What's new with powdery mildew

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Across Australia, one pathogen more than any other causes fear amongst grape growers: powdery mildew (*Erysiphe necator*). Hard to predict and even more difficult to eradicate, this pathogen causes on average $76 million in losses to the Australian wine industry each year (Wine Australia 2016).

Why is the disease an issue and how does it develop?

Powdery mildew originated in the eastern part of North America, much the same way that phylloxera originated in Europe. The fungus overwinters on infected buds and as blackened spores (chasmothecia) under the bark of established cordons (similar to common trunk diseases such as *Eutypa lata* and *Botryspheria*), which is what makes it so difficult to eradicate. The overwintering spores require only 2.5 mm of rain in favourable temperatures (10–30 °C is sufficient for ascospore production) and are dispersed by wind to create a primary infection on the green tissue it lands on. Flag shoots from infected buds will develop early in spring producing conidiospores which spread to create further infections during the season; this is the largest cause of the infection in Australia. Spores can cause infection within 24 hours of dispersal and within 1 week can begin to exhibit the familiar white powder on the leaf surface that every grape grower fears.

High humidity, low light and cloudy conditions will promote growth and secondary infections. Given that powdery mildew proliferates in temperatures between 6–3 °C, the fungus is near impossible to eradicate or predict. Powdery mildew, when out of control, will inhibit the photosynthetic capacity of the vine (sugar and metabolite production) and can cause issues in the winemaking process, especially on varieties that are fermented on skins. Affected vineyards will struggle to reach full ripeness and are often rejected by the purchaser when powdery mildew levels are over 5%.

What can be done?

Typically in Australia, a robust fungicide program is utilised containing wettable sulfur and a number of different chemicals with differing modes of action. This method has questionable success given the cost to industry and the rate of fungicides used for protection globally. For instance, in Europe alone, grapes account for 6% of agricultural land area but 70% of the fungicide used (CSIRO 2017). We seem to be applying more fungicides each year for less result.

The world seems to be turning in its approach and taste for organic produce and a sustainable, health conscious way of life. Worldwide, the market for organics was valued at USD $81.6 billion in 2015, a fourfold increase from 2000. Australians are the 16th largest consumer of organic produce globally, averaging $26 per capita spent on organics annually. Logically these lifestyle choices will flow onto alcohol preferences and in particular, the wine industry.

Many wine companies across Australia employ organic principles and a select number exhibit certified organic status for not only their vineyard practices but also their winemaking facilities. However, in NSW only 17 wine companies hold an organic certification status out of the many across the diverse regions (150 producers in the Hunter Valley alone).

An organic example

To gain a better understanding of how powdery mildew is managed in an organic system, we asked Clayton Keily, viticulturist and nominated organic farmer of the year (2017) from Tamburlaine wines. Clayton admits:

"Over the course of growing wine grapes for the past 25 years, there is only one fungus that causes personal anxiety and that is powdery mildew. The problem with powdery mildew is that by the time it visually appears, it is very difficult to control or eradicate. More often than not it starts to appear about a week before Christmas, hence the term 'Christmas disease' that some growers call it."

Over time, Clayton has narrowed down his approach to managing powdery mildew for a cooler climate with a combination of spray application techniques in regard to sulfur rate, water rate and timing:

"After having powdery mildew in chardonnay 5 years ago we evaluated every step of our spraying program. We looked at water rates, product rates and ground speed. The only thing we could not alter was temperature. This is a major problem for growing organically as wettable sulfur needs to have a temperature of around 27 °C to volatilise and effectively 'gas' the canopy. In Orange, it may not reach 27 °C until mid to late November which is usually around our 4th spray or flowering. Our water rates for the first 3 sprays used to be 300 L/ha but this was increased to 500 L/ha. Comparatively, sulfur is very economical, so we use the top label rate of sulfur although Galet (1996) suggests that rates of 8–10 kg/ha of wettable sulfur are needed in cooler climates. Finally, we adjusted our ground speed. Previously we had been travelling at 7.5 km/h. This was reduced to 6 km/h so we could achieve full coverage inside the canopy rather than a feel-good coating on the outer leaf surface. By doing this we could visually see sufficient coverage throughout the canopy."

The debate around sulfurs' ability to have a 'fuming' effect in higher temperatures is interesting. Most literature suggests improved efficacy at 18 °C in moderate climates. However, anecdotal evidence in cooler climates with lower humidity suggests the temperature needs to be higher to have a greater effect on fungal control.

Canopy management techniques are crucial for the reduction of most grapevine pathogens and diseases, especially when there are limited chemical resources at your disposal. Ultraviolet light for example, is a brilliant sterilising agent and will limit the germination of conidiospores and spread of the colony. Clayton explained his approach in the early spring for risk reduction once spray techniques were resolved:

"Our next hurdle was flag shoots, which to an untrained eye can be mistaken for *eutypa* dieback, vine strangulation or even early zinc and boron deficiency (which we can get if there is a weather-related lock up issue in the soil). We instructed the shoot thinning team to remove any zig zag shoots they saw on vines with greater than 10 cm of growth, whether it was a flag shoot or not. This eliminated a thought process on their behalf which can escalate the cost of shoot thinning. By doing this we reduced our powdery mildew pressure at the very beginning of the season. This has become a standard practice for us now and if we have any arms with suspected *eutypa*, we cut them back to a point where we can run an unaffected arm and burn the removed wood."

Even with optimum management techniques in place, powdery mildew can often still develop due to its wide range of favourable conditions. So how do you eradicate or inhibit the growth if an outbreak is observed?

"Firstly, we will leaf pluck by machine to open up the area around the bunches. Secondly, we will set the water rate to 1000 litres and concentrate the nozzles at the bunch zone and travel at 4.5 km/h (I know this sounds slow, but you have one shot at stopping this fungus). Finally, we use a high rate of sulfur and Horti Oil (label rate) to smother the powdery mildew. This is done at night so the spray can dry slowly and move into the bunches before evaporation can dry it out. These sprays will be applied 5 days apart and if necessary repeated, but once is usually enough."

Powdery mildew research

Powdery mildew research and protection methods have developed significantly in the last 20 years with many synthetic options now available for conventional growers. However, with this progress in innovation has come the development of resistant strains to many of the groups in the category (Strobilurins for example). As powdery mildew has the ability to sexually reproduce and has multiple life cycles within a single growing season, there is a reasonably high risk of resistance to particular fungicides if used multiple times during the season and in consecutive seasons. How can we best protect against further resistance and control the existing problems?

South Australian Research and Development Institute (SARDI) researchers Barbara Hall and Suzanne McKay are at the forefront of the investigation into powdery mildew fungicide resistance in Australian viticulture. Barbara and Suzanne are currently heading a Wine Australia funded project aimed at a greater understanding of fungicide resistance. With a combined 50 years' experience in plant pathology, who better to discuss the issues, both present and in the future in the battle against powdery mildew?

What project are you currently working on and how will this benefit the grape growing industry?

Our projects aim to improve the understanding of fungicide resistance in Australian viticulture. This will assist growers to better manage the risk of resistance by understanding the mechanisms involved. Widespread resistance has been detected in laboratory tests to various fungicides for downy mildew, powdery mildew and botrytis. However, this does not mean there is a corresponding widespread field failure. We are working towards trying to understand the relationships between the laboratory tests and field performance of the various fungicides. At SARDI (in collaboration with the Australian Wine Research Institute) we are concentrating on powdery mildew, while colleagues at Curtin University in Western Australia are working on botrytis.

Wettable sulfur is widely used across the world as a protectant for the pathogen. Are we going to encounter resistant strains to sulfur or is this still a best practice option, and what are its limitations/advantages?

No, it is highly unlikely that resistance will develop to the multi-site contact fungicides such as copper and sulfur. They have been successfully used for hundreds of years worldwide with no indication of any resistance. It is still the best practice option to use sulfur as a protectant early in the season. However, its limitations are that in hot humid weather it may cause burning, and in high disease pressure it may not be as effective as the modern synthetic fungicides.

Many of the modes of action for powdery mildew control are encountering resistance. Does rotating between modes of action inhibit this resistance in the long term?

Rotating between the modes of action will definitely reduce the risk of resistance developing and ensure that field efficacy is maintained for the foreseeable future. However, it may not completely prevent the development of resistance in the long term. The mutations in powdery mildew that confer resistance may exist in the population at low levels without causing loss of field performance. Poor fungicide choices and application methods can allow the level of these mutations to increase until resistance in the field is evident. There are still a lot of unknowns in this area, which we are working towards understanding.

Where do you see powdery mildew control methods progressing in the next decade? Will we still be chemistry based or moving towards more organic practices?

Even organic methods are chemistry based, i.e. sulfur and copper, and often at much higher quantities than conventional practices. We still see synthetic fungicides as viable control methods, however, they should be effectively utilised (i.e. spray application, rates and choice) and other control methods e.g. canopy management also needs to be addressed.

With another season of unknowns ahead for grape growers all over Australia, working together and sharing experience greatly assists in reducing issues. With so many variables involved in the proliferation of the fungus, every small gain may be the difference in quality and yield for the coming season. Canopy management, early prevention sprays with a well thought out chemical choice, vigilant monitoring and immediate action when symptoms arise, will make for a prosperous 2019 vintage.

Further reading

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