Wine Australia for Australian Wine

Factsheet

January 2012

Managing vines during heatwaves

Peter Hayman, South Australian Research and Development Institute (SARDI); Mardi Longbottom, Australian Wine Research Institute (AWRI); Michael McCarthy, (SARDI); Dane Thomas, (SARDI)

What is a heatwave?

A heatwave is a prolonged period of excessively warm weather. The effects of a heatwave on winegrapes will vary depending on the location of the vines. This is partly because vines acclimatise to certain conditions but also because viticulturists design irrigation systems and manage vineyards with a sense of what is normal or expected in their region.

The South Australian Regional Office of the Bureau of Meteorology (Bureau) defines a heatwave as either 5 consecutive days with maximum daily temperatures above 35°C, or 3 consecutive days with maximum daily temperatures above 40°C. Many viticulturists in southern Australia make vine management decisions based on this definition.

What causes hot days in Australian winegrowing regions?

In all Australian winegrowing regions, very hot days are generally associated with a wind bringing heat from the interior of the continent. This is obviously the case for coastal regions on the mainland, but is also true for Tasmania. Likewise for warm inland regions, the source of extreme heat is northerly winds from the desert. Figure 1 shows how summer for many of the winegrowing regions of southern Australia is dominated by high pressure systems, which are about 2000–3000 km in diameter and usually take 5–7 days to cross Australia from west to east. One of the keys to reading a weather map is to follow the anticlockwise movement of air around high pressure systems and the clockwise movement around low pressure systems. The leading edge of a high pressure system brings cool air from the Southern Ocean; the following days warm up as the middle of the high pressure system brings stable, still conditions; and the trailing edge brings the hot inland air.

But what causes a run of hot days?

The weather patterns at the tail end of a high pressure system explain a hot day but do not explain a run of exceptionally hot days. For heatwaves in winegrowing regions in south-eastern Australia, a high pressure system needs to stay in the same position in the Tasman Sea. This is what meteorologists refer to as *blocking* and occurs where the pattern in Figure 1b persists and is strengthened.

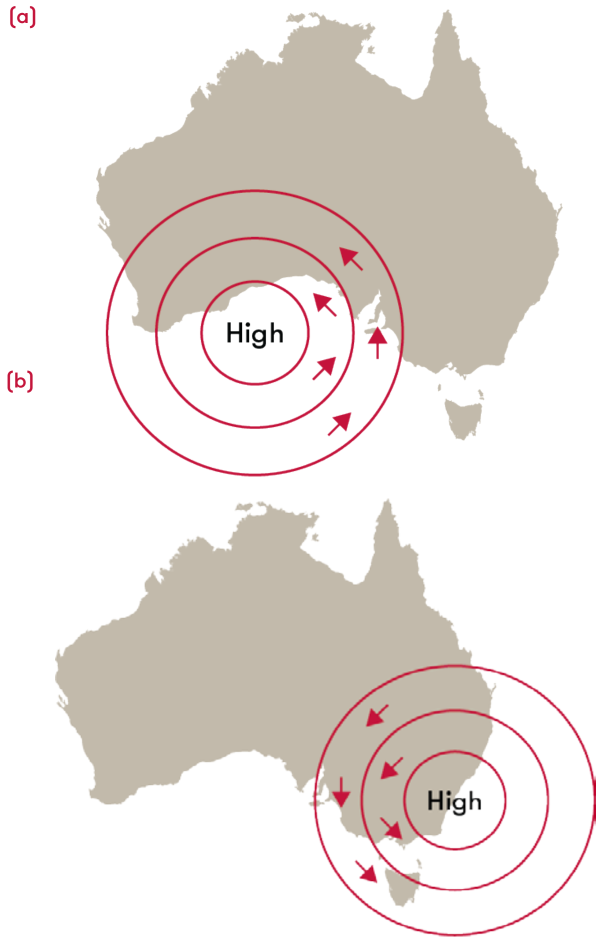
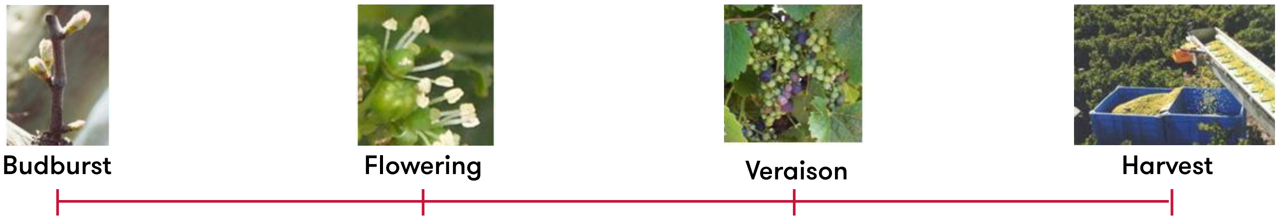


Figure 1: Schematic of airflow across SE Australian wine regions when high pressure system is in the a) Great Australian Bight or b) Tasman Sea. Note that a high pressure system will move across land quite quickly.



Flowers are highly susceptible to heat, wind and water stress. Exposure to extreme weather events may result in poor fruitset = **yield loss**

Grapes become more susceptible to heat damage as they soften. Dark coloured grapes may get much hotter than the surrounding air temperature. Berries may shrivel or be sunburnt. Losses may also occur at the winery due to the increased requirement for cooling = **loss of yield and quality**

Figure 2: The susceptibility of grapevines to yield and quality losses as a result of extreme heat varies according to their developmental stage

How reliable is the forecasting of heatwaves?

Heatwaves are rarely a surprise to weather forecasters. The synoptic conditions that lead up to a heatwave are well understood and easily recognised. Exactly how hot it will be and the duration of a heatwave are much more difficult to predict. Recent heatwaves (February 2004, March 2008 and January 2009) were well predicted by the Bureau. A feature of the March 2008 and January 2009 heatwaves was their long duration and this could not be predicted at the beginning of the heatwaves, but during these heatwaves the Bureau was able to provide information on their likely duration and the expected time before cooler conditions would return.

What damage to grapevines can be caused by heatwave events?

The effects of extreme heat on grapevines vary depending on the timing of the heat event relative to the developmental stage (or phenology) of the grapevine (Figure 2).

Recent extreme heat events in winegrowing regions in south-eastern Australia have highlighted the industry's vulnerability to heatwaves and enabled us to learn some of the best ways to manage these events. The two heatwaves shown in Figure 3 represent an event that was unusually late in the season (March 2008) and one that was unusually early (November 2009), and the impact of these events on varieties differed. The impact and lessons from the Black Saturday heatwave in January and February 2009 are well documented by Webb et al. (2009). Between 30 January and 6 February 2011, the Hunter Valley experienced a heatwave that was not only hot, but also exceptionally humid (Bureau of Meteorology 2011). This contrasts with southern Australian events, which are associated with extremely drying conditions.

March 2008 – autumn heatwave

This heat event (Figure 3) was a major concern for many of the cooler regions and late ripening varieties. Vines were defoliated and grapes suffered from sunburn and heat damage. Ripening was temporarily delayed and harvest intake schedules were thrown into disarray.

November 2009 – late spring heatwave

Varieties that were flowering during this heat event (Figure 3) suffered from poor fruitset and subsequent low yields. Examples of this were observed on Grenache in the Barossa and Merlot in the Limestone Coast.

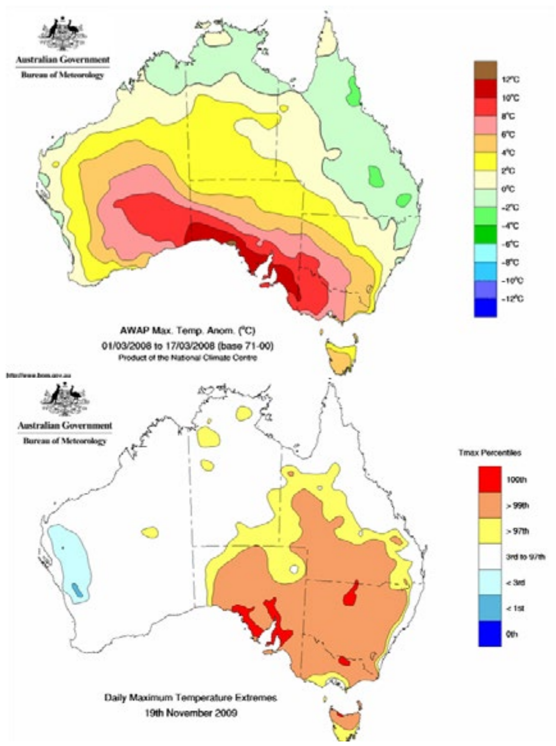


Figure 3: Two recent heat events in Southern Australia (top) maximum temperature anomaly across Australia, 1-17 March 2008; and (bottom) maximum temperature as percentile of November for 19 November 2009 (Australian Bureau of Meteorology).

How do grapes and grapevines get hot?

Bunch temperature is determined by:
- air temperature
- absorbed radiation (from both incoming and reflected radiation), and
- convective heat loss (through evaporation / transpiration) (Figure 4).

As incident radiation (sunlight) intensity increases, so does bunch temperature.

Bunch temperature depends on:
- vine water status
- radiation load
- wind velocity
- the degree of exposure
- berry/bunch size and compactness
- berry colour. White berries and green berries before veraison don't get as hot. Dark berries in the sun and under low wind conditions can get much hotter than the surrounding air temperature (up to 15°C greater than ambient temperatures) due to incoming and reflected radiation.

What strategies should we employ to protect grapevines from extreme heat?

1. Maximise transpirational cooling

Water loss through the open stomata of grapevine leaves has a cooling effect on the leaves and the surrounding environment. Vineyard experiments have shown large differences in canopy temperature that result from differences in irrigation and grapevine transpiration rates (Figure 5).

Transpiring grapevines will contribute to vineyard cooling. Another way to achieve cooling of the vineyard is with the use of sprinklers.

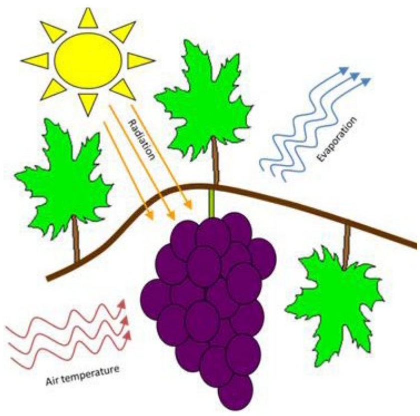


Figure 4: Bunch temperature is determined by air temperature, absorbed radiation and evaporative cooling.

2. Minimise incoming radiation

Incoming radiation intensity (or bunch exposure) can be reduced by natural shading provided by the canopy. A good canopy should be established early in the season through careful management of pruning, irrigation and nutrition. Radiation absorption can also be reduced using row orientation (applicable to new vineyards), the trellis system, foliage wires and artificial shading. Radiant heat may also be reflected from bare soils. Measures to reduce this are discussed later.

Action guidelines for extreme heat events

These guidelines are aimed at established vineyards in the season of an extreme heat event. Longer-term strategies for dealing with heat events are outlined later in this document.

When dealing with limited resources such as water availability or an irrigation system, prioritise varieties and/or blocks according to their value, sensitivity to damage (developmental stage), soil depth/texture, aspect, age and type of grapevine rootstock (if present).

Based on your prioritisation:

What to do immediately BEFORE a forecast heatwave

- Apply irrigation and refill as much of the rootzone as possible to field ahead of the forecast heatwave.
- If a deficit irrigation strategy is being employed, resupply irrigation.

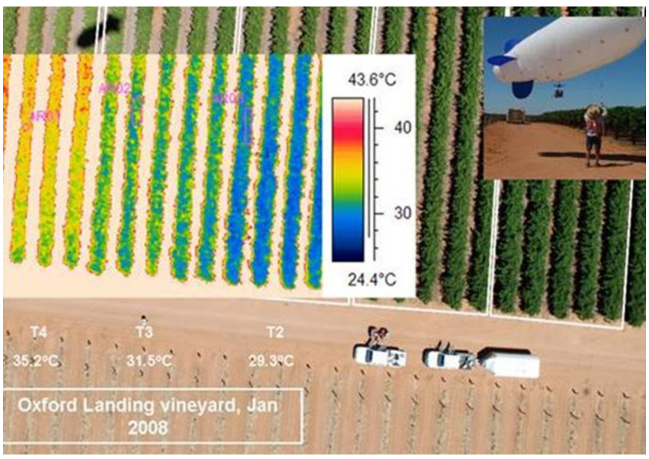


Figure 5: Aerial images of an irrigation trial in the Riverland, South Australia, on 9 January 2008. Treatments T0 to T4 received irrigation ranging from approximately 6 ML/ha (T0) to less than 1 ML/ha (T4). A thermal image is superimposed over the digital image for T2,T3 and T4, clearly showing the large differences in canopy temperature that result from differences in transpiration rate. T4 is approximately 8 degrees hotter than T2. The ambient temperature was between 34 and 35°C during the measurements. (Image provided by Brian Loveys, CSIRO, from the work of Ashley Wheaton, University of Melbourne. This work resulted from a collaboration between the University of Melbourne, University of Dundee, CSIRO, SARDI and Yalumba Oxford Landing Estate).

- Consider applying a sunscreen spray (check with your winery before application to ensure that these products are approved).
- Reconsider any planned leaf removal or canopy manipulation (e.g. foliage wires) strategy that may lead to increased bunch/berry exposure.

Remember that if the heatwave does not eventuate, it is still very likely to be hot to very hot, so any pre-emptive action will not be wasted.

What to do DURING a heatwave

- Apply irrigation to maintain soil moisture at a level that enables vines to regain their turgor overnight in preparation for the next hot day. If using overhead irrigation, apply at night to avoid foliage burn.

What to do AFTER a heatwave

- Irrigate to replace lost soil moisture and decrease soil temperature.
- Monitor for pests and diseases that may have exploited damaged berries. Note that the symptoms of heat damage may take a few days to appear. If secondary invasion (from pests and/or diseases) is an issue, follow the recommendations outlined in Agrochemicals registered for use in Australian viticulture (the Dog Book), available at http://www.awri.com.au/industry_support/viticulture/agrochemicals/agrochemical_booklet/booklet.pdf

Action guidelines for vineyard managers before, during and after a heatwave

Before	During	After
Irrigate*	Irrigate*	Irrigate*
Cease deficit irrigation		Monitor for pests and diseases
Reconsider any leaf removal or canopy manipulation strategy		

*See the following section on Irrigation for further discussion of irrigation requirements.

Best practices for the management of heat in established vineyards

Irrigation*

Enough water should be applied to vines early in the season to ensure the development of a healthy canopy that can be maintained throughout the growing season to protect bunches from exposure. If a deficit irrigation strategy is being employed and an extreme heat event is forecast, reapply irrigation to field capacity. Grapevines should be irrigated before an extreme heat event to maximise transpirational cooling and prevent physiological damage. As stated earlier, apply irrigation to refill the soil profile or maintain soil moisture at a level that enables vines to transpire sufficiently to allow evaporative cooling. If using overhead irrigation, apply at night to avoid foliage burn.

Irrigation infrastructure

Consider the capacity of the irrigation system to deliver the required quantity of water for the entire vineyard. In many cases it is impossible to irrigate the whole vineyard before every forecast heat event, or the delivery rate of the irrigation system (mm/hr) may not be sufficient to meet the demands of the grapevines. It is critical to identify and prioritise blocks according to both their value and the sensitivity of their stage of development to heat stress.

Water quality

Ensure that irrigation water applied to grapevines is of adequate quality. The application of saline water, especially through sprinklers, may result in defoliation, and this will be exacerbated under highly evaporative conditions such as occur during heatwaves.

Water availability

In vineyards where water supply is restricted or unavailable, other strategies to conserve soil moisture should be considered. Examples of these might include spraying out or mowing the midrow sward, or the application of compost or mulch to the under-vine area. If mulch is applied, the dripper line should be located underneath the mulch.

Other considerations

Applying additional irrigation to the vineyard may be expensive and/or costly in terms of allocation volume. It is important to consider seasonal water allocations and the seasonal water budget to ensure sufficient water supply until the end of the season, especially if water demand is high in spring due to early heatwaves. In the event of extreme heat conditions, it is unlikely that over-watering will have a detrimental effect on vine growth. Increased canopy humidity and/or free moisture (in the case of overhead irrigation) may increase the potential for development of fungal diseases. However, under heatwave conditions this risk is relatively low.

Canopy management

Canopy management practices should be designed to achieve the desirable level of bunch exposure to influence fruit compositional characters as well as disease management, and protection/shading from the sun. The simplest way for winegrape producers to protect bunches from exposure is through canopy management (shading of bunches by leaf layers) and by changing the reflective surface properties of the inter-vine rows (discussed later). Grapevine leaves are effective at absorbing photosynthetically active radiation (PAR). Therefore, only one leaf layer is required to protect a bunch from direct radiation.

Pruning

The aim of pruning is to achieve a balance between yield and vegetative growth in the following season. Overcropping will be at the expense of protection by leaves later in the season. Cane-pruned vines and young vines may be at risk of the canopy rolling and exposing fruit. Consider additional support for these canopies (e.g. foliage wires).

Trellis type

In 2009, vineyards with sprawling, non-positioned canopies had the least heat damage, and vertically shoot positioned (VSP) trellis had the most heat damage, particularly in cool regions with a high proportion of VSP trellis and bunchzone leaf removal. The increased bunch exposure provided by a VSP trellis may be desirable in a cool, cloudy and wet climate; however, in warm to hot and sunny climates, single-wire sprawl systems may produce comparable yield and wine composition with less risk of bunch heat damage and loss in quality.
In warm to hot and sunny climates, VSP trellis may be retrofitted with a narrow T and fixed foliage wires, either directly above or displaced to the west (on N-S rows). This will produce a protective veranda effect. Alternatively the western side of N–S rows may be loosely lifted to produce a 'lazy ballerina' (Figure 6).

Leaf removal

Bunch zone leaf removal is commonly used in cool climates to reduce disease risk and enhance fruit composition. If the aim of leaf removal is to avoid bunch rots, consider alternative strategies such as basal leaf removal at flowering to decrease bunch compactness (Poni et al. 2009). Lateral leaf growth in the bunch zone later in the season may compensate for the early leaf removal and provide protection of bunches.
In hot, dry and sunny regions, leaf removal is unlikely to have the same positive effects as in cool and humid regions. In these hot, dry and sunny regions, leaf removal should be avoided altogether or, if necessary, only remove leaves from the eastern side of N–S rows.

Artificial shading

Tablegrape producers sometimes use artificial shading to prevent bunch overexposure. In many cases, winegrape vineyards have the existing infrastructure to support artificial shading. The installation of artificial shading may be considered for high-value or heat-sensitive grapevine varieties.

Mid-row management

The mid-row of a vineyard is an important source of reflected heat, even more so than the under-vine strip due to its greater area. In 2009, vineyards with bare soil suffered the most heat damage. Vineyards with stubble or mown sward in the mid-rows and mulch (mostly under-vine) suffered less heat damage than those with bare soil (Webb et al. 2010).

Consider growing a mid-row cover crop or maintaining a mid-row sward throughout the season. In low-rainfall regions, the cover crop can be mown or sprayed out in spring to avoid competition with vines. Mown mid-row crops may be thrown into the under-vine strip to provide mulch to this area.

Reflective sprays

A number of 'sun protection agents' or 'sunscreens' can be applied to grapevines as foliar sprays to reduce visible radiation, reflect UV and infrared, and reduce transpirational loss. These particle film technologies (PFTs) are:

- products based on processed and refined kaolin (e.g. Surround®, Screen®)
- calcium carbonate crystals (e.g. Parasol®)

Australian research has shown that these products may be used to reduce leaf temperature and increase juice sugar and acids without any affect on yield (Cooley et al. 2008).

PFTs are not considered to be agrochemicals and, as such, do not require registration for use on grapevines. However, advice should be sought from the purchasing winery regarding the use of these sprays to avoid potential grape and wine residues that may be detrimental to quality.

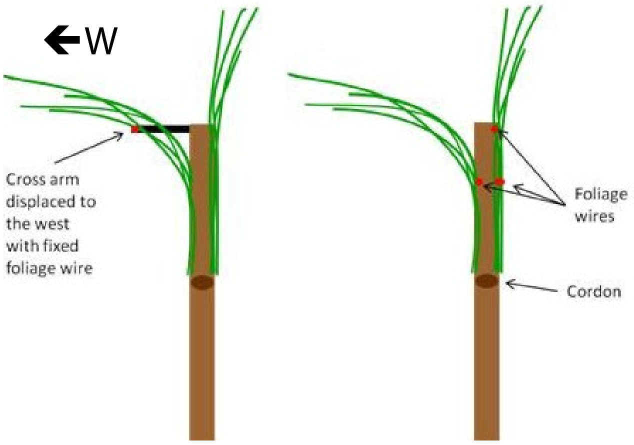


Figure 6: Examples for conversion of VSP trellis on N–S rows; retrofit with a cross arm displaced to the west (left) or a 'lazy ballerina'(right) on the west side of the row to create shading in the afternoon.

Best practices for the management of heat in new/redeveloped vineyards

Vineyard design – row orientation

North–South rows are common in Australia; however, the thermal properties of bunches on the western side of a row are very different to those on the eastern side due to differences in incoming radiation levels over the course of the day.

In warm to hot and sunny climates, protection of bunches from over-exposure should be considered when deciding the row orientation of a vineyard. For VSP and other trellis systems with vertical canopy faces, the use of E–W or NW–SE (NE–SW in the northern hemisphere) should be considered so that the daily sun track is over the top of the canopy.

Variety choice

Grape varieties differ in their drought and heat tolerance. As the climate becomes warmer and drier, there will be an increasing need to grow those varieties that are more tolerant and it is therefore important that we know which characters to look for in both existing and new varieties.

Some of the ways that different varieties can influence water use and thus drought tolerance include:

- Stomatal control: grape varieties vary in their ability to control water loss due to transpiration. For example, Grenache maintains its water supply longer than Shiraz by closing stomata sooner in response to a soil water deficit.
- Leaf area: transpirational water loss increases in proportion to the size of the grapevine canopy. Varieties that maintain vigorous shoot growth (e.g. Shiraz) under conditions that would inhibit others (e.g Cabernet Sauvignon) require more water.
- Hydraulic conductivity: some grape varieties are more susceptible to cavitation (the forming of a vacuum) in the xylem (Keller 2010) under water stress and may be less efficient at extracting and transporting water around the vine.
- Root/shoot ratio: varieties such as Shiraz maintain a larger root/shoot ratio than varieties that are more susceptible to water stress (e.g. Grenache) (Keller 2010).

Heat and drought tolerance are not one and the same but they are indirectly related. For example, preservation of leaf area in drought will reduce the likelihood of heat damage to bunches. On the other hand, since transpirational cooling is essential to reduce leaf damage, varieties that close their stomata in response to heat stress may be more susceptible to leaf damage if soil water status is low. For this reason, irrigation management may need to be tailored according to variety during heatwaves.

Rootstocks

Rootstock choice is also an important consideration when planning a new vineyard or redeveloping blocks as different rootstock varieties have varying tolerances to drought. Further information about rootstock selection for drought tolerance can be found on the websites of the Phylloxera & Grape Industry Board of SA www.phylloxera.com.au and the Yalumba Nursery www.yalumbanursery.com.

Irrigation design

As discussed earlier, the capacity of the irrigation system is an important consideration when designing a vineyard. Ensure that the system can deliver sufficient water to the entire vineyard in the event of a forecast heat event. Use a licensed irrigation engineer/designer when planning the installation of any new irrigation system to ensure that the system has sufficient capacity and delivery rate under extreme heat conditions.

Forecasts of heatwaves in the coming season or the coming decades

It is something of a paradox that climate scientists are much more confident to bet on there being more heatwaves in 2030 than being able to say anything about next year. As the world warms the frequency of heatwaves is likely to increase, but there will still be variability on a year by year basis.

One of the advantages of the large amount of resources going into understanding climate change is that there will be improved models of local climate. Because of the economic and human cost of heatwaves they will be a high priority for research. A challenge for the winegrape industry is to access this information and use it in practical risk management frameworks. In the past, it may have been the case that the message about a coming heatwave was not communicated. The risks of bushfire and human heat stress mean that it is likely that there will be plenty of warning of heat waves in the future. The challenge will be for grapegrowers to appropriately manage the risk once warned.

Using climate information to manage the risk of heatwaves

The table below shows the four outcomes of a weather forecaster predicting a heatwave and a winegrape grower acting on the warning. The two columns show the predictions and the two rows show what happened.

	Heatwave forecast	No heatwave forecast
Heatwave 	**True positive** Some damage from heatwave but loss is reduced by extra water applied prior to the event	**False negative** Severe damage from heatwave as action was too late to minimise the damage
No heatwave 	**False positive** No damage from heatwave but grower bears cost of extra water applied	**True negative** No damage and no cost

Obviously we would like to spend most time in the bottom right hand corner (true negative); no forecast of a heatwave and no losses from a heatwave – this is what we hope for in a comfortable vintage. When heatwaves do occur, both forecasters and grapegrowers want to be in the top left hand corner where a warning is given and appropriate action is taken.

The worst outcome is the top right hand corner where a heatwave is a surprise to both the forecaster and the grapegrower. As outlined earlier, it is rare that a forecast is not made in advance of a heatwave although communication to the grapegrower may be imperfect. The bottom left hand corner is often called a false alarm or false positive. There will be more false alarms than failures to warn. The most likely outcome of a false alarm will be a run of days that are above average but not exceptionally hot; rarely will days be substantially below average. Therefore, the most likely outcome is that the extra irrigation will be used by the crop that will have a cost in water rather than substantially increased disease pressure.

Acknowledgements

Many of the viticultural guidelines in this document were developed using the technical notes written by Peter Dry for the GWRDC Innovator's Network and the climate risk information from a series of articles written by Peter Hayman and Warwick Grace in ANZ Wine Industry Journal.

We also acknowledge the work of Leanne Webb and colleagues who conducted a survey of Australian grapegrowers and evaluated the effects of the 2009 heatwave in different grapegrowing regions.

The Australian Bureau of Meteorology not only provides forecasts of heat waves but also a thorough analysis of the weather conditions of recent events available at http://reg.bom.gov.au/climate/current/special-statements.shtml

Further reading

Anderson, K.et al. (2008) Viticulture, wine and climate change. *Garnaut Climate Change Review.*

Anon. (2004) Vineyard cooling still under investigation. *Aust. Vit.* Jul/Aug, 79-85.

Anon. (2006) Bunch exposure studies raise more questions. *Aust. Vit.* Sep/Oct, 50-51.

Australian Bureau of Meteorology (2008) An exceptional and prolonged heatwave in Southern Australia. Special Climate Statement 15.

Australian Bureau of Meteorology (2009a) The exceptional January-February 2009 heatwave in south-eastern Australia. Special Climate Statement 17.

Australian Bureau of Meteorology (2009b) A prolonged spring heatwave in central and south-eastern Australia. Special Climate Statement 19.

Australian Bureau of Meteorology (2011) An exceptional summer heatwave in greater Sydney and the Hunter Valley. Special Climate Statement 27.

Cooley, N. et al. (2008) The effects of water deficit and particle film technology on Cabernet Sauvignon grape composition. Proc. 5th Int. Symp. Irrigation Horticultural Crops. Acta Hort. 792, 193-200.

Crothers, N. and Downey, M. (2006) Effect of sun exposure on Chardonnay grapes and wines. *Aust. Vit.* Jan/Feb, 19-20.

Dimos, N. (2008) Do foliage wires really reduce sunburn. Aust. Grapegrow. W'maker Feb, 26-27.

Dry, N. (2007) Grapevine rootstocks. *Selection and management for SA vineyards* (PGIBSA/Lythrum Press).

Dry, P. (2009) A brief history of bunch exposure. *ANZ Wine Industry Journal* Nov/Dec (in press).

Grace W.G., Sadras V.O., Hayman P.T. (2009) Modelling heatwaves in viticultural regions of southeastern Australia. *Australian Meteorological and Oceanographic Journal* 58:249-262.

Greenspan, M. (2006) Manage your canopy to prevent overexposed fruit. Wine Bus. Monthly, Sept. (accessed on-line).

Greenspan, M. (2008) Row direction- which end is up? Wine Bus. Monthly, July (accessed on-line).

Greer, D. and La Borde, D. (2006) Sunburn of grapes affects wine quality. Aust. Grapegrow. W'maker March, 21-23.

Gilbert, D. et al. (1970) Cooling of vineyards. *Calif. Agric.* 24, 12-14.

Hayman P.T., Leske P., Nidumolu U.B. (2009) Climate change and viticulture. Informing the decision making at a regional level. South Australian Wine Industry Association and SARDI. Wine Australia Project SAW 06/01, Adelaide, Australia.

Hayman, P.T., Grace W and McCarthy, M.G.. (2009) Assessing and managing the risk of heatwaves in SE Australian wine regions. Aust Grapegrow. & W'maker 543, 22-24.

Jones, G. et al. (2005) Climate change and global wine quality. *Climatic Change* 73, 319-343.

Kliewer, W. and Torres, R. (1972) Effect of sprinkler cooling of grapes on fruit growth and composition. *Amer. J. Enol. Vitic.* 26, 71-77

Nadal, M. et al. (2009) Canopy side sun exposure effects on bunches during ripening of Syrah/R99. Proc 16th Int. GiESCO Symp., July 2009, UC Davis; 171-176.

Nuzzo, V. et al. (2009) Preliminary investigation on sunburn in Chardonnay. Proc 16th Int. GiESCO Symp., July 2009, UC Davis; 183-187.

Sadras V.O.et al. (2007) Quantification of time trends in vintage scores and their variability for major wine regions of Australia Australian *Journal of Grape and Wine Research* 13:117-123.

Smart, R. (1973) Sunlight interception by vineyards. *Amer. J. Enol. Vitic.* 24, 141-147.

Smart, R. and Robinson, M. (1991) *Sunlight into Wine*. Winetitles.

Tarara, J. et al. (2005) Asymmetrical canopy architecture due to prevailing wind direction and row orientation creates an imbalance in irradiance at fruiting zone of grapevines. *Ag. For. Meteor.* 135, 144-155.

Vandeleur, R. et al. (2009) *Plant Physio*l. 149, 445-460.

Webb, L. et al. (2008b) Climate change and winegrape quality in Australia. *Climate Res.*36, 99-111.

Webb, L. et al. (2009) Extreme heat: managing the grapevine response. Report to Wine Australia. Univ. of Melbourne.

Webb L, et al. (2010) Managing Grapevines through Severe Heat: A Survey of Growers after the 2009 Summer Heatwave in South-eastern Australia. *Journal of Wine Research*, 21, 147 - 165.

Winter, E. et al. (2007) Bunchzone temperature monitoring throughout ripening and grape and wine quality of Shiraz in NE Victoria. *Aust Vit. J/F*, 48-53.

This factsheet has been produced by Dr Mardi Longbottom (AWRI), Dr Peter Hayman (SARDI), Dr Michael McCarthy (SARDI) and Dr Dane Thomas (SARDI). Both AWRI and SARDI are key partners in the Wine Innovation Cluster (WIC) in Adelaide, SA.

Wine
Australia
for
Australian
Wine

Wine Australia
Industry House, Cnr Botanic and Hackney Roads, Adelaide SA 5000
PO Box 2733, Kent Town SA 5071
Telephone: (08) 8228 2000
Facsimile: (08) 8228 2066
Email: research@wineaustralia.com
Website: www.wineaustralia.com

This factsheet was first published in January 2012.