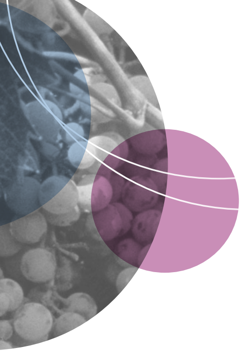

Developing heatwave management strategies through grapevine phytomonitoring

Riverina vineyard sap flow and dendrometer demonstration

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Introduction

In the NSW Riverina, vineyard irrigation and irrigation scheduling are critical considerations to maintain vine health, yield and winemaking specifications of wine grapes, especially during extreme heatwaves.

To record sap flow and dendrometer observations from two grapevine varieties, three vineyard phytomonitoring sites were installed; two at the start of the 2017–18 growing season and another at the beginning of the 2018–19 growing season.

During the 2018–19 growing season, grapevine trunk diameter (measured by dendrometers) and sap flow were measured (Figure 7). During January 2019, the daily maximum temperature exceeded 40 ˚C on 17 days (Table 3) at the Griffith Airport Weather station Bureau of Meteorology (BoM station 075041). The variances in the data collected shows that dendrometers and sap flow meters are useful tools for assessing grapevine stress during heatwaves. They might also be useful for monitoring seasonal development and grapevine stress from causes other than heatwaves.

Table 3. Bureau of Meteorology Griffith Airport weather station data during 11–26 January 2019.

Date (January 2019)	Minimum air temperature (˚C)	Maximum air temperature (˚C)	9 am relative humidity (%)	3 pm relative humidity (%)
11	20.1	38.4	19	30
12	17.9	42.0	19	15
13	22.9	41.7	7	16
14	26.1	45.7	30	11
15	26.2	45.9	17	11
16	27.1	46.4	11	11
17	25.5	45.4	13	12
18	28.3	43.9	31	15
19	23.4	36.8	15	15
20	18.2	37.3	9	17
21	18.5	40.8	20	20
22	27.3	43.7	20	17
23	24.1	42.6	17	14
24	25.9	43.1	20	21
25	30.5	46.1	31	14
26	27.8	43.8	17	16

Figure 7. Dendrometer (side) and sap flow meter (middle) on a grapevine at the Griffith Research Station.

Seasonal trunk diameter changes

A typical grapevine trunk seasonal growth curve, measured with a dendrometer is shown in Figure 8. Key growth stages of budburst (EL 4), veraison (EL 35) and harvest (EL 38) are indicated by breakpoints, including rapid trunk growth (around two months) and slight trunk diameter shrinkage, followed by no change until harvest.

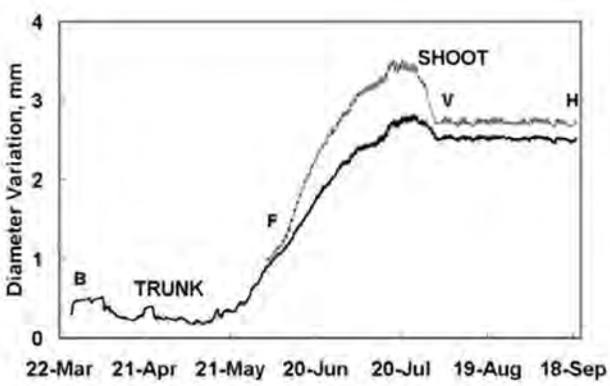

Figure 8. Typical seasonal trunk and shoot diameter curves, recorded from budburst to harvest. B = budburst, F = flowering, V = veraison and H = harvest. Source: Ton and Kopyt (2004). Note: the dates are from the Northern Hemisphere.

During the 2018–19 growing season, dendrometers measured seasonal trunk diameter growth on four varieties; Merlot, Shiraz, Cabernet Sauvignon and Chardonnay (Figure 9). Between 1 September and 15 October, trunk diameter contracted 0.1–0.3 millimetres (mm), except for Cabernet Sauvignon which expanded approximately 0.5 mm. Trunk diameter expanded by approximately 1 mm between mid-October and late December. The largest trunk diameter growth was recorded on the Chardonnay 3 vine, growing by approximately 3.5 mm. The dendrometer stopped recording after reaching the maximum measurement range. During the last week of December to early January, grapevine trunk diameters contracted. The most pronounced was Merlot (0.4 mm). After this period there was little to no stem diameter change between January to the end of April.

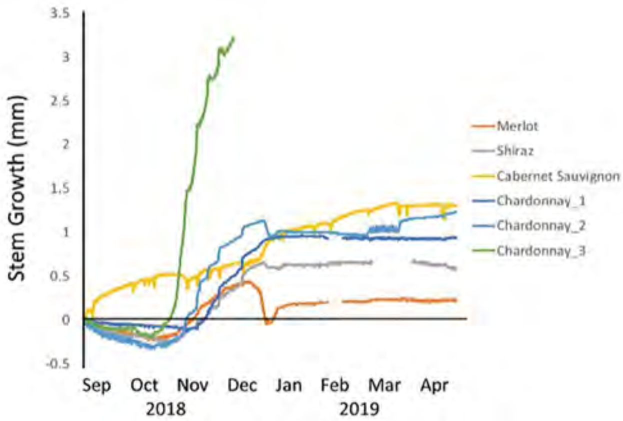

Figure 9. Seasonal trunk diameter curves, 2018–19 Riverina dendrometer demonstration.

Maximum daily shrinkage

The maximum daily shrinkage (MDS), which is the difference between the maximum and minimum stem diameter during one day, can be an indicator of grapevine water stress. Generally, larger MDS values indicate lower soil moisture availability as plants work harder to absorb moisture from the soil. Figure 10 and Figure 11 outline the Shiraz and Cabernet Sauvignon MDS, respectively, recorded during January 2019. Generally, the decreased MDS values suggested there was sufficient soil moisture. However, there were two MDS spikes on 8 and 29 January. Soil moisture was consistent during this period and the spikes corresponded with cooler weather and a decreased vapour-pressure deficit. More data and measurements are needed to understand why these MDS spikes occurred, but these patterns suggest the vines needed to work harder on cooler days to absorb available soil moisture.

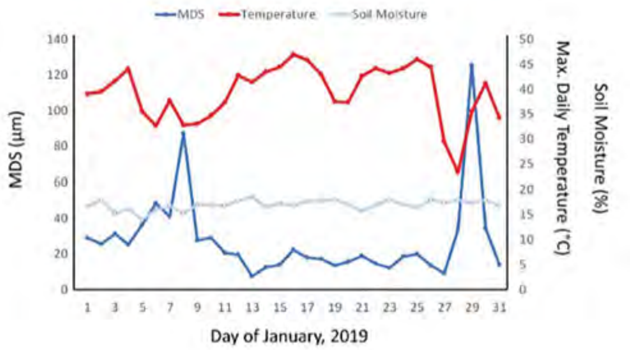

Figure 10. Maximum daily shrinkage (MDS, µm), air temperature (°C), and volumetric soil water content (%) for a Riverina Shiraz grapevine during January 2019.

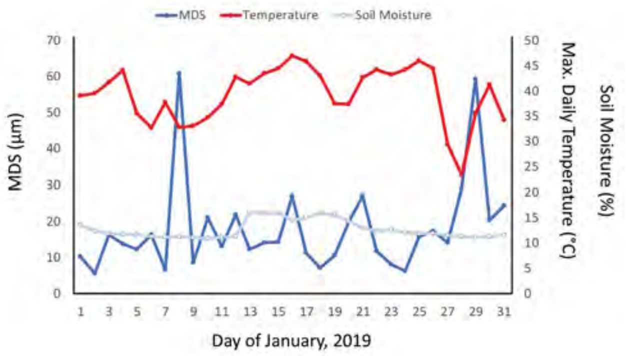

Figure 11. Maximum daily shrinkage (MDS, µm), air temperature (°C), and volumetric soil water content (%) for a Riverina Cabernet Sauvignon grapevine during January 2019.

Sap flow

Grapevine sap flow (a combination of water, nutrients and plant hormones) is a synonymous measure of grapevine transpiration. Transpiration has a cooling effect within the canopy which increases canopy relative humidity. This might help grapevines to cope with extreme weather such as heatwaves. Daytime irrigation is another mechanism to decrease vineyard canopy temperatures and relative humidity. Irrigation during the 11–26 January 2019 heatwave at the Shiraz and Cabernet Sauvignon demonstration sites ensured increased evaporative cooling effects from grapevine transpiration.

There was a strong positive correlation between sap flow and maximum daily air temperature for Shiraz (Figure 12) and Cabernet Sauvignon (Figure 13). Sap flow was greater on hotter days than cooler days; the reduced sap flow recordings occurred on the two coldest January days (27–28) when the maximum temperatures were 27.9 ˚C and 25.5 ˚C respectively.

There was no relationship between sap flow and soil moisture in Cabernet Sauvignon (Figure 14) or Shiraz (Figure 15). If the Shiraz or Cabernet Sauvignon vines were under significant water stress during the 11–26 January heatwave, sap flow would reduce with extreme temperatures. This was seen during the 18–23 January 2018 heatwave (Figure 16 and Figure 17). Lower soil moisture in 2018 caused lower sap flow (transpiration) which, in turn, caused lower relative humidity, or a drier atmosphere inside the vine canopy (Figure 18). The drier atmosphere, coupled with extreme temperatures, caused physiological stress as exhibited by leaf and berry scorching.

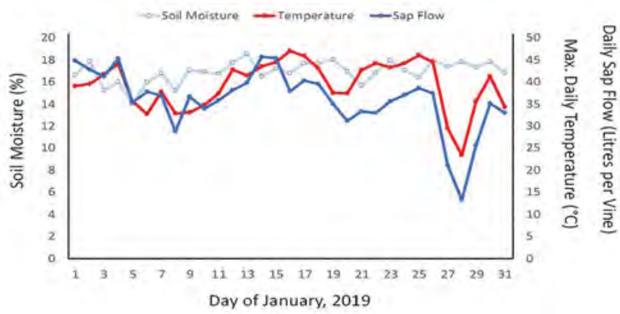

Figure 12. Sap flow (litres per day per vine) and air temperature (°C) for a Riverina Shiraz vine during January 2019.

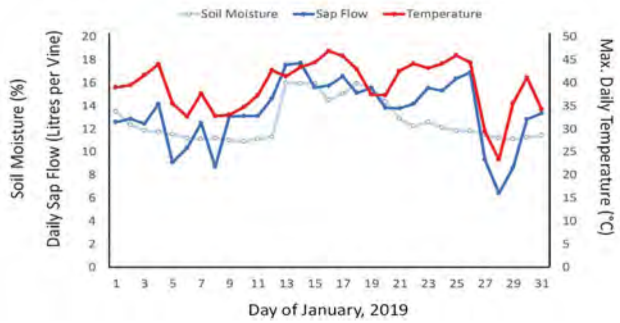

Figure 13. Sap flow (litres per day per vine) and air temperature (°C) for a Riverina Cabernet Sauvignon grapevine during January 2019.

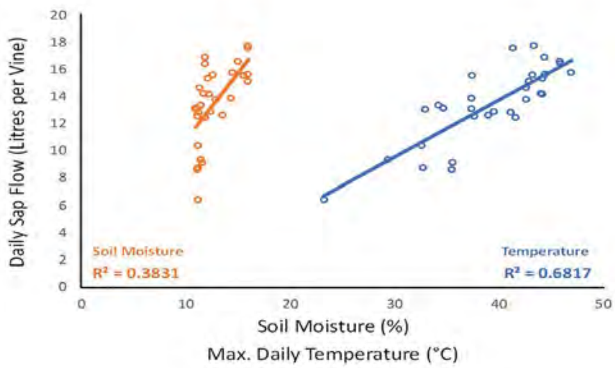

Figure 14. Volumetric soil water content (%) for a Riverina Cabernet Sauvignon grapevine during January 2019.

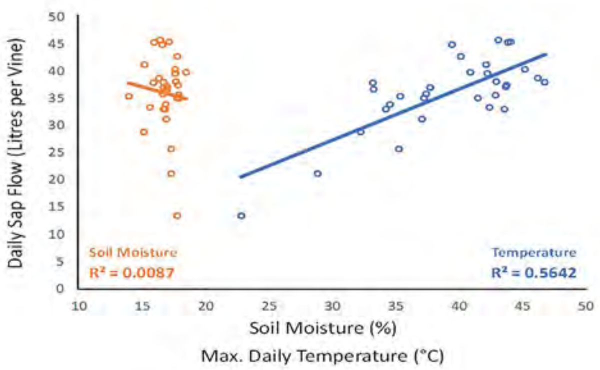

Figure 15. Volumetric soil water content (%) for a Riverina Shiraz vine during January 2019.

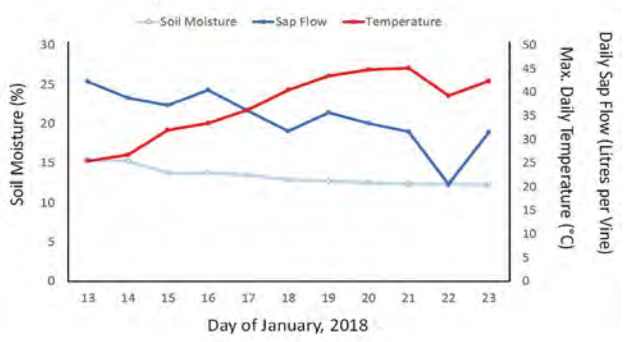

Figure 16. Soil moisture, sap flow and temperature recorded during heatwave conditions indicating Shiraz grapevine stress where insufficient soil moisture is limiting grapevine transpiration.

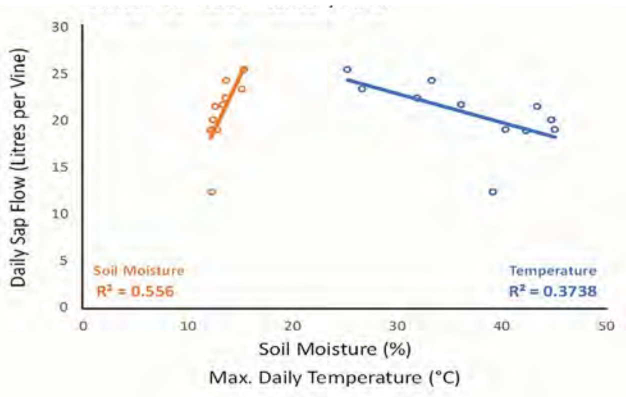

Figure 17. An example of parameters recorded indicating grapevine stress in a 2018 Shiraz where insufficient soil moisture is limiting grapevine transpiration during heatwave conditions.

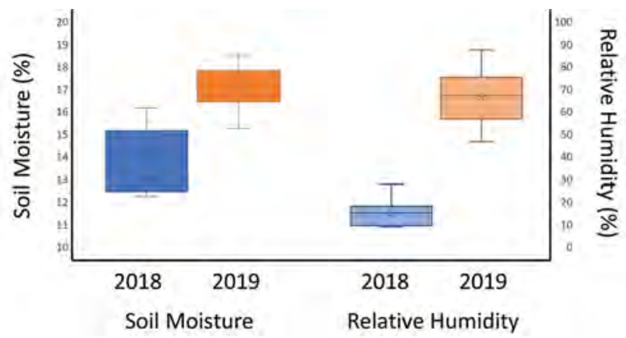

Figure 18. The effect of irrigation on soil moisture and the relative humidity inside a Shiraz canopy during the 2018 and 2019 heatwaves (days where the maximum temperature exceeded 40 °C).

Conclusion

During the 11–26 January 2019 heatwave, growers in the Riverina would have expected some level of grapevine stress due to the extreme temperatures, with 13 of the 16 days during this period recording a daily maximum temperature above 40 ˚C. However, the phytomonitoring data from the 2018–19 Riverina sap flow and dendrometer demonstration suggests the vines had ample soil moisture, with minimal discernible influence on grapevine trunk growth or sap flow measurements. Data was strongly coupled with ambient air temperature conditions.

The results from the 2017–18 and 2018–19 Riverina sap flow and dendrometer demonstration will be used to develop further phytomonitoring demonstrations. At the time of writing, proposals for the 2019–20 season include evaluating grapevine response to different irrigation schedules throughout the growing season.

Acknowledgements and further information

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

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