post-harvest (low risk phase): check inoculum loads till 3–4 weeks prior to leaf fall. If little or no infection is present, maintain a watching brief and spray only to prevent first generations of cleistothecia from developing. No need to spray within one month of leaf fall.



Botrytis and other bunch rots

Key issues identified in the GWRDC pest and disease survey

- **A very difficult season**: Bunch rots (mostly Botrytis) developed destructively in many vineyards during the favourable wet conditions of season 2010–11. There were numerous lengthy periods of high relative humidity, canopy wetness and warm temperature without the usual hot dry conditions interspersed. This led to high disease pressure from an array of bunch rot organisms. The most recent season with similar widespread wet conditions was 1992–93 but in contrast, in 2010–11, the wet conditions continued through harvest with significant effect on the ripened fruit. The result was that many growers had not experienced these conditions in their working lifetimes.

- **In a normal year**: Unsurprisingly, most (74%) of the growers surveyed indicated that the bunch rots are at very low pressure normally. Consequently, although some growers (30%) usually do not spray for the disease at all, most respondents (59%) apply several, between 1–3 sprays.

- **Spraying in season 2010–11**: As expected, this changed in season 2010–11. Most growers (64%) rated the pressure from bunch as rot high or extreme. In response, 45% of respondents applied at least 1–3 sprays; 38% applied 4–6, and a few (7%), applied more.

- **Spray targets**: Most growers targeted their sprays for bunch rot at 80% capfall, at pre-bunch closure and at pre-harvest, though numerous other bunch rot sprays were targeted across the growing season. Most (81%) growers used their own assessments of the weather to determine the timing of these sprays though 43% accessed at least some data from an AWS. Some 65% of growers first saw symptoms of bunch rots after veraison and before harvest. For one quarter (25%) of respondents, this was when Baume levels were ≤ 10°; for 55%, bunch rots were first seen when fruit maturity reached 11–12° Baume**.**

Botrytis bunch rot developed in a cluster of berries. Infection of a single berry in the centre, perhaps at flowering, probably triggered invasion of Botrytis into adjacent berries. This clustered infection is often hidden inside the bunch and may go unnoticed for some time. It is usually then too late to control the spreading rot. (Photo: A. Weeks, CCW.)

- **Fungicides used.** The frequency with which particular fungicide products were applied for bunch rots was aligned with their withholding periods. This reflected the growers’ increasing demand for a permitted fungicide as the bunch rots increased in pressure during the season. For instance, Scala® (pyrimethanil), used by 29% of respondents, is permitted for use no later than 80% capfall and Switch® (cyprodinil + fludioxonil), used by 36% of respondents, is permitted to 60 days prior to harvest. Captan®, used by 48% of respondents, is permitted to within 30 days of harvest while the protectant Rovral® (iprodione), was the most frequently used product applied by 70% of respondents. It is permitted right up to 7 days before harvest.

- **Reported effectiveness**: Despite its high level of use, Rovral® was considered ineffective by nearly a quarter (26%) of the respondents. Similarly, Captan® was thought ineffective by 18% of respondents. However, as with the mildews and especially with the bunch rots, there is a huge dynamic of non-chemical factors that determine the control level achieved. An additional issue for Rovral® is that being used close to harvest, it was likely often applied as a last ditch measure when the bunch rots were at a high level of severity and when fungicide control was nearly impossible.

- **Fungicide supplies**: In signalling success in spraying for control of the bunch rots, most respondents (79%) did not consider they were troubled by any lack in the supply of the fungicides. To the contrary, 21% of respondents indicated they were significantly hindered in not being able to access the products of their choice while attempting to control the bunch rots. Of these, some respondents (10%) indicated that they were not able to source Rovral® at critical times.

- **Avalanche of inoculum**: The extreme conditions with long periods of canopy wetness late in the season coincided with the ripening of berries. The fruit become more susceptible to the bunch rots at that time and this posed significant problems. Many growers had difficulty in controlling the diseases despite the extra sprays they had applied because of the extreme disease pressure at this time. In most vineyards, the conditions favoured a rapid build up in spore numbers and a veritable avalanche of inoculum cascaded on to the surviving healthy berries in the closed and shaded canopies.

- **When fungicide sprays were failing**: At this critical time pre-harvest when levels of bunch rot were increasing, an assortment of disease control practices were deployed in attempts to protect the maturing crop. A majority (68%) of growers tackled the dense canopies by opening them up for improved airflow and spray penetration. They did this by skirting or hedging their vines, while 43% also thinned and 14% trained their shoots. Additionally, 27% adjusted foliage wires and 24% removed bunches to achieve the same outcome. A large number (~45%) also opted to slow sprayer ground speed and to increase water rates, to increase spray coverage, while 8% opted to make two passes with their sprayer.

- **Was control achieved?**: The attempt to control bunch rot was achieved through management practices that reduced canopy humidity, opened airflow and exposed the inner foliage to better spray penetration. At the end of the season, about half the surveyed respondents (53%) considered the losses from bunch rots moderate or higher while the remainder (47%) judged that the losses in their vineyard were of lesser consequence. In considering the role of the spray program in achieving this control, a large majority (73%) considered fungicide applications to be at least a useful contributor while 12% considered spraying fungicides was a significant positive factor in attaining the control achieved. These sprays were assisted by the various methods used to open up the canopy. A majority of growers (82%) considered manipulation of the canopy was a successful ploy.

- **Differences between varieties**: Variations in the severity of bunch rot were attributed to a number of different factors. Among these, 62% of respondents considered the variety Cabernet Sauvignon to be least susceptible to bunch rots while 66% considered Shiraz and 58% considered Chardonnay the most susceptible varieties. No other varieties were especially noted as either ‘resistant’ or ‘susceptible’.

- **Differences between blocks**: In the survey, differences were noted in the level of control achieved in different vineyard blocks. These were attributed to a number of factors that varied in relevance in different vineyards. They included the exposure of bunches and the airflow around them, canopy size and vineyard aspect.

- **Differences in harvest dates**: An additional and at times, critical factor, was the time of harvest for the different varieties. For example, this was a significant factor in many blocks in the Riverland when mature, initially sound fruit was left on the vine for too long. At times, this fruit was held over while attempts were made to harvest infected fruit from elsewhere in the region. Rain and continued favourable conditions for the bunch rot organisms sometimes led to a rapid decline in the health of some of this fruit which then exceeded the winery's threshold of acceptance and was rejected at harvest by that winery. This issue was not a problem in some other regions where small wineries found greater flexibility to vary dates of harvest for individual vineyard blocks at risk.

- **Delayed ripening**: A related critical issue was a consequence of the cooler season and the significant delays this caused in the maturing of the fruit. Often, growers were obliged to cease spraying through the operation of withholding periods in the expectation that harvest dates would be 'normal'. The cool cloudy conditions that prevailed across south-eastern Australia in 2010–11 resulted at times, in significant delays in the ripening and consequently, the harvest date of the fruit. During this time, the late season rains in some vineyards induced successive infection periods and the build up of massive inoculum loads (see earlier) which induced an avalanche of bunch rot in fruit which, by then, was able to be sprayed with only a very limited array of fungicides active against the bunch rots. This led to significant amounts of bunch rot and crop loss in some vineyards.

Questions and answers

[For additional Q&A on bunch rots, refer to 'Botyrtis *Bunch Rots and Non-Botrytis Bunch Rots Questions and Answers. December 2010 (*GWRDC website)

The organisms that cause bunch rots

Q 1: You have talked about bunch rots, but what are they?

- Most are fungi. The most important one is Botrytis (Grey Mould), but others include rhizopus rot, black mould (*Aspergillus*), ripe rot (*Colletotrichum*), bitter rot (*Greeneria*) and blue mould (*Penicillium)*. There are many others including the 'wood diseases' Botryosphaeria and Phomopsis rots. Ripe rot and bitter rot are rarely seen outside the warm, sub-tropical regions like the Hunter where conditions favour these organisms. Other micro-organisms like yeasts also invade and rot fruit. These are quite common and cause sour rot with its distinctive yeast (vinegar) smell.

Q 2: Why are bunch rots so severe in a wet season?

- Since most are caused by fungi (see Bunch rots Q1 above), they grow best in warm moist conditions. Season 2010–11 brought many periods almost perfect for the development of the bunch rots and in the good conditions, vine growth was more vigorous and bunches were tighter – all leading to more favourable conditions for bunch rots. Frequent heavy rains saturated the soil and soaked the canopy and foliage. Often followed by warm, misty weather with little wind, periods of 24, 36, or 48 hours of ideal conditions induced fungi to infect, sporulate (produce spores) and spread. New ripening berries were rapidly infected and bunches rotted. All this, near harvest, led to destructive crop loss.

Q 3: How does *Botrytis* get into the berries and cause disease?

- The three major foliage diseases of grapevines were thought to be caused by fungi [downy mildew is now considered caused by algae]. Despite these similarities, each invades grape tissue by a different method. For instance, downy mildew invades through the stomata, the breathing pores, which are only on the undersides of green tissue such as the leaves. It then invades nearby cells as it grows inside the plant, and its spores to spread disease are formed only through these same natural openings. In contrast, powdery mildew is a 'stronger' pathogen since, to draw its nutrients from the foliage, it actively 'bores' holes in either the upper or the lower surfaces of leaves - like an oil well draws oil from the ground beneath.

It then produces a network of pipes, the fungal mycelia, on the surface of green foliage. The mildews are diseases of healthy tissue. To the contrary, Botrytis and most other bunch rotting fungi are 'weaker' pathogens invading tissue and producing spores, only through an existing open wound. They are diseases of damaged/necrotic tissue.

Bunch rots are caused by a range of fungi and micro-organisms, though the fungus, Botrytis is the best known. The buff-grey coloured spores on the berry in the centre of this bunch are typical of Botrytis infection. (Photo: PA Magarey, MPP.)

Q 4: I've heard it said that downy and powdery mildew are 'green diseases'. Then, what colour disease are the bunch rots?

- Downy and powdery mildew, known euphemistically as green diseases, only invade and live in green (living) tissue. Quite the reverse, Botrytis and the other bunch rots live on dying and dead (necrotic) tissue and enter through wounds on the grapevine tissue. Since this damaged tissue is usually brown, the bunch rots can be called 'brown' diseases.

Q 5: Downy mildew has specific conditions that favour its spread. Does this apply to the bunch rots?

- Yes, but less so. The conditions needed for bunch rots are much less specific. Take Botrytis for instance. This fungus needs humidity to sporulate and free water to infect, just like downy mildew, but it can progress in a much wider temperature zone than downy mildew. Botrytis is a cool weather disease which can grow at temperatures near zero – like in your refrigerator – but it grows best at around 15–20°C whereas downy mildew grows best at 20–25°C. Although secondary infection of downy mildew can occur quickly, requiring wet conditions for 6–8 hours, Botrytis requires wetness for up to 15–20 hours. Despite this, there was no shortage of sufficiently long periods of wetness at adequate temperature for Botrytis and the other bunch rots to wreak havoc in 2010–11.

Q 6: Some reports last season indicated a predominance of the Botrytis grey mould compared to the other bunch rots. Was this correct?

- Yes. Grey mould (Botrytis) grows better in cooler conditions (see Bunch rots Q3 above). Season 2010–11 was unusually cloudy and cool with less than average solar radiation and fewer days over 35°C (Table 2, page 8). The cooler temperatures probably accounted in part, for the higher level of grey mould with lesser amounts of the other bunch rots seen in some areas.

In many regions during 2010–11, Botrytis, as seen here on a red variety, was the most frequently seen of the bunch rotting organisms because of the cooler conditions that prevailed.

In average seasons in most inland regions of Australian viticulture, there is little need to control Botrytis or the other bunch rots. To the contrary, the bunch rots are a major problem in the cooler and wetter coastal regions. (Photo: PA Magarey, MPP.)

Q 7: Season 2010–11 was torrid. There seemed to be disease everywhere; on leaves, bunches, shoots and sometimes even the tendrils!

- The season began with downy mildew. In some locations such as the Riverland, downy mildew began just after budburst before progressing rapidly and, where uncontrolled, killing all bunches by mid- to late-November. Then powdery mildew came to the fore. Having progressed steadily since budburst, disease levels increased dramatically causing severe loss, in some regions by early December. Finally the bunch rots caused their devastation. Having thrived on the rains and high humidity both as the berries began to ripen and during the harvest period, they caused drastic disruption to the progress and economy of the season's gleanings. Add to this the costs and trauma of having to spray so many times and frustratingly, on occasions in vain. Three avalanches of destructive disease in devastating succession. Any profits during 2010–11 were annihilated in all but a few vineyards. For a grower to hold one's own this season was a credit to their determined fight against Australian viticulture's worst three foliage diseases spreading at almost full capacity in the most favourable conditions seen in the previous 38 years.

Q 8: It seemed that no matter what I sprayed, the bunch rots continued to spread. What was happening?

- Bunch rots are not controlled by chemicals alone. Many factors determine the level of increase in the disease potential for bunch rots. In 2010–11, these included the more dense and shaded canopies, with increased humidity and canopy wetness. The increased shoot length and mild weather meant foliage growth remained softer and more susceptible for longer. The presence of low levels of powdery mildew that developed before effective controls 'kicked in' meant that there may have been diffuse infection, that is, many microscopical infection sites on berries (though the fungus remains unseen to the naked eye). These wound sites were opportune for the bunch rot fungi to enter. Also, the increased occurrence of LBAM (light brown apple moth) in some vineyards and other agents that caused wound sites, all added to increased bunch rot damage potential. With these extremes also aided by conditions very favourable for fungal growth, the avalanche of bunch rot spores that followed superseded the capacity of some spray programs to achieve successful control of the bunch rots. It was likely neither your fault, nor that of your sprayer, if you failed to control the bunch rots in the extremes of last season. The influence of these vineyard factors, not influenced by chemicals, swamped the disease management undertaken through spraying.

Q 9: So what could I have done differently?

- Probably nothing. In most regions of south-eastern Australia, the varietal mix, the vineyard aspect, row orientation, the vineyard ground cover and floor management, the canopy design, pruning system, bunch configuration and the like are pre-determined or nearly so, before the season begins. Along with management of wounding agents like LBAM and powdery mildew, these all contribute significantly to the potential for bunch rots to occur at an economic level or above. Unlike the warm wet regions, growers in most regions are not well equipped to successfully control the bunch rot diseases because of the factors that pre-dispose the system to high levels of infection. The single main controlling factor apart from these is the weather and vineyard microclimate over which we have little control. With no dry period to break the sporulation process, this was in effect, a heavy artillery assault on bunches. A warm wet season threw the balance much in favour of the bunch rots and, in many vineyards in 2010–11, they won.

Q 10: But bunch rots in my crop seemed under control right up to the late rains. These events were 'killers'.

- Sure were. Under these circumstances, one additional management factor might have made a difference – this was harvest date. In many smaller regions, the extra flexibility of small wineries to adjust the time of harvest, gave the critical extra control needed for success in the bunch rot system. In the high volume wineries, it takes a great deal more flexibility, logistical control, and wine storage space to accommodate the varied demands for the host of vine blocks to be picked in a timely manner in relation to the progressing bunch rots. Many a crop went 'down the gurgler' while the owners watched and waited for the harvest which, at times, never came.

Q 11: When are berries infected by Botrytis?

- There are two periods of high risk but berries are susceptible at almost any time if the conditions are very favourable. The first high risk period is at and near flowering, particularly when the caps fall off. The fallen caps and the flowering process leave susceptible wound sites (the vascular bundles and flower parts) exposed to infection. A protectant spray applied early flowering will lose effective coverage when the sprayed caps fall. This exposes very susceptible, unsprayed flower parts to infection. The second period of high susceptibility begins as the berries begin to ripen. Many chemical changes occur in the developing berry, including the 'sugaring up' process. This leads to tissue being more susceptible to Botrytis and the other bunch rots. It also leads to the resumption of development of the latent infections that lay quiescent (inactive) since flowering. If uncontrolled at flowering, latent infection can trigger signific ant spread of disease at this time. In addition, ripe berries are more prone to splitting, leaking sugared juice down the bunch and to creating favourable infection sites for more disease.

Young bunches and berries are most susceptible to Botrytis bunch rot at flowering, if the weather is wet and humid. Though some infection can occur at any time if the conditions are right, it was the light brown 'litter' from flowering (as seen in this picture) that led to a build up of disease during the very wet season 2010–11. This litter is made up of dead flower parts and it was a good source of Botrytis spores. (Photo: A. Weeks, CCW.)

Q 12: Are there other 'drivers' of infection?

- Yes, despite all said above, canopy wetness is the most significant factor in the risk of infection by bunch rots (Bunch rots Q2). Dry canopies and dry flower parts will not be infected no matter how susceptible. However, in a 'knee-jerk' reaction, the rains and wetness of season 2010–11 will likely prompt many more sprays this season than in recent 'drier' seasons. In most regions of south-eastern Australia, if the weather stays dry, there is very little risk of Botrytis and the other bunch rots and, accordingly, very little need to spray. Warm, wet regions and the cooler southern regions are at higher risk from bunch rots than are the drier inland districts of the Riverina, Sunraysia and Riverland. The risk of bunch rots and the need to spray in any region is dependent on rainfall, particularly at the times of high risk (see Bunch rots Q11 above).

Q 13: What is latent infection?

- Latent means to 'hide' or 'lie hidden'. Botrytis infection at flowering lies hidden inside the young fruitlets until they begin to ripen and the internal berry tissue favours growth of the fungus bunch rots (see Bunch rots Q11 above).

Q 14: I noticed less bunch rots where downy mildew was worse.

- Yes, this illustrates the point made in Bunch rots Q11 above. As unsprayed downy killed parts of bunches and infected and dropped the leaves, it played a valuable but costly part in thinning the canopy and increasing the airflow around bunches. This assisted spray coverage for the bunch rots and it reduced disease potential and increased efficacy (operational power) of spray programs.

Q 15: We hear a lot about Botrytis, but what about the other bunch rots?

- Bunch rots other than Botrytis develop in extreme wet conditions like 2010–11 but they usually require warmer conditions than occurred. Often they are secondary invaders that infect and rot berries damaged by Botrytis or other wound agents (see Bunch rots Q3 above). They often appear together and also open the way for invasion of the yeast rots that lead to the smelly sour rot.

Q 16: I can only pump water from my dam which, during heavy rains, accumulates a lot of clay matter in it. Can I still spray with this water?

- Often no. Some dam and/or bore water has a pH approaching 8-10 and it may also have a high colloidal clay content. If used in your spray tank, this can deactivate fungicides like Captan and Rovral® within 30-60 minutes. In this case, before spraying, filter or sediment the water and buffer it to pH to 6-7.

Q 17: Do sprays destroy the berry's waxy layer and lead to more bunch rots?

- This is a debated topic and the answer is unresolved. However, avoid excessive use of wetters and spray additives. A useful rule of thumb is: 'Only use additives and wetters if the product label indicates it is required.' Some oils help spray deposits stick better but anything that weakens the cuticle surface on berries risks increasing the opportunity for wound damage and for bunch infection as a result.

Q 18: My mate missed some early sprays and in one patch, lost his whole crop. He then stopped spraying and saved any further spray costs. Whereas, I sprayed 16 times and then it bucketed down at harvest and I still lost my crop! It would have been better if I had quit earlier and saved my money too.

- This was a big dilemma for many. As the rains and wetness continued into the usual harvest period, the decision to keep spraying required evaluation of crop loads, of canopy design and exposure, and penetration of sprays. The cost of spraying already invested in the crop, the expected date of harvest, the rate of maturity of the crop and, importantly, the price to be paid for the grapes, were also relevant. It was, at times, impossible to calculate the cost:benefit of continuing the spray program because not all the factors were known at that time.

Q 19: In the cool, moist mornings after overnight rain, often there was a heavy deposit of dew and the canopies were dripping wet till at least early afternoon. It seems that my spray deposits were less effective at that time. Did it wash off?

- Probably not so much washed off, as was diluted. A wet canopy like this is difficult to spray effectively to allow the spray to dry and as a result, to stick. Also, the layer of water on the foliage surface will dilute the spray product, sometimes to below active thresholds. Last season, this probably hindered some canopies from receiving an effective spray at critical times.

Q 20: Speaking of canopies, last season's rapid growth meant that often spray coverage was restricted and control of the bunch rots made more difficult.

- This highlights a significant point. In wet conditions it is critical to ensure maximum efficiency is achieved with every spray. Dense canopies were often hedged, thinned and/or trimmed (see earlier). It is critical to match spray volumes to canopy dimensions and to adjust sprayer configurations to ensure the canopy is fully covered. 'Technique', the third T in the ***Three Ts*** rule of thumb for good spraying, reminds us of this.

Q 21: I tried to control sour rot with my botryticides, but why didn't they work?

- Probably for two reasons. First, most of the other (non-Botrytis) bunch rots are not controlled by the Botrytis fungicides; and second, once the sour rot yeasts have invaded a bunch, it is almost impossible to control the disease even if spray coverage with a useful fungicide could be achieved.

Q 22: I have heard that the 'knock down' disinfectants worked well against these bunch rots ... but others say they don't. Who is right?

- For me, the answer is unclear. The disinfectants may have assisted control in some cases, as may also have Ecocarb® (potassium bicarbonate) (see Powdery mildew Q6). Often though, the times in which these products have worked best, or appeared to have worked best, were times when the spraying coincided with 'higher temperatures'. Perhaps this meant that the canopy was drying out and becoming less favourable to infection. Either way, there are no products specifically registered for 'other bunch rots' and this season has shown the need for more evaluation of potentially useful products.

Q 23: Last season was so frustrating for other reasons too. I often missed my best spray timing because of boggy or flooded vineyards or, if this had dried, my sprays were hindered or prevented by windy and rainy weather.

- Yes, this was a great difficulty. Robert Burns, the renowned Scottish poet, immortalised a truism when he wrote that often: 'All the best laid plans of mice and men 'gang aft agley' (get messed up!) … and leave us nothing but grief and pain, instead of the promised joy'. Season 2010–11 was like that for many. Perhaps it is best to acknowledge this and press on with hope and diligence to use what we have learned from last season to help build a more productive season in 2011/12 and beyond.

Best practice approach to managing bunch rots

Key elements pre-season:

- **Fungicides**: As for downy mildew, check your access to this season's supply of fungicide for Botrytis bunch rot.

- **Calibrate vineyard spray equipment**: Effective spray coverage is needed especially around flowering and again late in the season when canopies thicken.

- **Spray strategy**: This will vary greatly depending where you grow grapes. Bunch rots are wet weather diseases. The warm, moist regions of the Hunter Valley and coastal regions of NSW and Qld, and the cooler but wetter southern regions will have a high likelihood of favourable conditions for Botrytis bunch rot in spring. This is especially so, at and near flowering and again near harvest as the berries ripen. These are periods of high susceptibility to Botrytis infection. Design a strategy to protect the developing bunches at flowering and especially, pre-bunch closure. Consider spray withholding periods and choose products to best fit the window of opportunity that is defined.

  Inland regions where it is warmer and drier rarely have conditions that favour significant levels of Botrytis at flowering or at harvest - spraying for bunch rots is usually not required in wine grape production in these regions. Following a season as wet and destructive as 2010–11, the temptation is to spray vines more often than needed. In whatever region, work with your weather as it unfolds during the season. If possible, take advantage of the 'normally dry' spring and summer in Mediterranean climates to foster sustainable viticultural practices with functional minimum sprays applied for good control. Maintain a low chemical input system where possible through your access and evaluation of local vineyard weather data. If needed, for greater detail, seek out disease and pest advisory services that assess weather data and advise of the risk of infection events and of management options through the season.

- **Know your 'enemy'**: Be familiar with the bunch rot diseases and the conditions that favour infection and spread. Remember that they are a 'brown' disease and invade through wound sites. Consider deploying management actions that reduce wounding of the developing fruit and that open the canopy to improved airflow and spray penetration.

Key elements within-season:

[The following applies to the regions with favourable conditions for Bunch Rots. In drier inland regions, use the details as a guide but only spray as necessary.]

- In high risk weather, take care to spray at flowering and pre-bunch closure to defend the susceptible flower parts and the developing fruit.
- Spray thoroughly according to the rate of new vine growth and to disease risk. Alternate with a selection of fungicides with different chemistry and adhere to anti-resistance management strategies.
- Use canopy management and adjust crop loads to minimise bunch tightness when required to improve spray penetration, increase air flow, reduce shading and reduce risk of infection.
- From budburst (E-L stage 5-7) till pre-flowering (E-L stage 12-15) (moderate risk stage): be vigilant of infection conditions. Monitor levels of leaf damage and of pests that damage the foliage and potentially, the bunches. Early season control is an advantage; inspect vines and monitor spray effectiveness to eradicate/prevent build up in the foliage; as appropriate, remove water shoots (de-sucker) to allow good airflow in the vineyard.
- From pre-flowering (E-L stage 12-15) till capfall (E-L stage 25) (high risk stage): monitor closely for duration of stages of flowering and for forecast favourable conditions; spray <u>before</u> wet weather ; if necessary at 80% capfall – a critical spray to protect the fruitlets as they form and expand.

- From capfall (E-L stage 25) to berries peas-size (E-L stage 31) (moderate risk stage): continue monitoring closely; look for fungal growth on flower parts and other trash trapped inside bunches; spray if needed to ensure spore loads are low prior to when pre-harvest withholding periods begin; bunch thin if necessary and monitor for berry damage.
- From berries pea-size (E-L stage 31) to pre-bunch closure (E-L stage 35) (last chance for effective spraying if needed; moderate risk stage): continue monitoring closely for fungal growth on trash in and on bunches; undertake leaf removal (if needed) to 70% bunch exposure before spraying again (if needed) - but avoid sunburn; this will ensure coverage of inner berries as the bunches expand and close; monitor for berry damage.
- From pre-bunch closure (E-L stage 35) to pre-harvest (E-L stage 37) (moderate risk stage): continue monitoring bunches and vineyard microclimate; undertake bunch thinning (if needed) before spraying again (if needed) to ensure coverage of inner berries as the bunches expand and close; and monitor for berry damage. Harvest early if needed.

Further reading

1. GWRDC website www.gwrdc.com.au:
    - Managing Downy Mildew fact sheet
    - Managing Downy Mildew technical booklet
    - Managing Downy Mildew PowerPoint presentation
    - Managing Powdery Mildew fact sheet
    - Managing Powdery Mildew technical booklet
    - Managing Powdery Mildew PowerPoint presentation
    - Managing Downy & Powdery mildew and bunch rots post-harvest 2011
    - Botrytis Management PowerPoint presentation

- Evans, KJ and Emmett, RW (2011) **Botrytis: Questions and answers fact sheet**. (www.gwrdc.com.au/webdata/resources/factSheet/GWR_Botrytis_QA_PDF.pdf)
- Somers, T and Steel, CC (2010) **Non-Botrytis bunch rot: Questions and answers fact sheet**. (www.gwrdc.com.au/webdata/resources/factSheet/GWR_Non_Botrytis_QA_PDF.pdf)
- Essling M. and Cijvers, K (2011) **Agrochemicals registered for use in Australian viticulture, 2011–12**. AWRI (www.awri.com.au/industry_support/viticulture/agrochemicals/agrochemical_booklet/booklet.pdf)

2. The web-site www.GrowCare.com.au (under development) provides fact sheets and other information on the diagnosis, epidemiology and management of the mildew diseases of grapevine.

3. Nicholas, P.R., Magarey, P.A. and Wachtel, M.F. (1994). (Editors).'Diseases and Pests', Vol. I. Grape Production Series. Winetitles, Adelaide, South Australia. ISBN 1-875130-15-2.

4. Magarey, P.A., MacGregor, A.M., Wachtel, M.F. and Kelly, M.C. (1999). (Editors). *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. ISBN 1 875130 33 0. (634.82).

5. Emmett, RW *et al*. (2003). Strategic use of sulphur in integrated pest and disease management (IPM) programs for grapevines. Final Report to GWRDC. Project Number: DAV 98/1. GWRDC, Adelaide, South Australia.

6. Pearson, RC and Goheen, AC. (1988). *Compendium of Grapevine Diseases*. APS Press, USA. ISBN 978-0-89054-088-6.

7. Flaherty, DL *et al.* (1992). *Grape Pest Management*, Second Edition, Univ California, Publication No. 3343, Berkeley, Calif, USA.

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To simplify information, trade names of chemical products have been used. Reference to any chemical product is in no way intended as an endorsement of that product above or beyond any other product nor is criticism implied of similar products not mentioned.

Front cover photos: PA Magarey
First and fifth photos: Fresh oilspots of downy mildew and bunch infection
Second and fourth photos: Bunch rots. Botrytis infection predominated in the cool wet conditions of 2010–11.
Third photo: Powdery mildew is effectively controlled on the upper leaf (sprayed with food grade Biopest Oil®) compared to lower leaf (unsprayed) (see page 22).

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