Heatwave management in Riverina vineyards: 2017–18 sap flow and dendrometer demonstration

[1]Adrian Englefield and [2]Michael Forster
[1]NSW DPI Development Officer Viticulture
[2]Edaphic Scientific and The University of Queensland

Introduction

Heatwaves can have a significant impact on grapevines, causing scorched leaves, decreased canopy growth, reduced grape quality and vine yield. Grape growers deploy various strategies to protect their vines during extreme heat. In the Riverina, irrigation management is critical. Ensuring soil profiles are at field capacity before heatwaves and maintaining soil moisture during and after a heatwave is common practice. During times of limited water availability (system delivery access or reduced water allocations) growers need to maximise vineyard water use efficiency.

Through the 2017–18 Wine Australia Riverina regional program, the NSW Department of Primary Industries (NSW DPI) and Edaphic Scientific installed a series of phyto-monitoring stations in Riverina vineyards. Four vineyard sites were selected, covering Chardonnay, Shiraz, Merlot and Cabernet Sauvignon. Canopy temperature and relative humidity were monitored, and soil volumetric water content was measured at 20 cm indicating timing of irrigation.

This project aims to demonstrate phyto-monitoring with sap flow and dendrometers (measuring tiny changes in vine trunk diameter) as useful tools to monitor vine water stress during heatwaves. The sensors were installed in December 2017 and this article outlines the initial results from the first season's data, focusing on the heatwave experienced during18–23 January 2018 in the Riverina. The demonstration will continue into the 2018–19 growing season.

The heatwave experienced during 18–23 January 2018 in the Riverina

Weather conditions

Table 10 outlines weather conditions recorded during a January heatwave period at the Bureau of Meteorology's (BOM) Griffith Airport weather station (075041). Figure 61 outlines air temperature within the canopy during the corresponding period. A maximum air temperature of 46.4 ˚C was recorded in the Shiraz canopy on 21 January.

Table 10. BOM Griffith Airport weather station recordings during 18–23 January 2018.

Date (January 2018)	Minimum air temperature (˚C)	Maximum air temperature (˚C)	9 am relative humidity (%)	3 pm relative humidity (%)
18	15.6	37.9	16	10
19	16.7	40.7	22	7
20	21.4	43.0	15	7
21	24.5	44.2	13	6
22	23.3	38.4	25	20
23	26.2	43.1	23	11

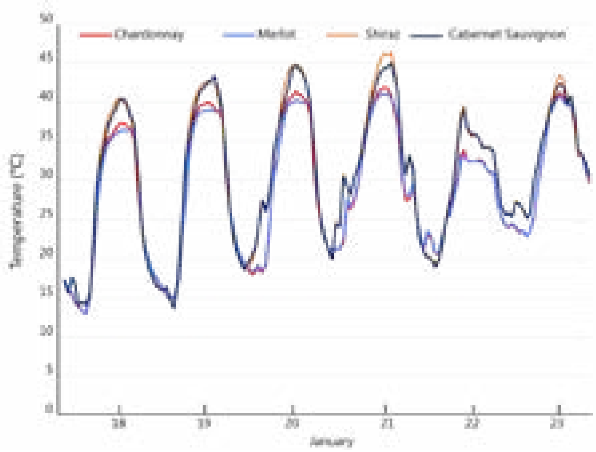

Figure 61. Canopy air temperature (˚C) recorded at Riverina phyto-monitoring sites.

Soil moisture

Grapevine transpiration has a cooling effect within the canopy. However, adequate soil moisture is required. Irrigation during the day will also reduce vineyard temperature and increase relative humidity. During a heatwave it is important to ensure irrigation applications are sufficient to enable grapevines to regain turgor (or recover) overnight. The ability of a plant to repair the air pockets (embolisms) that develop in the vascular system (xylem transpiration stream) during water stress is critical for vine health. These air pockets prevent the rehydration of tissues so that parts or whole components of the tissue die. Night-time repair of embolisms is facilitated by readily accessible water taken up by the roots. New research is required to examine these mechanisms in further detail.

Figure 62 shows the soil moisture volumetric water content (VWC) at 20 cm for the four demonstration sites and the timing of irrigation prior to and during the 18–23 January 2018 heatwave.

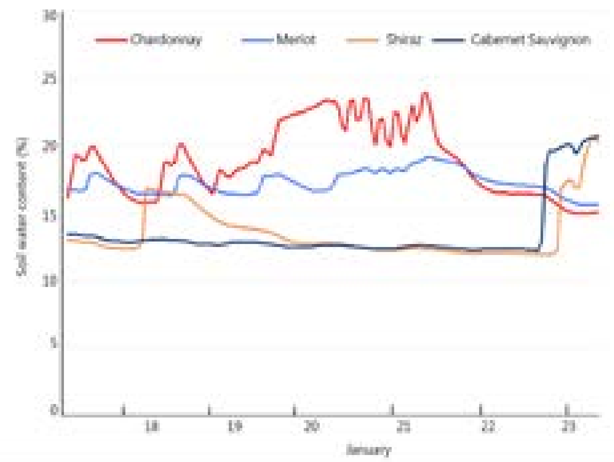

Figure 62. Phyto-monitoring with the use of sap flow and dendrometer sensors can be a useful tool to help identify critical control points for vine stress and irrigation management.

Sap flow

Sap flow in the Chardonnay and Merlot grapevines was maintained at a higher rate (compared to the Cabernet Sauvignon and Shiraz grapevines) of over 2 litres per hour during the heatwave (Figure 63). Additionally, in the Chardonnay and Merlot varieties sap flow increased on the hottest days (20–21 and 23 January). In contrast, sap flow in the Shiraz and Cabernet Sauvignon grapevines declined to approximately half the rate of the Chardonnay and Merlot varieties.

Increased rates of sap flow are highly correlated with increased rates of transpiration. There are two primary purposes for transpiration:

1. the exchange of gases (primarily water and carbon dioxide) between the plant and the atmosphere
2. evaporative cooling for the plant.

During a heatwave, evaporative cooling may be an extremely important coping mechanism for plants. In the Riverina demonstration, the vines with the higher rates of sap flow (Chardonnay and Merlot, Figure 63) also had lower canopy temperature during the heatwave (Figure 61). Canopy temperatures in the Shiraz and Cabernet Sauvignon grapevines were 4–6 °C higher than the Chardonnay and Merlot grapevines during the heatwave (Figure 61).

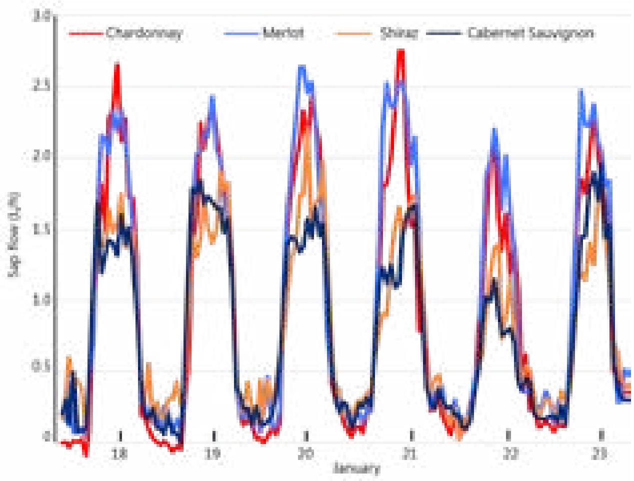

Figure 63. Grapevine sap flow during 18–23 January 2018.

Overnight sap flow

Sap flow overnight is reduced (compared to during the day) because the stomata on the leaves close with decreased light. However, this closure may not be complete and the environmental conditions may impact on overnight vine water use.

At night, the percentage of total sap flow increased relative to normal conditions (Figure 64). This is most likely because of higher night-time vapour pressure deficit during the heatwave.

Overall, Cabernet Sauvignon had the greatest overnight sap flow and this might be a factor of greater night-time stomatal conductance (stomatal pores are more open) of this variety relative to the others.

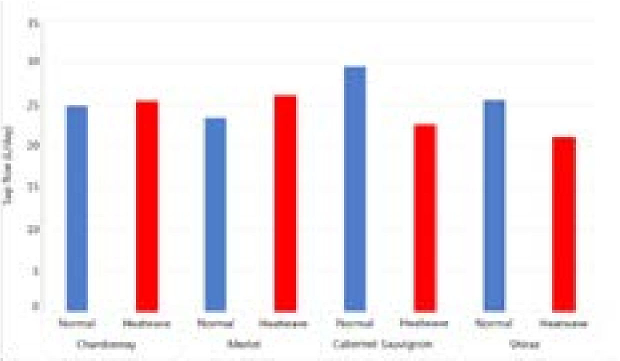

Figure 64. Comparison of vine water use between 'normal' weather days and heatwave days.

Trunk diameter

A healthy plant (including the grapevine) exhibits a smooth dendrometer cycle with daily maximum and minimum values. This cycle is referred to as the maximum daily shrinkage (MDS). An unhealthy plant will show deviations from a consistent MDS pattern and show decreased trunk diameter in times of water stress.

Differences in MDS were observed between the Merlot and Shiraz (Figure 67) grapevines for the different irrigation schedules. Despite the lack of overall growth, the generally greater soil moisture content (VWC %) in the Merlot vines relative to the Shiraz vines most likely contributed to the pronounced daily MDS pattern. However, the Merlot vines did experience a degree of water deficit on 22-23 January as soil moisture reduced (Figure 62). The dendrometer cycle of the Shiraz vines (Figure 65) indicates that the vines were water stressed during 18–23 January with a reduction in trunk diameter and no clear MDS fluctuations.

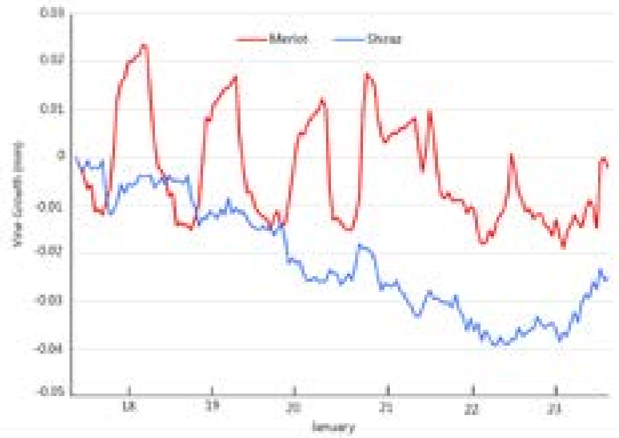

Figure 65. Dendrometer readings (trunk diameter) for Merlot and Shiraz grapevines 18–23 January 2018.

Heatwave damage

On 30 January 2018, visual inspection of the demonstration sites revealed the full extent of damage to the Cabernet Sauvignon and Shiraz grapevines caused by reduced irrigation during the heatwave. Both varieties experienced extensive damage to the canopy and berries (Figure 66 and Figure 67). The Chardonnay and Merlot grapevines experienced a minimal level of damage with only isolated berry and leaf burn observed.

Figure 66. Damage to Cabernet Sauvignon canopy and berries from reduced irrigation during the heatwave, recorded 30 January 2018.

Figure 67. Damage to Shiraz canopy and berries from reduced irrigation during the heatwave, recorded 30 January 2018.

Conclusion

For the Chardonnay and Merlot grapevines that were receiving more frequent irrigation, total daily sap flow increased slightly during the heatwave period with a clearer MDS pattern. Minimal heatwave damage occurred. In the less-irrigated (Cabernet Sauvignon and Shiraz) vines, total daily sap flow declined during the heatwaves with an overall reduction in trunk diameter and no clear MDS pattern. Significant damage occurred to both the canopies and the fruit at the Cabernet Sauvignon and Shiraz sites.

Preliminary results from the phyto-monitoring system over the 2017–18 growing season and the 18–23 January heatwave suggests maintaining adequate soil water content, particularly in heat sensitive varieties, can be a simple management strategy for growers to assist their crops through extreme weather events.

Grapevine and soil moisture monitoring will continue via the phyto-monitoring stations through future growing seasons to demonstrate their potential applicability as an irrigation management tool and to help demonstrate the effectiveness of heatwave management techniques in Riverina vineyards.

To view the live sap flow and dendrometer data please visit the DPI grapes website: www.dpi.nsw.gov.au/agriculture/horticulture/grapes/vineyard-technology/riverina-vineyard-dendrometer-and-sap-flow-demonstration

Acknowledgements and further information

Dr Michael Forster, Edaphic Scientific Pty Ltd. www.edaphic.com.au

Wine Australia: Managing vines during heatwaves.

Wine Australia Riverina regional program 2017–22.

Riverina Wine Grapes Marketing Board.

edaphic scientific
environmental research & monitoring equipment

Riverina
WINE GRAPES
MARKETING BOARD

Wine
Australia