

Botrytis

Questions and answers

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Australian Government
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Development Corporation



Identifying the disease

Botrytis rot, caused by *Botrytis cinerea*, is one of a 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.

Q 1. When is botrytis first seen and what does it look like?

Shoot, leaf, flower and early berry 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, individual immature berries in bunches develop a soft brown rot (mid-season rot or green berry rot, Figure 2 overleaf) 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 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.



Figure 1. Botrytis on berries in Chardonnay bunches damaged by downy mildew (Photos: RW Emmett, DPI Victoria)

Identifying the disease (continued)



Figure 2. Botrytis green berry rot in Chardonnay bunches (Photos: RW Emmett, DPI Victoria).



Figure 3. Botrytis bunch rot (Photos: KJ Evans, TIAR).

Identifying the disease (continued)

Q 2. Is the rot botrytis?

Botrytis can be identified by looking at the fungal growth on rotting berries or other vine tissues with a x10 hand lens (magnifying glass) or dissecting microscope. Clusters of light grey or colourless spores at the ends of branched dark brown stalks (Figure 4) confirm that the rot is caused by *Botrytis cinerea*.

Q 3. 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* (blue mould), *Alternaria* spp., *Cladosporium* spp., *Colletotrichum* spp. (ripe rot), and *Greeneria uvicola* (bitter rot). Sour rot is caused by a mixture of microorganisms that cause 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. See the GWRDC's *Non-Botrytis Bunch Rots: Questions and answers* for more information on other berry and bunch rots.

Q 4. 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.

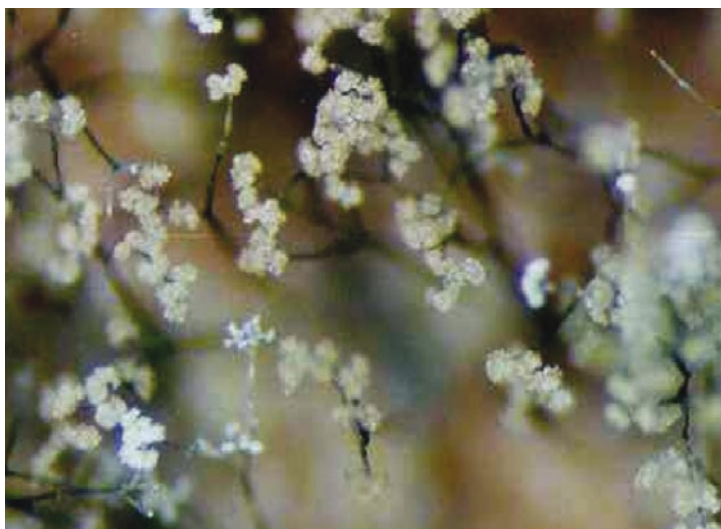


Figure 4. Spore heads of *Botrytis cinerea* (Photo: KJ Evans TIAR).

Q 5. 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 (necrotic) tissue (the cap scar) is exposed at the tip of the central flower part (the receptacle or torus, Figure 5). 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 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 /damage created by insects, birds, rain, hail, frost, sunburn, mildew fungi or wire lifting. 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 create 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. Both infected berries and berries which have broken away from the berry stem but remain in the bunch will release sugar-rich juice, creating a perfect environment for the germination of botrytis spores.

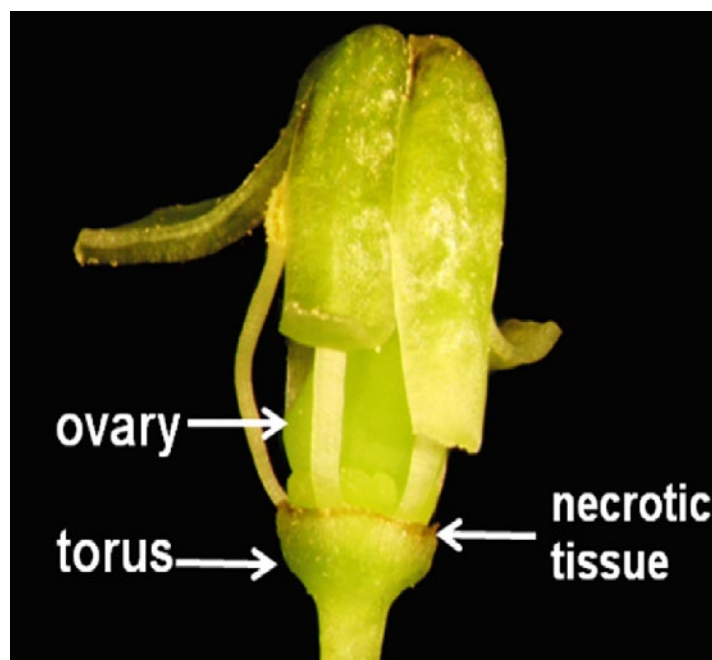


Figure 5. A grape flower at cap-fall with necrotic tissue (cap scar) that is a common site for botrytis infection in a young berry (Photo: M Longbottom, University of Adelaide).

How botrytis invades grape tissue and spreads

Q 6. 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. It is important to note that not all latent infections lead to rotten berries (Q 7). Rain that causes berries to split (Figure 6) often leads to direct infection of ripening berries.

Q 7. 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.

As stated in Q 6, 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 moisture.

Q 8. What conditions make botrytis worse?

Wounding increases the risk of berry infection. Managing LBAM (Figure 7) 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 limits the extent of berry splitting along with careful wire lifting helps to reduce botrytis.

Q 9. What vine and canopy conditions favour botrytis?

Botrytis risk is highest in thin-skinned varieties with compact bunches in humid canopies carrying high crop loads. Any canopy character that prolongs the duration of surface wetness in the bunch zone increases the risk of botrytis, especially excessive vigour and congestion created by inadequate shoot spacing or a high number of shoots. 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.



Figure 6. Berries with splits caused by heavy rain.
Photo: KJ Evans, TIAR.



Figure 7. Botrytis bunch rot arising from Chardonnay berries and bunch tissues damaged by a light brown apple moth caterpillar. Photo: RW Emmett, DPI Victoria.

How botrytis invades grape tissue and spreads (continued)

Q 10. Do conditions on the vineyard floor influence botrytis risk?

High soil moisture during berry ripening may increase botrytis growth in berries after latent infection. Adequate drainage and vineyard floor management can prevent excessive soil moisture, except, perhaps, in years with high and frequent rainfall. Pooling of water in wheel ruts can also increase the humidity in the bunch zone. Maintaining a mid-row sward can promote

extraction of water from the soil, and keeping the under-vine area weed free can also help improve airflow below the cordons.

Some mid-row plants can increase the abundance and diversity of natural enemies of LBAM and reduce its botrytis-promoting activity in bunches. Having tall mid-row plants, however, can reduce airflow. The type and extent of vegetation adjacent to vineyards, whether shelterbelt or remnant, may also encourage natural pest control. However, many plant species can also be hosts for over-wintering populations of LBAM.

Practical management

Q 11. 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. See Q 19 for selection of an appropriate fungicide. 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, so adjust spray machinery for the best spray coverage of the bunch zone. This may include lowering sprayer air 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.

Q 12. 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 and/or on 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 (Q 19). Set up the sprayer to achieve good coverage inside bunches.

Before spraying, trim long shoots on vines with excessive growth to improve vine canopy aeration and spray penetration. In cool climates, improve spray coverage by removing leaves around bunches to provide about 70% bunch exposure. However, leaf removal can result in sunburn, over-exposed bunches and undesired phenolics in white varieties, so consider the consequences of this practice. 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. At present, there are no scientific reports to support this practice and there is a danger that the force of the air, if too high, 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.

Q 13. Can latent infections be eradicated or their development stopped?

A number of fungicides specific to botrytis have been shown to reduce latent infection when it was assessed soon after application at veraison or earlier in berry development. Note that there can be severe restrictions on fungicide selection after flowering (Q 19). 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).

Q 14. How can botrytis be managed 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 a product registered for use at this time 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 that are leaking juice 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 a product with 'single site' chemistry to bunches with substantial rot will result in extensive exposure of the fungus to the fungicide and promote fungal populations with fungicide resistance. 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

Where bunches are in close contact, bunch thinning may be necessary to reduce bunch to bunch spread of botrytis.

At veraison, remove 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. Note that dense canopies will benefit more from leaf removal than sparse canopies. Leaf removal can also improve the penetration of fungicide sprays and botrytis control.

Assess botrytis severity and adjust the harvest date

The simplest method to limit disease increase is to monitor botrytis symptoms and to 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 or those from severely rotten sections of a block can be dropped to the ground to reduce overall botrytis severity of the remaining crop.

Q 15. How effective are 'sanitisers' applied in the pre-harvest period?

When botrytis berry rot (grey mould) has appeared in bunches, it is tempting to apply a spray to reduce the disease. Sanitisers (e.g. the product containing hydrogen peroxide plus peroxyacetic acid) and other biodegradable products have been promoted for this purpose because they do not develop 'fungicide resistance' and do not leave residues because they degrade readily.

However, these products, at best, only inhibit the fungus on the surface of berries and even if the surface grey mould is killed, the infection inside the berry is likely to 'come again'. Spray coverage is also an issue with these products because the spray droplets may fail to wet the water repelling (hydrophobic) fungal mat.

Check spray application to ensure the droplets spread and do not simply result in 'beads' that do not cover the target. If the surface 'grey mould' has been killed it should change colour (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 sunny and dry weather, sporulation and growth of the fungus will probably cease naturally and 'dry up'. If experimenting with a sanitiser, including multiple applications to see if it has an effect, then leave some vines and bunches unsprayed to see if the product worked.

Q 16. 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 do not miss the target completely. 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 the fluorescent dye/black light kit commercialised by the South Australian Research and Development Institute (SARDI).

Andrew Landers from Cornell University recently published a book called *Effective Vineyard Spraying: A Practical Guide for Growers*, which can be ordered from www.EffectiveSpraying.com. In short, adjust sprayer set up and ground speed to best fit the target.

Q 17. 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 are to be switched on or off. If there is any chemical left in the tank after spraying, then ask why.

Q 18. 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 the product that contains the active ingredient iprodione may improve late-season control of botrytis. However, too much wetter added to the tank mix can result in less chemical being deposited on bunches. An adjuvant should be used only if it is required. Most product formulations already contain adjuvants, so adding more is unlikely to provide any benefits. Selecting the right wetter and rate for the site and sprayer requires specific tests. The simplest strategy is to read the product label or ask the chemical supplier how to use the product for best results.

Q 19. What are the restrictions on chemical use?

Limits on the time of application of particular fungicide products in the season are required to minimise the risk of undesirable chemical residues in wine. Ask your winery for specific recommendations or consult the guidebook *Agrochemicals registered for use in Australian viticulture* (Dog Book). The latest version of this important booklet can be downloaded from the website of the [Australian Wine Research Institute \(AWRI – www.awri.com.au\)](http://www.awri.com.au). In short, spray programs should be designed to allow for product withholding periods that meet maximum residue limits, and for fungicide resistance management.

Q 20. What is the effect of botrytis on winemaking?

The botrytis fungus produces an enzyme called laccase that promotes oxidation of phenolic compounds in juice. This can lead to a loss of colour in red wine. Off flavours, odours (e.g. earthy, mushroom) and other biochemical changes in botrytis-affected grapes can also 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 mould) to produce geosmin, a compound that causes strong, damp, earthy aromas.

It is important to understand your winery's level of tolerance for grape botrytis. There may be nil tolerance for some grape varieties and wine styles whereas the winemaker may be prepared to undertake remedial wine making for other wine styles and cover the costs by imposing a price penalty on the grapes supplied. Obtain feedback from the winery so that you can record your assessment of botrytis incidence or severity (at harvest) against the actual wine making outcome. Build records that are specific to varieties and the end use of the grapes to assist fine tuning of the tolerated level of botrytis severity, a matter that is important for your business.

For further information on processing options and strategies for dealing with botrytis-infected fruit, please call the AWRI's Winemaking and Extension Services team on 08 8313 6600.

Q 21. 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. Higher canopy vigour, more compact (tighter) bunches, increased pedicel damage and berry splitting are often features of 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 simply walk away or harvest as much as possible and as early as possible. As with all management decisions, the likely extra benefit of spraying relative to the cost (e.g. for fuel, labour, target-specific fungicides) should be considered. The risk of fungicide resistance and elevated residues in the crop are added problems.

In cool climates (or high input viticulture), winter pruning, nutrition, shoot and bunch thinning to manage yield potential, 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 (Q8), 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.

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Further information

1. Refer to the GWRDC's Innovators Network website for the Botrytis Fact Sheet, Powerpoint presentation and presentation notes on botrytis management prepared by Dr Kathy Evans.
 - [Botrytis fact sheet](http://www.gwrdc.com.au/webdata/resources/files/BotrytisFactSheet.pdf)
<http://www.gwrdc.com.au/webdata/resources/files/BotrytisFactSheet.pdf>
 - [Botrytis technical notes](http://www.gwrdc.com.au/webdata/resources/files/BotrytisTechnicalNotes.pdf)
<http://www.gwrdc.com.au/webdata/resources/files/BotrytisTechnicalNotes.pdf>
 - [Botrytis presentation](http://www.gwrdc.com.au/webdata/resources/files/Botrytis_Presentation.pdf)
http://www.gwrdc.com.au/webdata/resources/files/Botrytis_Presentation.pdf
2. Evans K.J. (2008) Overview of R&D for managing botrytis bunch rot in Australia. In: Proceedings of the ASVO seminar 'Breaking the Mould: a Pest and Disease Update', K. DeGaris, M. Krstic, G. McCorkelle, S. McLoughlin (Eds), Australian Society of Viticulture and Oenology Inc., Adelaide, South Australia, pp. 4–15.

3. Magarey P.A., MacGregor A.M., Wachtel M.F. and Kelly M.C. (Eds) (1999) *The Australian and New Zealand Field Guide to Diseases, Pests and Disorders of Grapes*. A companion to 'Diseases and Pests', Grape Production Series No.1. Winetitles, Adelaide, South Australia. 108 pp.
4. Nicholas P., Magarey P. and Wachtel M. (Eds) (1994) *Diseases and Pests*, Grape Production Series No.1. Winetitles, Adelaide, South Australia. 106 pp.
5. Riley L. (2008) Practical management of bunch rots in high risk environments. In: Proceedings of the ASVO seminar 'Breaking the Mould: a Pest and Disease Update', K. DeGaris, M. Krstic, G. McCorkelle, S. McLoughlin (Eds), Australian Society of Viticulture and Oenology Inc., Adelaide, South Australia, pp. 19–23.

Authors

Dr Katherine J Evans, Tasmanian Institute of Agricultural Research (TIAR), University of Tasmania, New Town TAS and Dr Robert W Emmett, Department of Primary Industries, Mildura VIC.

