Agriculture Notes

Organic Farming: Managing grapevine powdery mildew

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David Madge, Mildura

Introduction

Grapevine powdery mildew is a widespread fungal disease. On unprotected, susceptible varieties it can cause crop loss and reduced fruit quality, wine quality and vine growth. The disease varies in severity from season to season, but generally requires treatment every season.

Organic grape growers are required to manage powdery mildew without the wide range of synthetic fungicides commonly used in viticulture today. Alternative disease management strategies that incorporate cultural control techniques and a limited range of applied treatments like sulphur, allow growers to produce quality crops of organic grapes in compliance with organic standards.

Powdery mildew is driven by inoculum and weather. Its severity in a season depends on the level of inoculum carried into the season, weather conditions and the grower's ability to achieve good early season control. Strategies that reduce inoculum levels are essential for long-term sustainable management of this disease, and are emphasised in this Agriculture Note.

The disease

Grapevine powdery mildew, also called oidium, is caused by the fungus *Uncinula necator*. This fungus infects green grapevine tissue including leaves, stems and berries. As the fungus grows, and especially when it produces spores, it gives infected tissue an ash grey powdery appearance.

Figure 1. A grape leaf covered with powdery mildew.

Powdery mildew infection distorts the growth of rapidly expanding leaves, which may become cupped. Old sites of powdery mildew infection on shoots are indicated by a red-brown to black staining on dormant canes.

Grapevine powdery mildew only grows on cultivated grapevines and very closely related ornamental grapes. There are numerous species of powdery mildew fungi, affecting a wide range of plants. It is important to note that *Uncinula necator* is the only one that grows on grapevines.

Crop damage

Powdery mildew can reduce the health and economic viability of vineyards in the following ways:

- Reduced viability of infected buds may lower the percentage of buds that burst in spring.
- Severe infection can cause death of shoots.
- Infection of flowers and young bunches around flowering can reduce berry and/or bunch development, resulting in significant crop loss.
- The skin of diseased berries stops growing. As the flesh expands, especially after wet weather, the berries may split, allowing rots like Botrytis to develop.
- Heavy infections reduce photosynthetic efficiency of leaves and may delay sugar accumulation in large crops.
- Wine quality is affected by off-flavours with as little as 3% of fruit infected with powdery mildew.
- Early defoliation caused by severe disease may reduce the build-up of nutritional reserves in vines for the following season.

Some terminology

- *Hyphae*: thin filaments of fungal growth.
- *Cleistothecia*: tough 'fungal resting bodies' about 0.1mm in diameter, that contain ascospores and remain viable in the bark of vines, and possibly in leaf litter, until the following season.
- *Ascospores*: sexually-produced spores from cleistothecia. They can germinate and infect green vine tissue. Because these spores are genetically variable, they allow the disease to develop resistance to fungicides.

- *Conidia*: asexually-produced spores (clones of the fungus) that can germinate and infect green vine tissue.
- *Flag shoots*: shoots that develop from buds infected with powdery mildew in previous seasons. These shoots emerge covered in fungal growth and rapidly produce new conidia, spreading the disease.

Disease cycle

The development of powdery mildew is documented in detail elsewhere, such as Fisher and Wicks (2003), Nichols et al. (1994) and Pearson and Goheen (1988). For completeness, a brief summary is included below.

In most Australian districts, flag shoots are the main source of primary inoculum. Flag shoots emerge during budburst and soon begin to produce conidia. The conidia are blown onto leaves or other green vine tissue, and germinate to start new infections in five to ten days. Wet conditions are not required for the germination of conidia.

Figure 2. A young flag shoot showing typical cupped leaves.

Cleistothecia are another source of primary inoculum. Given suitable conditions (2.5mm of rain or sprinkler irrigation, temperatures above 10°C and at least 13 hours of leaf wetness), cleistothecia burst and release their ascospores. The ascospores are splashed or blown onto leaves or other green tissue and, like conidia, germinate to start new infections.

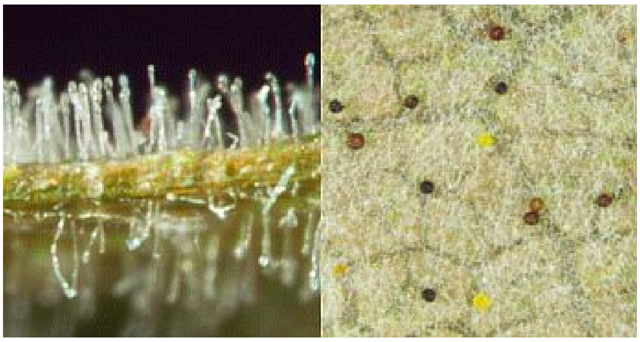

Figure 3. Left: Cross-section of a grape leaf covered in powdery mildew with new conidia developing at the end of the stalks. Right: Immature (yellow) and mature (black) cleistothecia on a Sultana leaf in early autumn.

In both cases, as the infections mature, the fungus starts to produce many more conidia (secondary inoculum). These are spread by wind to new vines, where they start even more infections.

Early in the season, vines start to develop new buds for growth in the following season. If these buds become infected with powdery mildew, and survive over winter, they may produce flag shoots in the following season.

Cleistothecia are produced from mid-summer through autumn by the fusion of hyphae of different strains of the fungus. They are blown or washed into cracks in the bark where they lay dormant over winter. Cleistothecia that fall to the ground are less likely to survive over winter.

Characteristics relevant to disease management

Major points for growers to be aware of when planning a management strategy for powdery mildew are:

- Early in the season, under favourable weather conditions, disease from an uncontrolled infection will develop exponentially to epidemic levels. Higher levels of primary inoculum (flag shoots and cleistothecia) lead to more rapid disease development.
- Early-season infections result in mature colonies of disease which produce cleistothecia, and more infected buds (potential flag shoots). This leads to greater disease pressure in the following season if control measures are not applied.
- Buds on shoots at the 'three to six leaf unfolded' growth stage (during the first two to three weeks after budburst) are very susceptible to infection. In reality, buds of this physiological age may be present on a vine during most of the season, if shoots continue to grow actively throughout the season.
- Flag shoots generally appear in very low numbers, eg. one in every 1000 shoots.
- Cleistothecia are not long-lived and survive only from one season to the next.
- Mature cleistothecia are generally not affected by fungicide sprays except by drenching sprays of water that may cause them to burst and release their ascospores.
- Ideal conditions for the growth of powdery mildew include temperatures of 20°-28°C, 80%-90% relative humidity (RH) and relatively low light levels such as those found inside dense vine canopies or during overcast weather.
- Low levels of ultraviolet (UV) light increase the susceptibility of vine leaves to powdery mildew because of effects on leaf physiology (Keller et al. 2003).
- High nitrogen status increases the susceptibility of vine leaves to powdery mildew. This effect is more pronounced when combined with low UV light levels (Keller et al. 2003).
- The RH factor is important. Powdery mildew can tolerate lower RH levels (eg. 40%), but production of conidia, and therefore the rate of disease spread, appears greatest above 80% RH. RH above 90% may not be as favourable because of the presence of free

water at very high humidity. Powdery mildew conidia burst or germinate abnormally in water.

- Some research suggests that nearby water bodies like channels, ponds or lakes may encourage the development of powdery mildew by increasing levels of humidity in vineyards.
- Under ideal conditions, spores can be produced in as little as five days after the start of a new infection.
- Temperatures over 35°C inhibit spore germination and slow the growth of the fungus and temperatures over 40°C kill spores (but not hyphal colonies). Occasional hot days do not usually suppress the disease to any useful extent, because favourable conditions overnight (warm, low light level and higher humidity) outweigh the effect of unfavourable daytime conditions. Heat-wave conditions (at least four sequential days over 40°C) are considered to suppress the spread of powdery mildew significantly.
- The fungus develops on both sides of the grape leaf and grows only on the outer surface of the leaf. This makes it inherently more exposed to contact sprays and UV light.
- Soft, actively growing vine tissue including flower buds, flowers and berries, is most susceptible to infection. Mature foliage is more tolerant of infection and brown vine tissue is resistant to infection.
- Berries are susceptible to infection until about four weeks after flowering.
- Bunch and berry stems remain susceptible to infection even after the berries become resistant.

Managing powdery mildew

With the above characteristics of powdery mildew in mind, the following approaches to disease management will help organic grape growers to minimise the impact of powdery mildew in their vineyard.

Design new vineyards to minimise disease risk

Aim: to make the vineyard inherently less favourable for powdery mildew.

Vineyard location has a bearing on disease pressure because of such factors as:

Climate – Regions experiencing warm, cloudy (low-light), humid conditions during the growing season are more favourable for powdery mildew than regions with a hot, dry, sunny climate.

Microclimate – Local topography, land use and wind patterns help to determine vineyard characteristics such as air drainage, wind exposure and humidity (eg. proximity to water bodies). These factors can affect the development of powdery mildew by influencing vineyard humidity and the drying rate of vine foliage.

Proximity to inoculum sources – Because powdery mildew spores are dispersed by wind, vineyards with the disease can act as a source of infection for other nearby properties, but only in mid-late season when the disease has become well established. It is important for growers to note however, that most inoculum typically comes from within their own vineyard.

Soil type – The need for supplementary irrigation on vines in higher rainfall areas depends in part on soil type. Light, shallow soils are more likely to require irrigation. Irrigation may then increase disease risk by increasing vineyard humidity levels (if applied by undervine sprinklers - see below).

Figure 4. Research results indicate that higher humidity levels near water bodies increase the risk of powdery mildew infection.

By taking these factors into account during site selection for a new vineyard, the susceptibility of the vineyard to powdery mildew and some other grape diseases may be lowered. Lowering of the inherent disease susceptibility of a vineyard may help reduce the level of intervention required for disease management on an ongoing basis.

Row orientation. Facing the ends of rows into the prevailing wind helps reduce humidity levels within vine canopies by increasing air movement around the vines.

Choice of variety can influence disease risk, as the susceptibility of different grape varieties to powdery mildew varies. However, the information regarding varietal susceptibility does not appear very reliable. What is known, is that most *Vitis vinifera* varieties (upon which the Australian industry is based) are susceptible to powdery mildew. In practical terms, choice of grape variety is still driven by market requirements and performance under local soil and climatic conditions.

Canopy structure should be designed to avoid dense canopies, as they create shade and higher humidity. By maximising exposure of the foliage to sunlight, and reducing humidity levels through greater air movement, an open canopy structure helps to create an environment less favourable for powdery mildew and other diseases.

This effect may, however, not be so pronounced in cooler districts characterised by higher humidity levels and lower light. In vineyards of moderate to high vigour, open canopies are usually achieved through shoot positioning systems like VSP (vertical shoot positioning) and Smart-Dyson that produce 'ordered' canopies, as opposed to the random growth of 'unordered' canopies sometimes referred to as ‘Aussie sprawl’.

Irrigation systems may influence powdery mildew development through the extent to which they:

- wash spores off the foliage; and/or
- increase vineyard humidity.

Overhead sprinklers may remove spores by 'washing' the foliage, but they create high humidity. Drippers do not wash spores off the foliage, but they contribute much less to humidity levels. Low-level sprinklers do not wash spores off the foliage but they do create high humidity conditions. Some anecdotal evidence suggests that low-level sprinklers encourage the development of powdery mildew. These characteristics of irrigation systems are worth considering when designing such systems for vineyards.

Manage vines to reduce disease risk and spread

Aim: to minimise the risk of infection and spread of disease.

Cultural management techniques have a very important role to play in managing powdery mildew, because of the degree to which they reduce the risk of infection or increase the efficacy of applied treatments.

Canopy management is critical because it can be used to:

- improve air flow through the canopy, and therefore reduce humidity levels;
- reduce the level of shading within the canopy;
- improve spray application efficiency and spray distribution throughout the canopy.

Because UV light reduces the susceptibility of grapevines to powdery mildew, maximising the exposure of vine foliage to UV light through good canopy management, will help inhibit disease development.

To achieve the above canopy management objectives, organic grape growers can use the common techniques of shoot positioning, foliage trimming and manual or mechanical removal of leaves from around bunches.

Figure 5. The disease risk on these organic vines is reduced by the canopy structure that maximises air flow and opens the canopy to direct sunlight.

Water and nutrition management can also be used to avoid dense canopies by restricting canopy growth. Excess water and nitrogen both result in lush, soft growth which is very susceptible to powdery mildew. Overwatering also contributes to higher humidity levels which may promote powdery mildew development.

Flag shoot removal early in the season also reduces the impact of powdery mildew by helping to minimise early spore production. To do this, growers need to monitor their vineyard closely from budburst onwards, particularly during the third to fifth weeks after budburst. Any flag shoots that are detected should be cut off.

Although this is a time-consuming task, it has potentially great rewards. This strategy helped to reduce the seasonal requirement for fungicide applications from six sprays to three in a Riverland vineyard, and has enhanced the control of powdery mildew on the very susceptible variety Verdelho in a mildew-prone district (Peter Magarey, personal communication).

Because powdery mildew infections begin from flag shoots or cleistothecia that have overwintered on the grapevine, the removal or destruction of prunings will not have any useful impact on powdery mildew.

Figure 6. Early removal of flag shoots can help reduce powdery mildew infection levels.

Minimise seasonal carry-over of the disease

Aim: to minimise the development of new flag shoots and cleistothecia.

Practices that reduce the inoculum level of powdery mildew will help to reduce the risk of disease development or delay the onset of infection, more effectively than seasonal control programs aimed at managing the disease once it is established. These practices will:

- reduce bud infection and flag shoot development; or
- reduce cleistothecium development.

Minimising the development of these primary inoculum sources during the season, will lead to reduced disease pressure and better control in the following season. This is a realistic approach for organic growers and others interested in reducing their medium to long-term dependence upon fungicides.

Reduce bud infection and flag shoot development

The following conditions have to be met during the current season, for flag shoots to develop in a vineyard in the next season:

- powdery mildew must be present in the vineyard;

- next-season's buds must be at a developmental stage susceptible to infection; and
- infected buds must be retained into the next season.

The period during which next season's buds can become infected may vary greatly between vineyards, because of differences in such things as grape variety and canopy management techniques.

Spur-pruned varieties will tend to have a short 'window of infection', because only the buds which develop early in the season, will be retained for the following season. Regardless of how much the vines grow, it is only those few early buds that can carry inoculum into the following season as flag shoots.

Cane-pruned or minimal-pruned vines have a much longer 'window of infection', because more of each cane is retained on those vines from one season to the next. Those canes develop over a longer period, and carry a larger number of buds, that collectively, were susceptible to infection over a much longer period. Shoots can even grow actively and develop new buds towards the end of the season, when the infection pressure in vineyards with uncontrolled powdery mildew can be very high.

Spray programs intended to prevent infection of buds, need to protect the actively growing shoots that will carry the buds into the next season. This is part of the rationale behind the early-season spray program (see below) in vineyards where powdery mildew was a problem in the previous season. The aim of this program is to minimise the risk of early disease development and prevent bud infection on the young shoots.

Reduce cleistothecium production

The production of new cleistothecia will be reduced if foliar infection is minimised by good early season control. This is because early control will limit the size of mature powdery mildew colonies and hence their potential to produce cleistothecia.

Late treatments, eg. post-harvest sprays, will be of limited value if earlier infections were not controlled. These infections are likely to have produced many cleistothecia already. Overall, more benefit is likely to be gained from a good spring/summer spray program than from post-harvest sprays for powdery mildew (Wicks et al. 2002).

Monitor the disease and its spread

Aim: to detect infections early and to determine the effectiveness of disease management actions.

Monitoring should be performed at least fortnightly from budburst until berry softening. Growers should inspect 200 to 300 vines in each block. Up to 30 seconds should be spent scanning as many leaves as possible per vine. Less time will be required early in the season while the canopy is small. For best results, monitor under windless conditions, when leaves are dry and in full sun.

Early symptoms of infection are isolated, small, light green to yellow blotches on leaves. On the underside of the blotches, the leaf veinlets turn brown. Hyphal growth and spore production on the leaf surface make older infections look powdery. Flag shoots, with their distorted growth and powdery appearance, start to become obvious from the three-leaf growth stage (from two weeks after budburst).

Figure 7. Vineyard monitoring is necessary to determine the extent of infection and effect of any treatments applied.

To the untrained eye, symptoms of early powdery mildew infection may be confused with spray damage. More developed infections can be confused with dusty or hairy leaves. Correct identification of the disease is critical for effective management, so symptoms should be confirmed using grapevine disease guides (see References) or specialists with a good knowledge of grape diseases.

When monitoring, include powdery mildew 'hot spots', such as sites of previous heavy infections, humid sites (eg. near water bodies) and, as the season progresses, inside dense canopies. Different varieties should be monitored separately as they vary in their susceptibility to the disease. Blocks under different disease management regimes should also be monitored separately.

Monitoring can be used in different ways, depending on the disease history of the vineyard and the grower's approach to risk management.

For example:

- *Where powdery mildew has previously been a problem*, growers should apply early-season sprays and then monitor to determine the need for further treatments. Follow-up treatments are necessary if active powdery mildew is found.
- *Where disease pressure is low, or the disease has been very well controlled in previous seasons*, growers may monitor carefully from budburst until the first sign of new disease is found, then apply three sprays a fortnight apart, then resume monitoring to determine the need for further treatments.
- *Where cleistothecia are the main source of infection*, growers should monitor weather conditions and apply a treatment as soon as possible after conditions suitable for ascospore infection have occurred (see page two).

As well as helping to fine-tune the timing of treatments such as spraying, disease monitoring can be used to determine the effectiveness of those treatments. If new powdery mildew infections continue to be detected, this indicates that the management program is not effective and needs to be reconsidered. In these situations, the spray timing and coverage, equipment set-up and calibration and spray material and rate, may need to be reviewed.

Treat vines to reduce disease risk and spread

Aim: to minimise the risk of infection and spread of disease.

Application technique

Good spray coverage is crucial for good control.

Growers can monitor their coverage by inspecting vines, and using dyes and/or water-sensitive papers available from agricultural suppliers.

To achieve effective coverage, machinery calibration and set-up must be correct. It is particularly important to adjust spray volumes to suit the canopy volume, which varies markedly during the season. Growers can be assisted in equipment set-up by the equipment suppliers or training programs such as the 'Research to Practice Spray Application in Viticulture' workshops organised by the Cooperative Research Centre for Viticulture (see 'Additional information sources').

Figure 8. Thorough spray coverage is critical for good powdery mildew control.

If the desired level of control of powdery mildew is not being achieved during the season, the following strategy may be used to improve control:

- double-check the machinery set-up;
- double-check the spray volumes and rates;
- trim the vine canopy to improve spray distribution;
- apply two sprays, seven days apart;
- apply the two sprays in opposite directions to improve coverage; and
- reduce the tractor speed to improve coverage.

Early in the season, growers sometimes spray only every second row, and hope to achieve good control of powdery mildew. Spraying this way is not effective, as good coverage cannot be guaranteed.

Spray materials

As of early 2005, sulphur and potassium bicarbonate are the only effective registered treatments for powdery mildew control in Australia that are acceptable under organic standards.

Sulphur

Sulphur can be applied as a spray or dust. Dusting sulphur is popular in the USA but used rarely in Australia, even though it is considered an effective product (Possingham 2002). Wettable sulphur has the advantage of being more rainfast than dust.

Sulphur works by killing the spores of powdery mildew, thus protecting the vines from new infections. It does not kill the fungus itself. The best use of sulphur therefore, is to prevent vines from becoming infected, rather than to suppress infections once they have developed. Existing mature fungal colonies will begin producing more spores as soon as a week after a sulphur spray is applied.

Sulphur is a popular fungicide because it is relatively cheap and provides good results under less-than-ideal application conditions. The latter point is due to the fact that under suitable conditions (temperatures >15°C), sulphur becomes volatile, and to a degree it 'fumigates' the foliage and bunches, including areas that were not actually contacted by the spray or dust.

The optimum temperature for efficiency of sulphur is believed to be 25°C to 30°C. Its effectiveness is reduced at temperatures below 18°C. Phytotoxicity has been considered a risk at temperatures over 32°C, but this appears dependent upon humidity. Recent Australian research (Magarey *et al.* 2002) found that phytotoxicity occurred at temperatures exceeding 40°C only when RH exceeded 70%.

Phytotoxicity of sulphur is also related to the presence of mineral spray oils. It is recommended that to avoid damage, sulphur should not be applied with oil, or within three weeks of an oil spray.

Australian research has shown that thoroughly-applied sulphur remains effective on grape leaves for up to 50 days. However, much shorter spray intervals are required to ensure that new growth is protected by spray residues.

Copper is known to suppress powdery mildew, although not to the same degree as sulphur. This should be taken into account where copper-based fungicides are used for downy mildew management.

Timing of sulphur applications

The need for early treatment in vineyards with a history of powdery mildew has been mentioned above. In these vineyards, the following sulphur spray program is recommended to help prevent early disease build-up and reduce late season disease pressure (Emmett et al. 2003a).

- 5-6 leaves separated; E-L[1] growth stage 12-13 (Coombe 1995);
- 8-10 leaves separated; E-L growth stage 15-16;
- pre-bloom; 12-15 leaves separated; E-L growth stage 17-18;
- berry set; E-L growth stage 27. Spray if necessary as determined by monitoring.

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[1] Eichhorn-Lorenz

The sprays are timed to coincide, on average, with the appearance of four to five new leaves on each shoot, and are intended to protect that new foliage from infection. In the Sunraysia/Riverland and climatically similar districts, these growth stages equate to approximately two, four, six, and eight to ten weeks after budburst. The intervals between budburst and the first spray, and then subsequent sprays, will usually be extended in cooler districts and shortened in warmer districts. A general rule to follow is to apply three sprays at regular intervals before flowering.

The critical time for fruit infection is from pre-bloom to four weeks after flowering. Disease-prone vineyards may require further sprays at two to three week intervals from berry set to berry softening. Infections that start after berry softening are unlikely to result in crop loss. However, infections that continue to develop on bunch stems may affect wine quality, so a spray program beyond berry softening may be warranted under high disease pressure.

As mentioned above, vineyards that have been kept 'clean' in previous seasons can be monitored carefully, then sprayed three times at fortnightly intervals if and when disease is detected. Further monitoring will determine whether the spray program needs to be continued.

Post-harvest sprays of sulphur may help to maintain foliage health in vineyards where disease pressure is high. This can benefit the vines by maintaining photosynthetic activity, thus aiding the build-up of reserves for the following season. It should be noted however, that these sprays might put additional pressure on populations of predatory mites in the vineyard, and so reduce the biological control of pest mites.

Sulphur application rates

The application rate for wettable sulphur in Australian viticulture has traditionally been 200g/100L. This rate is significantly lower than that commonly used overseas. The low rate originated early in the history of Australia's wine industry, possibly in relation to vines with lower vigour and more open canopies. These vines would have suffered lower disease pressure as a result of better aeration and exposure to UV light. The low rate may also have been used to avoid problems with phytotoxicity experienced with early formulations of sulphur.

Recent local research (Emmett et al. 2003a & 2003b) has shown that management of powdery mildew can be improved through the use of the newer, higher label rate of sulphur, ie. 600g/100L, when applied at the volumes required to achieve thorough coverage of the vine foliage. This rate is registered for some sulphur products in Australia, and growers can choose between the two application rates depending upon the disease pressure in their vineyard. Note: the rates quoted above are based on products containing 800g of sulphur per Kg of product.

Spray additives

The research mentioned above also confirmed that wetters, spreaders and oils do not improve the control of powdery mildew with sulphur, if sprays are applied thoroughly.

Alternatives to sulphur - why consider them ?

Sulphur is currently permitted in organic agriculture because it is a largely unadulterated compound with a long history of use in organics. There are, however, good reasons to reduce its use. These include issues of human health and undesirable off-target impacts within our agricultural systems.

For example, the *Trichogramma* wasp, an important parasite of lightbrown apple moth, is very sensitive to sulphur (Thomson et al. 2000, Llewellyn 2002). Growers who want to rely more on the biological control of vineyard pests using beneficial species like *Trichogramma* may find that the use of sulphur limits the success of that control by suppressing the biological control organisms.

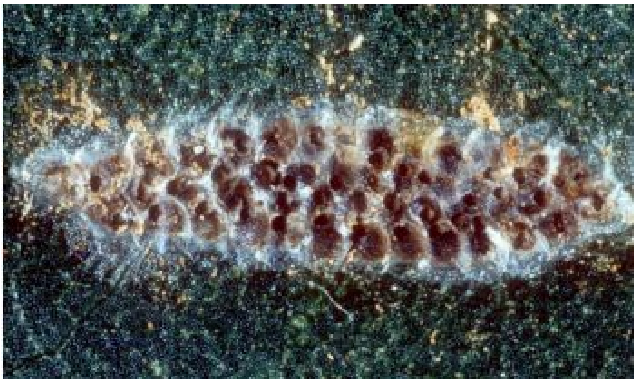

Figure 9. Lightbrown apple moth eggs parasitised by the wasp Trichogramma, *a beneficial species that is sensitive to sulphur.*

Potassium bicarbonate

Potassium bicarbonate is an alkaline substance commonly used in baking powder and antacid medications. It has been found to disrupt the cell walls of certain fungi, including grapevine powdery mildew, causing the fungal hyphae and spores to collapse. In Australia, one product based on activated potassium bicarbonate 'EcoCarb®' (Organic Crop Protectants P/L), is registered for the control of powdery mildew on grapes. EcoCarb, which has no withholding period on grapes and low toxicity to beneficial insects and mites, is usually applied with canola oil for powdery mildew control.

The important differences between potassium bicarbonate (PB) and sulphur, and implications for the use of PB are listed below.

☺ **PB acts as an eradicant.** This feature provides organic growers with a way to control existing infections, while reducing the amount of sulphur applied during the season.

☺ **PB is not temperature-dependent.** This makes PB an ideal alternative to sulphur early in the season, when low temperatures limit the effectiveness of sulphur.

☹ **PB provides no protection against new infections.** PB may, therefore, require more frequent application than sulphur, to achieve the same level of control. This has implications for issues like energy use, seasonal application costs and soil compaction. Because PB doesn't protect vines from new infections, it is generally recommended that PB be considered for use in situations of low disease pressure, such as early in the season or in vineyards where powdery mildew has previously been controlled very well.

☹ **PB does not have a fumigant effect** and, like sulphur, it is not systemic. This means that powdery mildew can be controlled only where the spray makes **direct contact** with leaves, stems and berries.

Thorough coverage is critical for good control!

Where thorough coverage cannot be guaranteed because of dense canopies or limitations of spray equipment, it is recommended that EcoCarb and sulphur be used alternately.

Remember that it is the responsibility of the user to read the product label and ensure that the chemical is used only for its registered purpose.

It is also important for winegrape growers to observe the withholding periods set by their winery. Withholding periods recommended by the wine industry are available from the Australian Wine Research Institute (Bell and Daniel 2004).

Other alternative fungicides

A number of alternative materials for powdery mildew control are available to grape growers overseas or have shown promise in Australian trials (e.g. Crisp et al. 2003). These include fungal and bacterial preparations, dairy by-products, sodium salts, silicate compounds, compost teas and vegetable and mineral oils. However, because these materials are not registered for use on grapes in Australia, they cannot be detailed in this Agriculture Note.

These alternative fungicides are sometimes suggested for use under conditions of low to moderate disease pressure, as they are not as effective as sulphur against the fungus.

Like potassium bicarbonate, most of these alternatives are also non-systemic and non-fumigant and would therefore require very thorough coverage for good disease control.

Exceptions to this are compounds that induce an immune response in the grapevine, and increase its resistance to powdery mildew infection. This is termed 'systemic acquired resistance' or 'induced resistance' and is currently the subject of research aimed at reducing the need for chemical control of grapevine diseases.

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- Organic Federation of Australia (OFA)
  PO Box 166
  Oakleigh South, VIC 3167
  Tel: 1300 657 435
  email:info@ofa.org.au Internet: www.ofa.org.au
  (Australia's peak organic industry organisation).

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