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Bunch exposure management

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Background

Severe heatwaves in southern Australia in recent years have resulted in high levels of leaf and bunch damage in many vineyards, with consequent losses in yield and quality (Figure 1). A high level of bunch damage was associated with a high degree of bunch exposure (1). There has been an increase in heatwave occurrences since the 1950s; and they are projected to increase in future (1).

Bunch overexposure causes losses in both productivity and wine quality. Excessive bunch exposure is detrimental to wine quality in warm to hot and sunny climates. Even at moderate air temperature, well exposed bunches can be 'chemically damaged' in the absence of any physical symptoms of berries or the bunch as a whole. Where there is physical damage, sunburnt fruit will often lead to increased bitterness and browning of wine. Also, skin damage caused by sunburn may lead to invasion by secondary bunch-rotting fungi.

Figure 1. Bunch damage after a heatwave (Source: M. Essling)

How do bunches get hot?

Bunch temperature is determined by air temperature, absorbed radiation and convective heat loss. As incident radiation increases, so does bunch temperature. The extent to which bunch temperature will exceed air temperature will depend on: the degree of exposure, radiation load, wind velocity, berry/bunch size, berry colour and bunch compactness. Dark berries in the sun and under low wind conditions can be up to 15ºC above air temperature (7). Leaves readily absorb solar radiation and just one leaf layer can provide good bunch protection (7).

Can we maintain a reasonable degree of bunch shading—particularly in a hot and sunny climate[1] —and still expect to get good expression of varietal character in wine?

An extensive review of the scientific literature on the effect of bunch exposure on the primary and secondary metabolites of grape berries—the compounds which determine wine composition and quality—allows us to answer this question. Fortunately, there has been extensive research on most of the important secondary metabolites: flavonoids (anthocyanins, tannins, flavonols), monoterpenoids, norisoprenoids and methoxypyrazines. In general, the formation and preservation of the aroma and flavour compounds of grape berries are much more under the control of temperature than light. It is not possible to specify a berry temperature limit which applies to all of the important compounds. However, once the air temperature exceeds 35ºC, it is likely that the chemical composition of well exposed bunches can be detrimentally affected (2). This is why, in warm to hot and sunny climates, the greatest aromatic intensity and varietal typicity is achieved in partial or reduced intensity sunlight plus moderate air temperatures. The main conclusions of this review[2] are that:

- In warm to hot and sunny climates, it is possible to maintain bunches with minimal exposure, i.e. 'dappled' light, particularly post-veraison.
- In cool and sunny climates, moderate exposure may be necessary for some varieties (but minimal exposure may be desirable in the afternoon).
- In cool and cloudy climates, full exposure may be necessary for some varieties.

Management strategies to protect bunches

Management strategies can be categorized as follows:

- Those where the aim is to increase shoot vigour and canopy development and thereby provide natural bunch shading: **pruning level; irrigation strategy; nutrition;** and, in new vineyards, **rootstocks and scion varieties with better heat and drought tolerance**.
- Those where the aim is to directly minimise the exposure of bunches to radiation, particularly in the afternoon: **trellis design and use of foliage wires; artificial shading; vineyard floor management; avoidance of leaf removal; chemical sprays;** and, in new vineyards, **row orientation**.
- Those where the aim is to directly reduce vine and bunch temperature: **sprinkler cooling**.

Pruning level

More severe pruning, i.e. fewer buds retained, is a simple and economical way to increase shoot vigour and to reduce crop load. The 2009 survey indicated that the worst heat damage occurred on vineyards with small canopies and high crop loads (9).

Irrigation

If water is available, one of the most effective methods to protect bunches is to use the natural shading of the canopy. This requires that sufficient irrigation be applied early in the growing season to develop shoots with adequate leaf number; and then sufficient water applied later in the season to maintain those leaves and to prevent defoliation. Although deficit irrigation strategies such as RDI have benefits for wine quality, the downside is that they tend to limit shoot growth, particularly if the deficit is applied early and thus leads to open canopies with exposed bunches. In order to provide better bunch protection, it may be necessary to ease off the level of stress applied. The 2009 survey indicated that the vineyards with least heat damage had irrigation applied in advance of the heatwave so that soil water was restored to full capacity and where irrigation was applied during the heatwave at frequent intervals, e.g. at least daily. Vineyards that had been subjected to 'severe' RDI, or that could not be irrigated at all due to lack of water, tended to have the greatest degree of bunch damage (9).

Recommendations

- Reconsider your deficit irrigation strategy if the aim is to develop more canopy growth before veraison.
- Application of 'severe' RDI to reduce berry size may not be necessary because it is not berry size reduction that is the cause of improved wine quality.
- If a heatwave is forecast, cease RDI, PRD etc and apply sufficient irrigation to refill the profile.
- Do not wait until 2 or 3 days into the heatwave before irrigation is started.
- Irrigate daily if possible during the heatwave and do not waste water with deep irrigations.
- Irrigate at night.

Nutrition

Good early season nutrition is essential for good shoot development. It is also important to maintain leaf function during stressful periods.

Rootstocks

The 2009 survey indicated that, in those regions where rootstocks are commonly used, the vineyards with least heat damage were on vigorous, drought tolerant rootstocks such as Ramsey, 140 Ru, 99R and 1103 P. Those which had the most heat damage were those on lower vigour and less drought tolerant rootstocks such as Schwarzmann and 101-14, and those on own roots (9). This result is hardly surprising and is likely to be due to a combination of better canopy growth and more bunch shading and better water uptake. For more information on rootstocks, consult (3).

Scion varieties with better heat and drought tolerance

This will be the subject of another GWRDC module. In general, those varieties that are drought tolerant, in the main, also tend to be heat tolerant. This is not surprising given their geographical origin. However, there has been very little research to distinguish between drought tolerance and heat tolerance. Anecdotally we know that some varieties are more tolerant of bunch exposure than others, with respect to both physical and chemical damage.

Trellis design and use of foliage wires

Vineyards with Vertical Shoot Positioned (VSP) trellis suffered the most heat damage.in 2009. Accordingly, those regions with a high proportion of VSP trellis, e.g. Yarra Valley, Mornington Peninsula, had some of the worst heat damage, particularly where leaf removal and/or shoot thinning had also been used. The use of VSP in cool, cloudy and wet climates on low potential sites is understandable. But there is little justification for its adoption in warm to hot regions. With north-south (N-S) rows, single wire trellis with sprawling canopy (SW) should have less risk of bunch damage and quality loss than VSP trellis in warm to hot climates—so long as the canopy density is adequate and there is not wind-caused canopy displacement to the east.

Recommendations

Cool, cloudy and wet climate with low potential site:
- Use VSP plus leaf removal etc in bunch zone.

Cool, cloudy and wet climate with moderate to high potential sites:
- Use an alternative system (7) .

Cool and sunny climates with low potential site:
- Use VSP trellis plus leaf removal etc in bunch zone only on morning side of canopy.

Cool and sunny climates with moderate to high potential site:
- Use an alternative system (7).

Warm to hot and sunny climate with N-S row:
- Use SW or any other system that does not have well-exposed bunches. Do not use VSP.
- If wind-induced canopy displacement to the east is a problem, use a fixed foliage wire above the fruiting wire to reduce this risk. The height will depend on the variety.
- If you must use VSP, do a normal lift on E side, i.e. both wires lifted. On the W side, only lift the lower wire. Do not lift the upper foliage wire. This should create a semi-ballerina effect and provide some shading of bunches in the afternoon. You may need to adjust the height of the single wire lift on the W side according to variety. A single wire lift may provide better bunch protection than no lift at all on the W side. You will need to experiment. This will only be possible where rows are wide enough to accommodate machinery pass. Do not use leaf removal at all.
- Attach a narrow T with fixed foliage wires to the top of the trellis post, either directly above or displaced to the west (Figure 2). This will produce a veranda effect if shoots on W side are not trimmed excessively.

Warm to hot and sunny climate with E-W row
- As for N-S row—but the risk of bunch damage and quality reduction with VSP or similar is less.
- For sprawling canopies, consider use of a fixed foliage wire at 30 cm or higher to prevent canopy rolling of vigorous varieties in hot N winds.

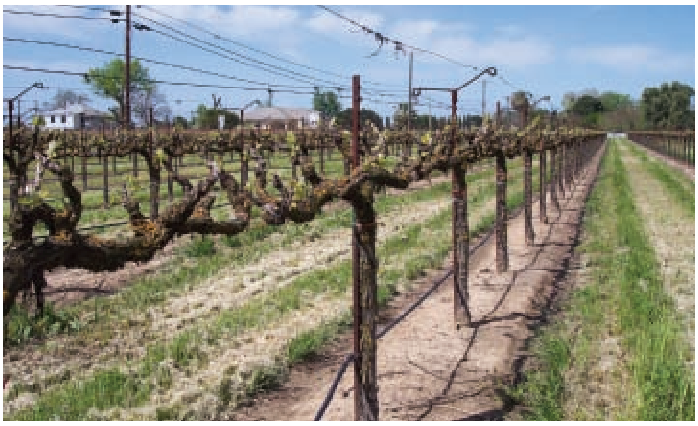

Figure 2. N-S row; single fruiting wire with T foliage wires offset to west; Lodi, California (Source: P.R. Dry)

Artificial shading

This is already utilised in some tablegrape vineyards (Figure 3). Although expensive, one has to consider that it is easier to use this in most vineyards than with tree crops because at least part of the supporting structure is already there, i.e. the trellis.

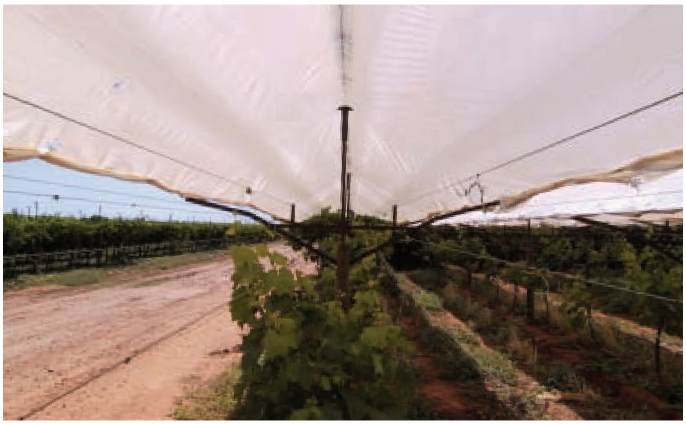

Figure 3. Artificial shading in tablegrape vineyard, Murray-Darling, Vic. (Source; P.R.Dry)

Vineyard floor management

Most focus is placed on direct radiation interception by bunches. However, we cannot ignore the impact of reflected radiation, particularly from the soil. This will be greatest for highly reflective soils such as pale-coloured sands. In addition, once the soil heats up, it acts as a radiant heater. In the 2009 survey, vineyards with stubble or mown sward in mid-rows and mulch (mostly undervine) suffered less heat damage than those with bare soil. The mid-row may be a greater source of radiant heat than the undervine strip.

The best treatment for the mid-row to reduce bunch zone temperature is probably a mown green sward. However, a green sward may use up to 2 ML/ha more water than the alternative (1). Therefore, unless vines are intensively irrigated, actively-growing sward is too competitive in a hot and sunny climate and both canopy growth and yield will suffer. As a result, the use of sward is generally counterproductive if the aim is to protect bunches because reduced shoot vigour will lead to increased bunch exposure. An alternative approach in winter-rainfall regions is to grow a winter cover crop (with a cereal in the mix) and, just before budburst, roll or mow and spray with a low rate of herbicide to prevent regrowth and thus competition with vines. The result will be a mid-row mulch (and undervine as well if possible) that will reduce soil reflectance. Furthermore, because water will be conserved, there will be potential benefits for canopy growth. Of course, the above strategy must take frost risk into consideration.

Avoidance of leaf removal

Bunch-zone leaf removal (BZLR) is one of the most common practices to increase bunch exposure. For cool and wet climates it may be an essential practice to reduce disease risk and to improve ripening. Is there any justification for its use in warm to hot and sunny climates? In terms of effect on fruit composition, response to BZLR is inconsistent.

Therefore, it is surprising that BZLR is so often used in situations where it is unlikely to have any beneficial effect for wine quality. Furthermore, experience in Australia and elsewhere has shown that may also be an undesirable practice because it increases the risk of heat damage and decreased wine quality.

Recommendations

Cool, cloudy and wet climates

This practice is necessary in cool climates to increase the bunch temperature (for enzyme activity) and to decrease risk of bunch rot. If there is not a requirement to reduce fruit set to make bunches looser or for yield control, then BZLR should be done immediately after fruit set to achieve maximum benefit for quality and to allow the most time for development of lateral shoots in the upper parts of shoots (to compensate for the loss of leaf area and to provide young leaves for the ripening period).

Cool and sunny climates

BZLR should only be done on the 'morning side' of the row. Remove only 2 to 3 leaves per shoot (and the associate lateral shoots). Leave 1 or 2 leaves below the bunch to protect from reflected radiation. Leaves retained above the bunch will act as an umbrella.

Avoid in warm to hot and sunny climates.

Row orientation

Which row orientation is best to prevent excessive bunch temperatures? The highest bunch temperatures are usually recorded for exposed bunches on the W side of N-S rows with a VSP trellis because their maximal radiation interception coincides with maximal air temperature in the afternoon (8). At that time, the canopy face is at right angles to the solar beam. Exposed bunches on the N side of an E-W row with VSP trellis in the southern hemisphere can also reach high temperatures, but not as high as those of W side bunches of N-S rows. This is supported by the observations in south eastern Australia after the 2009 heatwave: the most damage occurred on N-S rows, particularly with VSP.

Recommendations

- For VSP and other trellis systems with vertical canopy faces, the use of **E–W**—or even better **NW–SE**—row orientation should be considered for such sites.
- For trellis systems with non-positioned shoots and sprawling canopies, e.g. single fruiting wire, **N–S** orientation may be acceptable so long as the canopy is not too open (as for low 'vigour' vines) and there is not wind displacement of the canopy to the east.

Wind-caused canopy displacement needs to be taken into consideration:

- Prevailing south wind: Use E-W rows so that displacement is onto the N side, thus more bunch shading.
- Prevailing east wind: If N-S row, this is not a major problem and it could be advantageous to have more shade in the afternoon.
- Prevailing north wind (this is not common in terms of canopy displacement during spring): If E-W row, this can create a major problem for bunch exposure. Use foliage catch wires to minimise displacement.

- Prevailing south-west to west wind: If N-S row, this is a common situation and presents a problem. Use a westerly lean on the upper part of trellis to counter displacement (Figure 2) and/or foliage catch wires to counter displacement and to provide some overhead shading to the bunch zone in the afternoon. Consider thinning fruit on the W side to reduce the proportion of bunches on that side.

Sprinkler cooling

Overhead sprinkling can reduce vine and bunch temperature by 8 to 15ºC (5, 6). The availability of water for cooling is an issue in many regions. If this cooling was used in inland regions, for the whole of the period from December to February, whenever the air temperature exceeded 35ºC, it may require at least one extra ML of water per ha (1). Other problems may arise if overhead sprinklers were used frequently, e.g. salt damage, more fungal disease particularly downy mildew and bunch rot, excess vigour.

Chemical sprays

These products are also known as 'sun protection agents' and the process is referred to as particle film technology (PFT). This includes products based on processed and refined kaolin (Surround®, Screen®) or calcium carbonate crystals (Parasol®). These products are applied as a foliar/bunch spray, and contain either aluminium or calcium, both of which are known to cause instability in wine. There are no published data on their impact on winemaking in Australia. PFT may be useful to reduce heat damage of fruits of tree crops and vegetables because the PFT residues can be readily and economically removed by washing etc prior to dispatch to market. However, the same cannot be said for winegrapes. These products do not fit the current definition of an 'agricultural chemical product'in Australia. As a result, they are not required to be registered by the APVMA, nor is there any State or Territory legislation regulating their use. However, many winery companies have their own regulations and growers should not use these products without prior approval of said company .

Footnotes

[1] 'Hot' climatic region is one with an MJT of 23ºC or more, 'warm' with 20 to 22.9ºC and 'cool' with less than 20ºC. For specific climatic information by region, refer to reference 4).

[2] A copy of the detailed review is available from the GWRDC.

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