Factsheet

July 2013

Botrytis: questions & answers

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Summary

Botrytis rot, caused by *Botrytis cinerea*, is one of number of different fungi that can cause bunch rots on grapevines. The following information only relates to 'in season' management and does not cover other factors that affect botrytis risk such as site selection, variety and rootstock selection, row orientation, spacing and trellis type.

Identifying the disease

Q1: When is botrytis first seen and what does it look like?
Shoot, leaf and flower cluster rots (bud break to pre-bunch closure). In long periods of wet weather, botrytis can infect the dead and dying parts of young stems, leaves, flowers and bunches damaged by wind, hail or other factors. Botrytis can develop on soft, young leaves with no apparent damage other than a darkening of damaged tissue. The resulting leaf symptoms can have a light tan or soft calf leather-like appearance. Other infected tissues develop patches of soft brown rot with grey to buff coloured fungal growth (grey mould). Botrytis rot can also develop on berries in bunches damaged by downy mildew (Figure 1).

Berry and bunch rots (pre-bunch closure to harvest). In some seasons, occasional immature berries in bunches develop a soft brown rot (mid-season rot or green berry rot, Figure 2) after frequent periods of wet weather in late spring and early summer. Later, tufts of the grey to buff coloured botrytis fungus grow on the rotting berries during humid weather.

Most berry and bunch rots caused by botrytis develop in late summer and autumn (early- to mid-summer in warm/hot areas) as grape berries mature. The first signs of infection are small, round water-soaked spots that may be lighter in colour on red grapes. When berries are rubbed, the skin over these spots cracks and slips freely (slip skin), revealing the firm inner-berry pulp. Gradually infected berries soften and turn brown (or pink-brown

Figure 1: Botrytis on berries in Chardonnay bunches damaged by downy mildew. (Photo courtesy of R Emmett, DEPI).

Figure 2: Botrytis green berry rot in Chardonnay bunches. (Photo courtesy of R Emmett, DEPI).

in white grapes), but they may remain swollen as the rot spreads within them. Later, grey to buff coloured fungal tufts grow from splits in the skins of the infected berries. In compact bunches, the rot may spread rapidly from berry to berry until entire bunches are rotted and covered with matted grey velvet-like fungal growth (Figure 3). When dry conditions follow infection, the rotting berries dry up like raisins. While some fall from bunches others remain, especially in tight bunches.

Q2: Is the rot botrytis?

Botrytis can be identified by looking at the fungal growth on rotting berries or other vine tissues with a 10× hand lens (magnifying glass) or dissecting microscope. Clusters of light grey or colourless spores at the ends of branched dark brown stalks confirm that the rot is caused by *Botrytis cinerea*.

Q3: Is botrytis the only cause of bunch rot?

No. Botrytis is one of a range of fungi and other microorganisms (including yeasts and bacteria) that can cause berry and bunch rots. These include the fungi *Aspergillus* spp. (black mould), *Rhizopus* spp., *Penicillium* spp. (blue-green mould), *Alternaria* spp., *Cladosporium* spp., *Colletotrichum* spp. (ripe rot), and *Greeneria uvicola* (bitter rot). Sour rot is caused by a mixture of these and other microorganisms and results in a soft watery rot that leaks juice from the berries and that gives a distinctive vinegar smell. Many of these microorganisms are common in vineyards, depending on the region, and some infect berries and contaminate bunches in a similar way to botrytis. The incidence of different berry and bunch rots in vineyards is influenced by the presence of adequate inoculum (spores that trigger disease), berry and bunch susceptibility, bunch architecture (bunch tightness) and suitable weather conditions for infection and disease development. The *Non-botrytis rot questions and answers* factsheet on the Wine Australia website gives more information on other berry and bunch rots.

How botrytis invades grape tissue

Q4: Where are botrytis spores produced and how do they get to grapevine tissue?

Botrytis spores are almost always present in vineyards and are produced on many different plant species. Spores from decaying floral parts or leaf material within bunches or from bunch remnants in the vine canopy are more likely to cause bunch rots than spores from sources further away. These spores spread in air currents, by rain splash and by insect carriers (vectors) such as light brown apple moth (LBAM) caterpillars. Insects aid the movement of spores within and between bunches.

Q5: What are the main ways botrytis invades grape tissue?

The botrytis fungus invades (colonises) dead and decaying parts of plants and releases enzymes that move in advance of its colonisation to kill living tissues from which the fungus absorbs nutrients. Botrytis infects grape berries in two ways.

The first way involves latent or 'unseen' infection, which occurs from flowering onwards. When the flower cap falls, a strip of dead or necrotic tissue (the cap scar) is exposed at the tip of the central flower part (the receptacle or torus) (Figure 4). The fungus infects this tissue but it is inhibited from colonising the surrounding green tissue because it contains a high concentration of anti-microbial chemicals (stilbenes). When the berry ripens, the stilbene concentration declines allowing the fungus to resume its growth and rot the berry.

The second way the botrytis fungus infects berries is when spores or fungal threads (mycelia) from fungus

Figure 3: Botrytis bunch rot (Photo courtesy of K Evans, TIA)

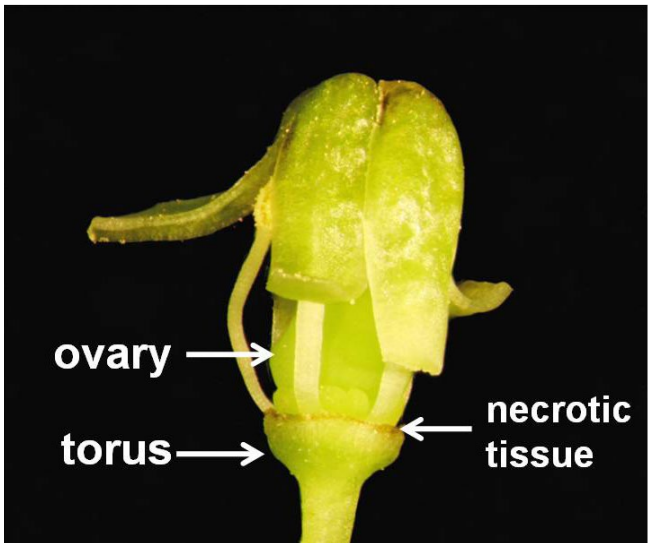

Figure 4: A grape flower at cap-fall with necrotic tissue (cap scar) that is a common site for botrytis infection in a young berry (Photo courtesy of M Longbottom, University of Adelaide).

on dead and dying plant tissues (such as flower debris, stems and leaves) infect berries after berry softening. The botrytis fungus is an opportunistic 'wound' pathogen that enters grape tissues through natural openings or wounds created by insects, birds, rain, hail, frost, sunburn or mildew fungi. The botrytis fungus can colonise berries that have become rotten after infection by the downy mildew fungus and even low levels of berry infection by the powdery mildew fungus creates microscopic holes through which the botrytis fungus can enter. Some wounds may not be visible to the naked eye and can include micro-fissures in the berry skin. Sugars and other cell contents such as amino acids can stimulate germination of botrytis spores. Infected berries 'leak', releasing more and more sugars as they ripen, creating a perfect environment for the germination of botrytis spores.

Q6: When are the critical times for botrytis infection?
Flowering is the first opportunity for latent infection of berries but latent infection may occur at any time after that. The frequency of latent infection can vary during a growing season and between seasons and sites, and it may increase after pre-bunch closure. Rain that causes berries to split (Figure 5) often leads to direct infection of ripening berries.

Q7: What conditions make botrytis worse?
Wounding increases the risk of berry infection. Examples of wounding include loose berry stalks (pedicels) and split berries, plus damage from insects, birds, mildew infection, frost, rain, hail, sunburn and machinery (e.g. wire lifting). Managing LBAM (Figure 6) and mildews is important for control of botrytis. The benefits of controlling LBAM are greatest when seasonal weather conditions are marginal for botrytis. When the weather is highly favourable, botrytis may be severe, regardless of the level of insect control. Any measure that prevents berry splitting helps to reduce botrytis risk.

Q8: What weather conditions favour botrytis?
Temperature determines how fast infection occurs. The optimum temperature for spore germination is 18–21°C, although some spores still germinate at temperatures below 10°C or above 30°C. A film of free water is essential for spore germination, with longer wetness periods needed to achieve the same level of infection at sub-optimum temperatures. Surface moisture can be created by rain, dew, mist or fog while high humidity may lead to sufficient condensation within the crevices of some tissues such as flowers. Temperature, relative humidity and wind speed determine the duration of surface moisture, and as a result, the level of infection.

Not all latent infections lead to rotten berries. Warm to hot and dry weather through summer and autumn can prevent the expression of latent infections in berries and the development of berry and bunch rots. The proportion of berries developing rots after latent infection appears to be correlated to high relative humidity, and possibly high soil water content.

Q9: What vine and canopy conditions favour botrytis?
Botrytis risk is highest in thin-skinned varieties with compact bunches in humid canopies carrying high crop

Figure 5: Berries with splitting caused by heavy rain. (Photo courtesy K Evans, TIA).

Figure 6: Botrytis bunch rot arising from Chardonnay berries and bunch tissue damaged by a light brown apple moth caterpillar. (Photo courtesy R Emmett, DEPI).

loads. Any canopy character that prolongs the duration of surface wetness in the bunch zone increases the risk of botrytis, especially in vineyards with excessive vigour and shoot congestion. In cool (and/or wet) climates, lifting wires on time to facilitate trimming or tipping will help improve airflow and spray coverage.

Berry-to-berry spread is faster in compact bunches than in loose bunches because berry skins have more pores and lower cuticle content. The berry cuticle is also thinner and there is less wax where berries touch each other in compact bunches. This allows the fungus to grow easily from berry to berry.

Bunch crowding promotes rapid bunch-to-bunch spread and may also lead to higher relative humidity in the bunch zone through the pooling or condensing of water in natural wells/pockets created by adjoining bunches.

Q10: Do conditions on the vineyard floor influence botrytis risk?

High soil water content during berry ripening may increase botrytis growth in berries after latent infection. Adequate drainage and vineyard floor management can prevent excess soil water, however, this may be difficult in years with high and frequent rainfall. Pooling of water in wheel ruts can also increase the humidity in the bunch zone. Upkeep of mid-row grasses by slashing can promote extraction of water from the soil. Keeping the under-vine area weed free can also help improve airflow below the cordons.

Some plants can increase the abundance and diversity of natural enemies of LBAM and reduce its botrytis-promoting activity in bunches when planted in the mid-row or adjacent to vineyards. More information can be found in the *Covercrops and vineyard biodiversity* factsheet on the Wine Australia website.

Practical management

Q11: How can early season botrytis infection be prevented?

Fungicide sprays are an effective means for preventing flower and berry infection. When botrytis risk is high, such as severe botrytis in the previous season, a high incidence of leaf botrytis and/or wet spring conditions, apply a protective fungicide at 80% cap-fall, when most of the cap scars are exposed. Monitor cap-fall and the weather forecast to ensure that fungicides are applied before rain. Evidence of the need for additional fungicide applications in wet conditions during periods of extended flowering is limited. Good spray coverage of the flowers (inflorescences) is vital. Adjust spray machinery for the best spray coverage of the bunch zone, which may include lowering sprayer air speed or travel speed.

Another critical time to apply protective fungicides for botrytis control is at pre-bunch closure (E-L 31). This is the last opportunity to achieve good spray coverage inside the bunch where latent infections often emerge. See Q 14 for fungicide use after bunch closure.

Q12: How can I manage botrytis if 'rot' appears in bunches between flowering and pre-bunch closure?

Signs of botrytis before bunch closure include 'grey mould' on aborted berries, damaged leaves, or in worst case situations, green fruit rot (Q 1, Figure 2). To prevent further spread of the disease, apply an effective fungicide for botrytis at pre-bunch closure, for example a product that contains the active ingredients 'cyprodinil plus fludioxonil'. Set up the sprayer to achieve good coverage inside bunches.

Before spraying, trim long shoots on vines with excessive growth to improve vine canopy airflow and spray penetration. In cool climates, improve spray coverage by removing leaves around bunches to provide about 70% bunch exposure. However, use caution as excess leaf removal can result in sunburn, over-exposed bunches and undesired phenolics in white varieties. To minimise sunburn, remove leaves from the side of the vines that receives the morning sun. Alternatively, remove fewer leaves on more than one occasion to gradually harden the berries to increasing sun exposure and eventually achieve the desired level of bunch exposure.

Blowing air into the bunch zone to dislodge infected 'bunch trash', after flowering and before bunch closure, is thought to reduce this source of botrytis spores. While this practice makes sense 'in theory', there is a danger that excessive air force will damage grape tissues and create wounds for botrytis infection. If experimenting with this practice, leave an area untreated to see if the procedure provided any benefit.

Q13: Can latent infections be eradicated or their development stopped?

Results from one trial conducted in Tasmania recently suggested that the product that contains the active ingredients 'cyprodinil plus fludioxonil', applied when berries were pea-size, reduced the amount of latent infection when it was assessed at pre-bunch closure.

As stated previously, not all latent infections lead to rotten berries (Q 8) and high relative humidity in the bunch zone and excessive soil moisture have been associated with activation of latent infections (Q 9).

Q14: How can botrytis bemanaged if bunch rot appears after bunch closure?

When berry rot appears after bunch closure, the objective of disease management is to slow berry-to-berry and bunch-to-bunch spread and reduce bunch rot severity.

Late season fungicide use. The challenge in spraying fungicides after bunch closure is that it is difficult to obtain good spray coverage inside the bunch where the fungus often emerges and spreads. If the use of products that contain the active ingredient iprodione is allowed by your winery, then it should only be used as a protective fungicide and **before** moderate levels of bunch rot have developed. When botrytis is present in very tight bunches, where juice is leaking from berries being pushed off the rachis (main stem), there can be a strong argument **not** to spray. This is based on lack of adequate coverage inside the bunch and the likelihood of further rotting from fruit breaking down. Application of iprodione to bunches with substantial rot will result in extensive exposure of the fungus to the fungicide and may promote fungicide resistance. The persistence of fungicide resistance can be reduced by confining the use of iprodione to pre-bunch closure or later in the following season. Also refer to Q 15 for information on the questionable use of sanitisers and other biodegradable products late in the season.

Canopy management after bunch closure. Bunch crowding promotes bunch-to-bunch spread of botrytis, therefore excess bunches should be removed to avoid this. At veraison, remove any later ripening bunches, bunch shoulders, bunches around trellis posts and damaged bunches.

In cool climates, removal of leaves in the bunch zone can improve airflow around bunches and penetration of fungicide sprays. Note that dense canopies will benefit more from leaf removal than sparse canopies.

Assess botrytis severity and adjust the harvest date. The simplest method to limit disease increase is to monitor botrytis symptoms and harvest early if botrytis risk is high. Assess botrytis severity using a valid, standard procedure and know what levels of botrytis the winery or grape buyer will tolerate. Mouldy bunches can be dropped onto the ground to reduce botrytis severity to meet winery specifications.

Q15: How effective are 'sanitisers' applied in the pre-harvest period?

When botrytis has appeared in bunches, it is tempting to apply a spray to reduce the disease. Sanitisers (e.g. products containing hydrogen peroxide plus peroxyacetic acid) and other biodegradable products have been promoted as they do not cause residue issues because they degrade readily. However, these products, at best, only inhibit the fungus on the surface of berries and even if the surface mould is killed, the infection inside the berry is likely to return. Spray coverage is also an issue with these products because the spray droplets may fail to wet the water repelling (hydrophobic) fungal mat (hyphae). Check to ensure applied spray does not simply result in 'beads' that do not cover the target. When berry botrytis has been killed it should change colour from grey, often to black, as the fungal colony dies. However, this may create more problems. The rotting berries and the dead fungal colony may be colonised by secondary bunch rot organisms, with unknown, possibly detrimental, impacts on wine quality. It is also important to check the weather pattern after spraying. In warm dry weather, sporulation and growth of the fungus will probably cease naturally and 'dry up'. If experimenting with a sanitiser, leave some vines and bunches unsprayed to see if the product worked.

Q16: How and when should spray coverage be improved?

Achieving good spray effectiveness starts with defining the spray target and the best time to protect that target. As 80% cap-fall is the time to prevent latent infection, attention should be paid to maximising coverage of inflorescences at this time, including adjusting air speed so that spray droplets hit the target. At pre-bunch closure, the target is the developing berries, especially inside the bunch. The spray itself can be directed solely to the bunch zone if no other disease is being targeted at that time. Various methods can be used to check spray coverage and spray drift, including water sensitive papers, spraying a highly visible kaolin clay product, or a fluorescent dye/black light kit.

Q17: What needs to be checked before spraying?

The quality of water used for spraying can have a profound influence on the effectiveness of spray materials. Check product labels or ask chemical resellers for advice on appropriate water quality

including pH, how to adjust the pH, and the compatibility of the product with other materials in the tank mix. Most importantly, check sprayer set-up and calibration, including which nozzles required.

Q18: Will adjuvants improve spray coverage?
Waxy grape berries are difficult to wet. Some research suggests that the use of wetters (a type of adjuvant) with products that contain the active ingredient iprodione may improve late-season control of botrytis. Read the product label or ask the chemical supplier as most product formulations already contain adjuvants and too much wetter added to the tank mix can result in less chemical being deposited on bunches.

Q19: What are the restrictions on chemical use?
Restrictions on the application timing of fungicides during the season are required to ensure maximum residue limits (MRL) are not exceeded. Ask your winery for specific recommendations or consult *Agrochemicals registered for use in Australian viticulture* (The dog book), available from The Australian Wine Research Institute (AWRI) website (www.awri.com.au). In short, spray programs should be designed to follow withholding periods and application per season guidelines to adhere to maximum residue limits and fungicide resistance management recommendations.

Q20: What is the effect of botrytis on winemaking?
The botrytis fungus produces an enzyme called laccase that promotes oxidisation of phenolic compounds in juice. This can lead to a loss of colour in red wine and off flavours, odours (e.g. earthy, mushroom) and other biochemical changes which cause a reduction in wine quality. The presence of secondary bunch rotting organisms can compound the problem further; for example, in cool climates, botrytis can interact with *Penicillium* (blue-green mould) to produce geosmin, a compound that causes strong, damp, earthy aromas in wine.

It is important to understand the grape purchaser's level of tolerance for grape botrytis. For some grape varieties, there may be some tolerance for botrytis but a grape price penalty may be imposed to cover the additional costs associated with winemaking. In other cases, the tolerance may be nil. Obtain feedback from the winery so that you can record your assessment of botrytis incidence and severity (at harvest) against the actual wine making outcome. Collect records that are specific to your varieties and the end use of the grapes to better understand the impact of botrytis.

For further information on botrytis management and processing options and strategies for dealing with botrytis-infected fruit, please call the AWRI Helpdesk on (08) 8313 6600.

Q21: Will spraying well be enough to manage botrytis?
There will be seasons when we have to accept that very favourable weather for botrytis can undo our best efforts in the vineyard. Higher canopy vigour, more compact (tighter) bunches, increased pedicel damage and berry splitting are often common in wetter seasons. A season-long spray program may not be enough to control botrytis when the risk of disease is very high.

In wet seasons, it can be very tempting to keep on spraying as long and as much as possible; however, once botrytis becomes highly visible in the vineyard and the weather forecast is for ongoing rain, it sometimes can be more cost-effective to do nothing and harvest as much as possible and as early as possible. Under these conditions, spraying provides very little, if any, extra benefit relative to the cost (e.g. fuel, labour, fungicides). The risk of fungicide resistance and elevated residues in the crop are added issues to consider.

Appropriate management of winter pruning, nutrition, shoot and bunch thinning to manage yield potential, reduction of canopy congestion and crop exposure can reduce botrytis risk significantly and hasten ripening for an earlier harvest. Even so, botrytis-prone varieties planted at the 'wrong' site may suffer severe botrytis in more seasons than can be tolerated. In these cases, removing the vines might be the most cost-effective option.

Finally, during years when it keeps on raining, it is vital to keep reviewing the conditions and weather forecasts, know your pest and disease 'pressure', reassess your options (to spray or not to spray, product choice and timing, canopy management), react accordingly, and communicate well with winemakers about disease thresholds and harvest dates.

Acknowledgements

The authors thank Liz Riley from Vitibit Pty Ltd; Jim Caddy and Andrew Weeks from CCW Cooperative; Kristy Bartrop from the Riverina Wine Grapes Marketing Board; Richard Hamilton from Hamilton Viticulture; Peter Magarey from Magarey Plant Pathology and Marcel Essling from AWRI for their assistance in the production of this document.

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Further information

For more information on botrytis management, go to the Wine Australia website: www.wineaustralia.com

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This factsheet was first published in July 2013.