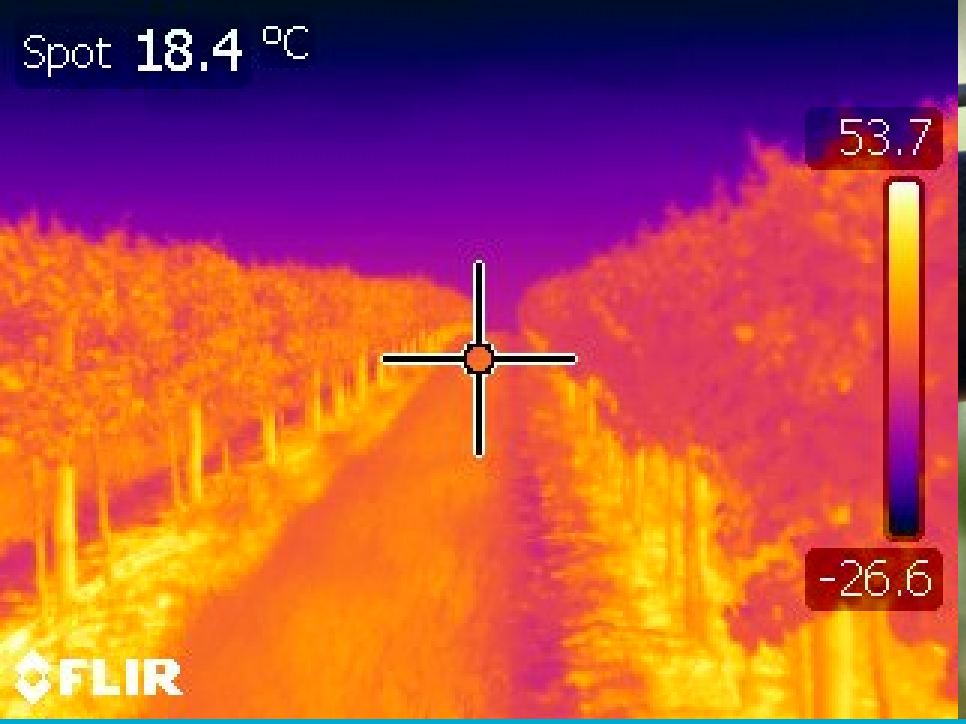

Understanding how vines deal with heat and water deficit

Everard Edwards

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How hot is too hot?

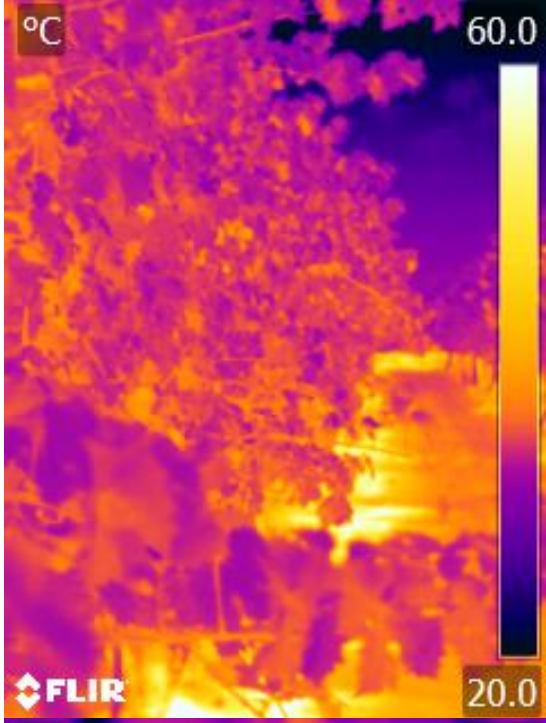
Cell death will occur in any vine tissue beyond a threshold (lethal) temperature

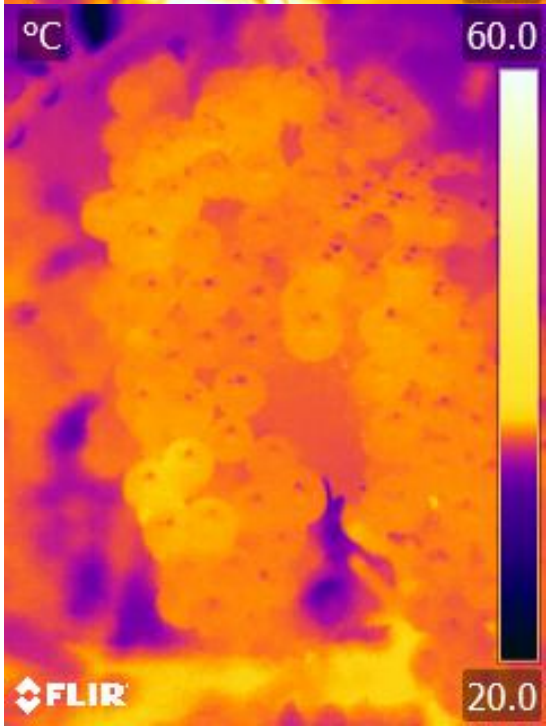
- cell membrane can ‘melt’,
- proteins can become ‘denatured’.

Threshold temperature for a grapevine leaf is probably >50°C

- exact temperature will depend on variety & level of heat acclimation.

We don’t grow vines in regions with air temperatures this high, so why is heat a problem?





The problem with heat

Water?

Exposed tissues (e.g. leaves) are absorbing energy from sunlight.

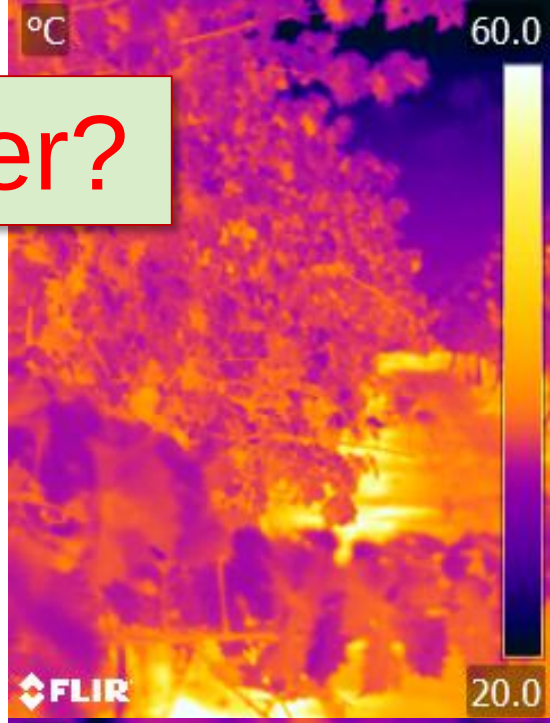
Energy that cannot be utilised (i.e. photosynthesis) will heat the leaf.

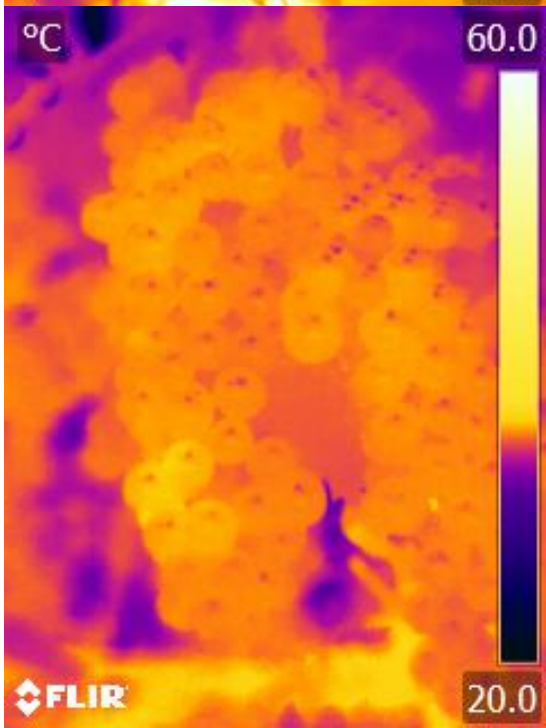
Vine productivity can be affected

- photosynthetic apparatus may be permanently damaged ≈10°C below lethal temperature,
- any leaf death reduces future carbon accumulation.

But, does the leaf reach >50°C?

- usually thought *hydraulic failure* precedes lethal temperatures.





Plants need water

Water is required for:

- cell function,
- photosynthesis,
- transport of photosynthate & nutrients.

Water moves from root to shoot and is lost from the leaves.

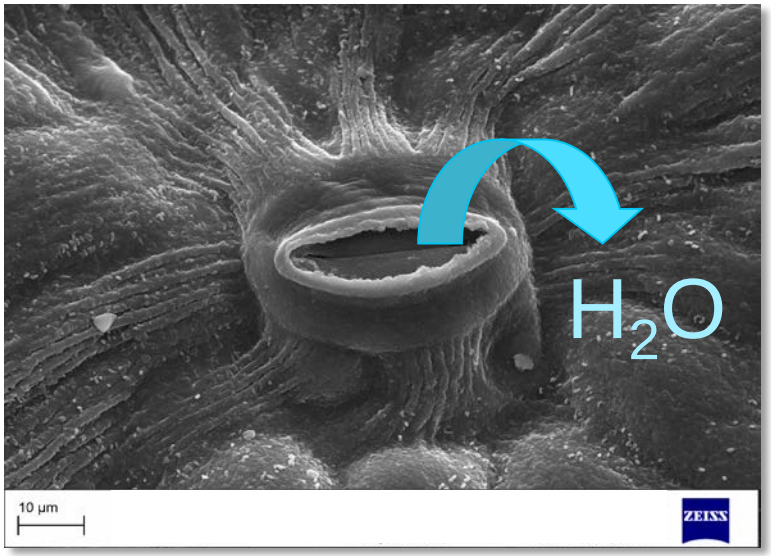
The plant is part of the “soil-to-air continuum”.

Water deficit interferes with these processes.

Stomata and transpiration

The underside of a vine leaf is covered in small pores: stomata.

Movement of water from the vine to the air is termed *transpiration* and occurs through the *stomata*.

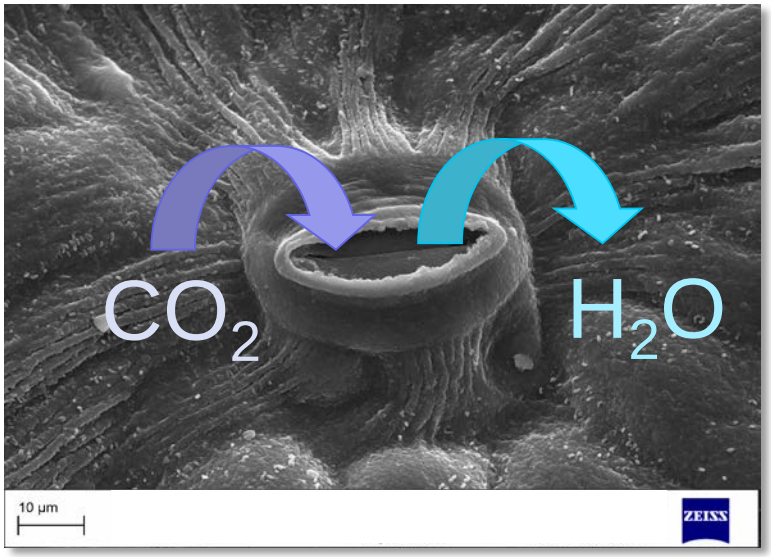


Stomatal conductance

Water loss and carbon uptake are directly linked!

Stomatal opening is under tight control by the plant. The extent of stomatal opening is termed *conductance*.

The stomata are also the site where CO_2 enters the leaf (for photosynthesis).



Vapour pressure deficit

Vine water use is determined by:

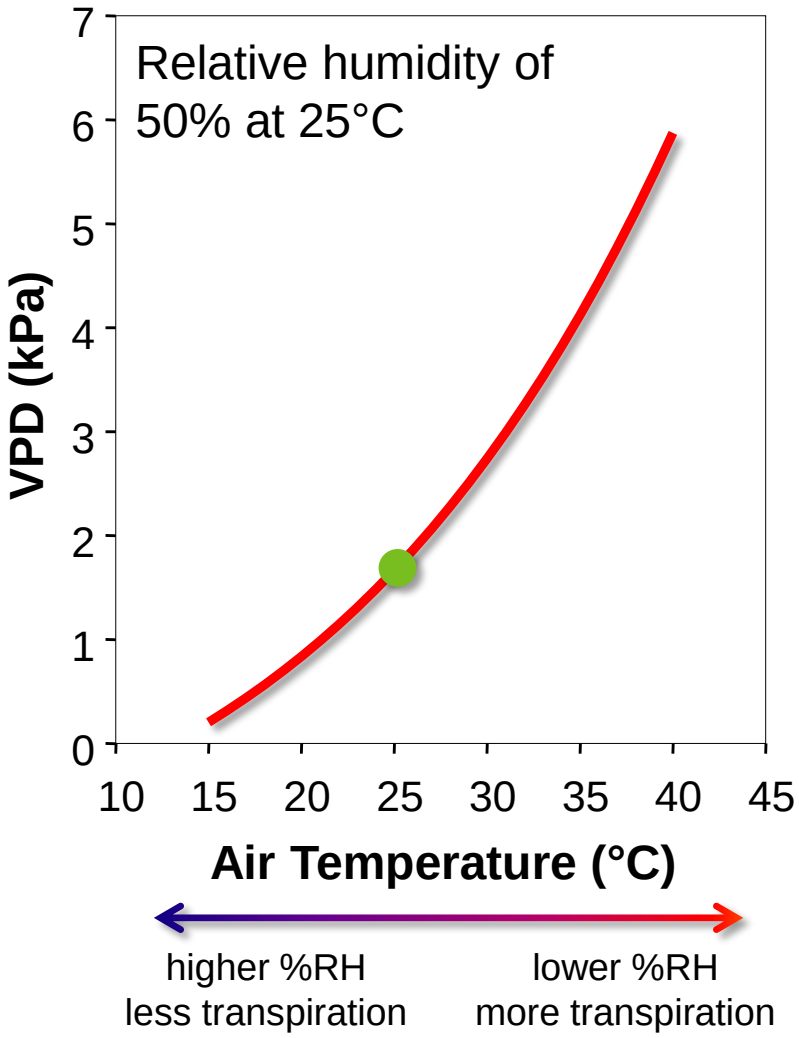
- ***stomatal conductance,***
- ***canopy size,***
- ***vapour pressure deficit.***

Vapour pressure deficit (VPD):

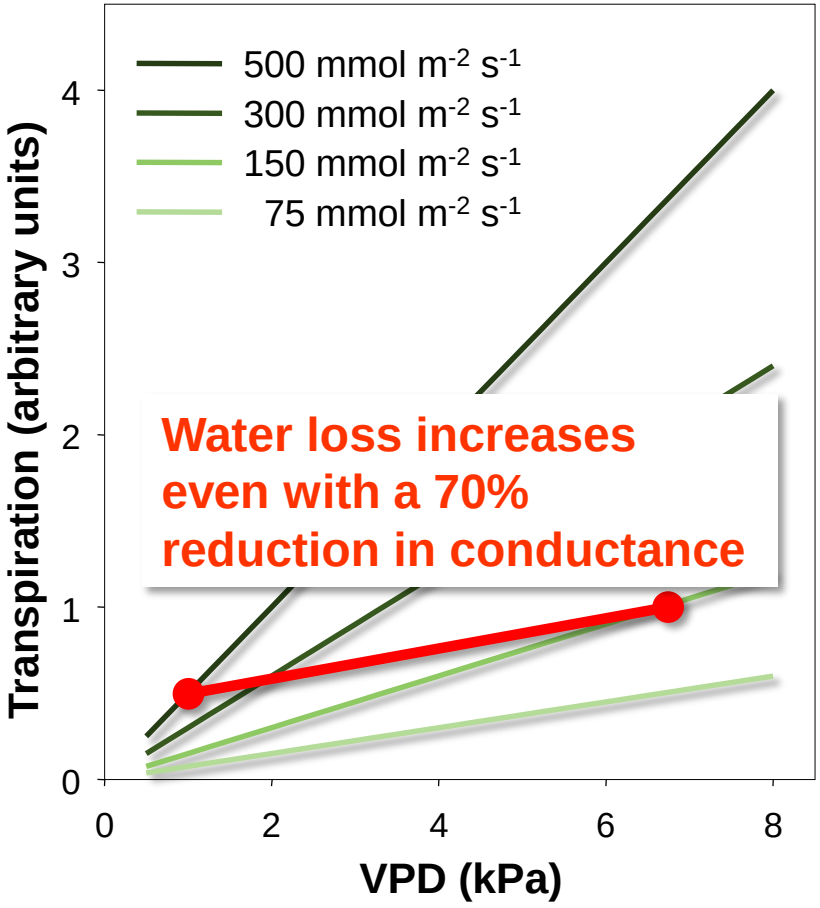
VPD = amount of water in saturated air (100 %RH) - actual amount of water in the air

The amount of water required to saturate air increases with temperature.

Therefore, VPD typically increases with temperature.



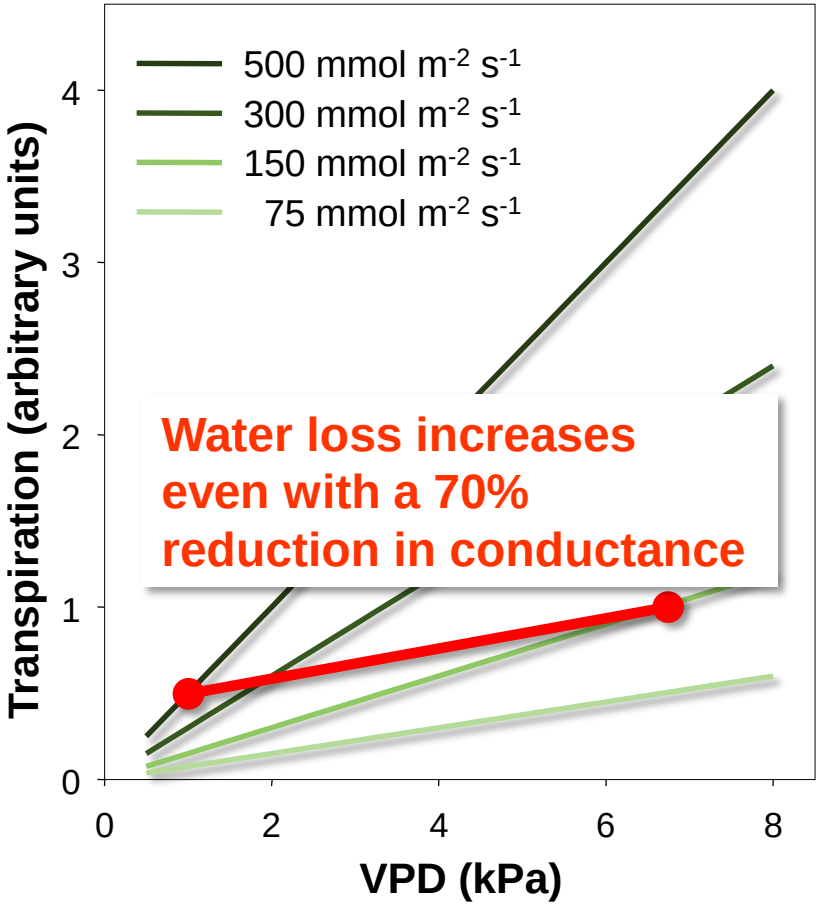
Effect of VPD and conductance on transpiration

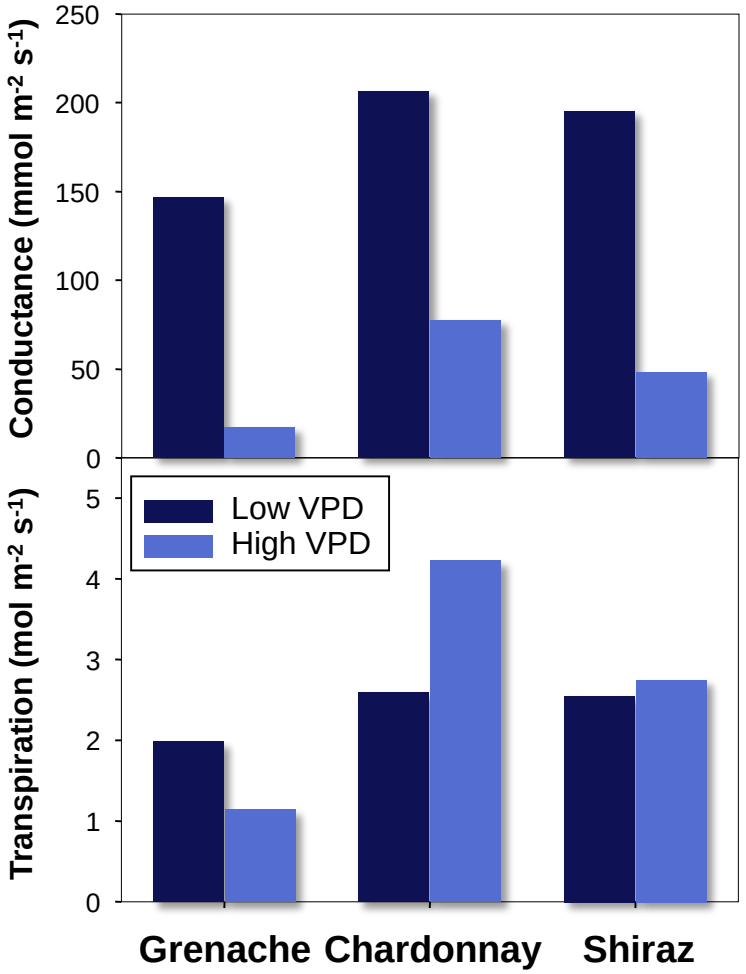


Increasing VPD results in greater water loss from the leaf for a given value of conductance.

Effect of high temperature on water use may be greater than the effect of reduced conductance.

Conductance responds to VPD: varietal differences



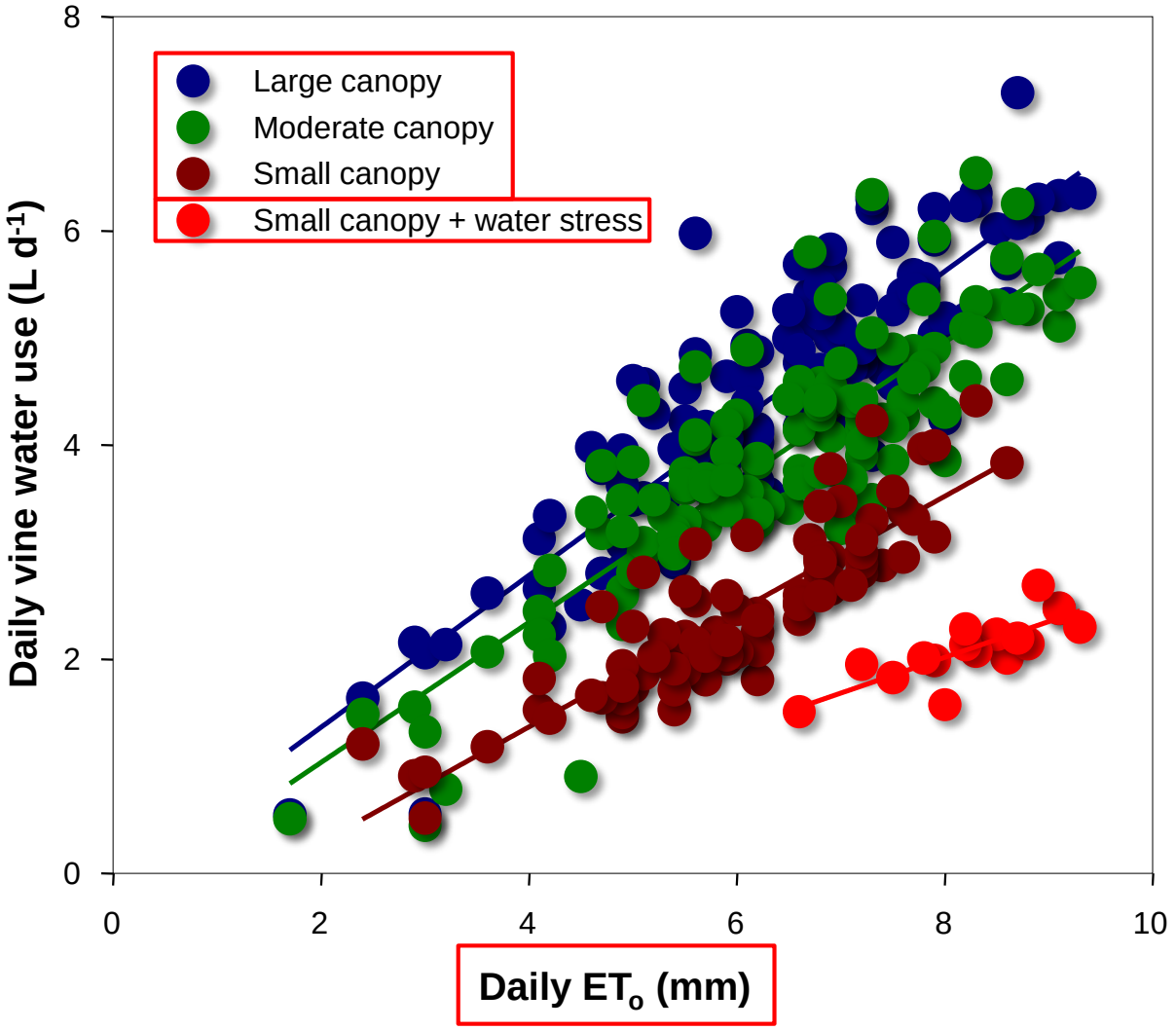


Soar *et al.* (2006) AJGWR

Drivers of vine water use – an example

Vine water use is a function of:

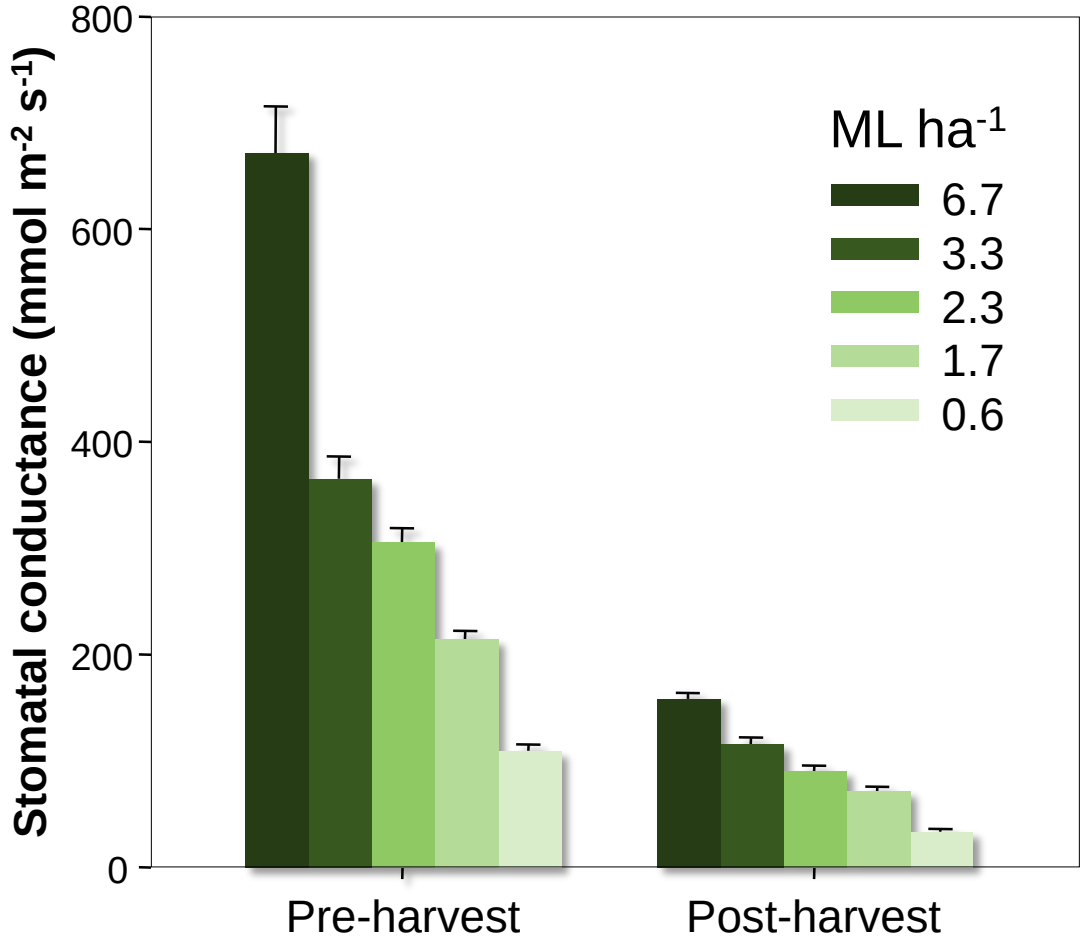
- *vapour pressure deficit (VPD)*,*
- *canopy size/structure,*
- *stomatal opening*.



*modified by boundary layer/wind.

Cabernet Sauvignon, Sunraysia (Edwards *et al.*)

Effect of water deficit on conductance



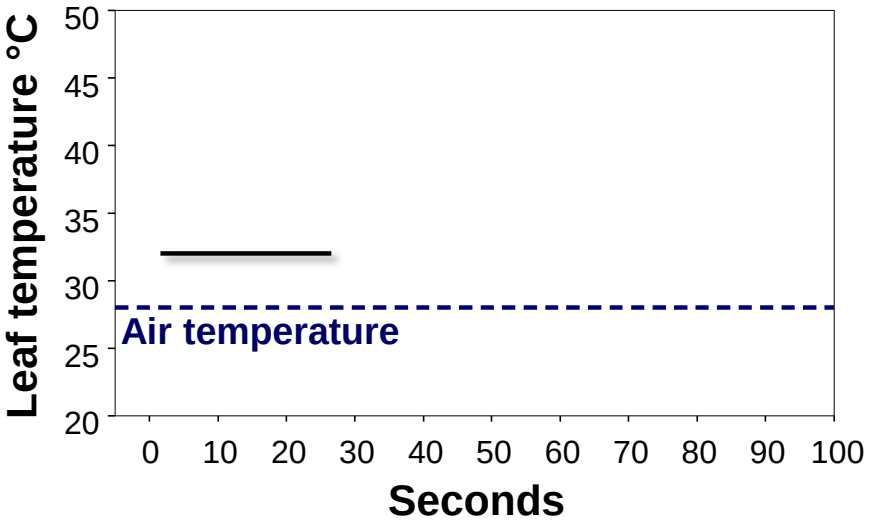
Sustained deficit irrigation (reduced from fruit-set to leaf fall).

Impact of reduced soil water availability present throughout season.

Low conductance reduces vine water use, but also reduces photosynthesis.

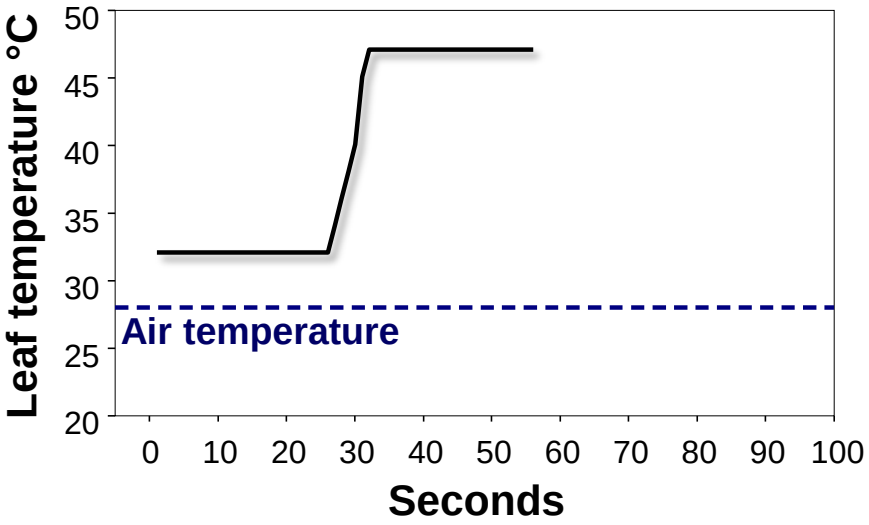
Loveys et al. *unpublished. Cabernet Sauvignon vines in the Riverland.*

Transpiration affects leaf temperature



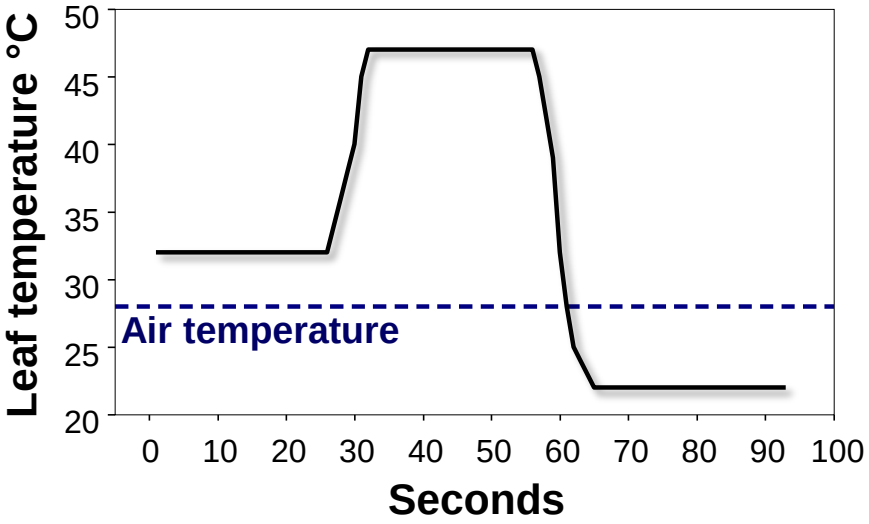
Slide courtesy of Brian Loveys

Transpiration affects leaf temperature



Slide courtesy of Brian Loveys

Transpiration affects leaf temperature



Slide courtesy of Brian Loveys

What is a heatwave?

High-temperature event and *heatwave* are relative terms:

- high temperature stress in one region may be normal growing temperature in another,
- the same temperature at different times of the season may have a different impact.

However:

- absolute temperature is important,
- duration is important,
- humidity is important.

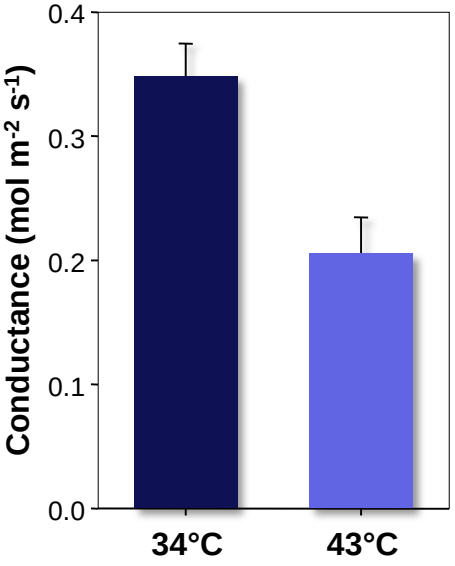
High VPD will stress the vine at any temperature.

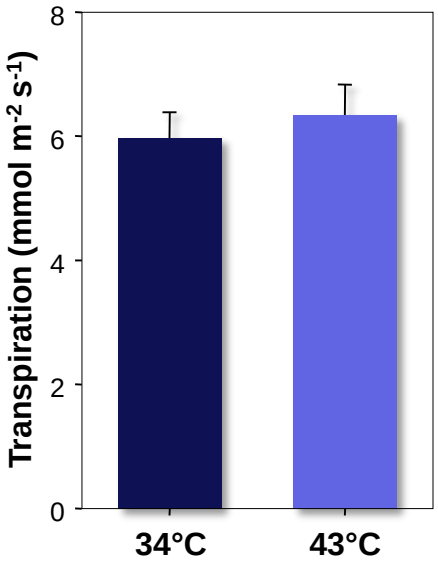
Low VPD may reduce the potential effects of high temperature.

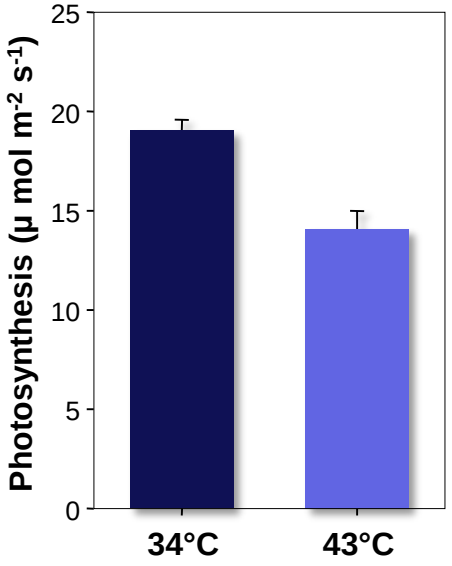
Impacts of heat on well-watered vines

Under well watered conditions, even air temperatures of 45°C may generate only mild heat stress symptoms in the canopy.

Supported by data from the field (under both natural and artificial heatwaves) and from the glasshouse (using both mature vines in large pots and young vines in small pots).







Edwards et al. (2013) unpublished. Artificial heatwave with Cabernet Sauvignon vines, Murray Valley.

Heatwaves and water deficit

But under water deficit conditions vines cannot cope with heatwaves.

2009/10 season,
13 days >40°C,
Murray Valley.

Edwards et al. *(2010) Cabernet Sauvignon vines from the same row.*

Water deficit and high temperature in combination

In general water deficit (drought) exacerbates heat stress due to:

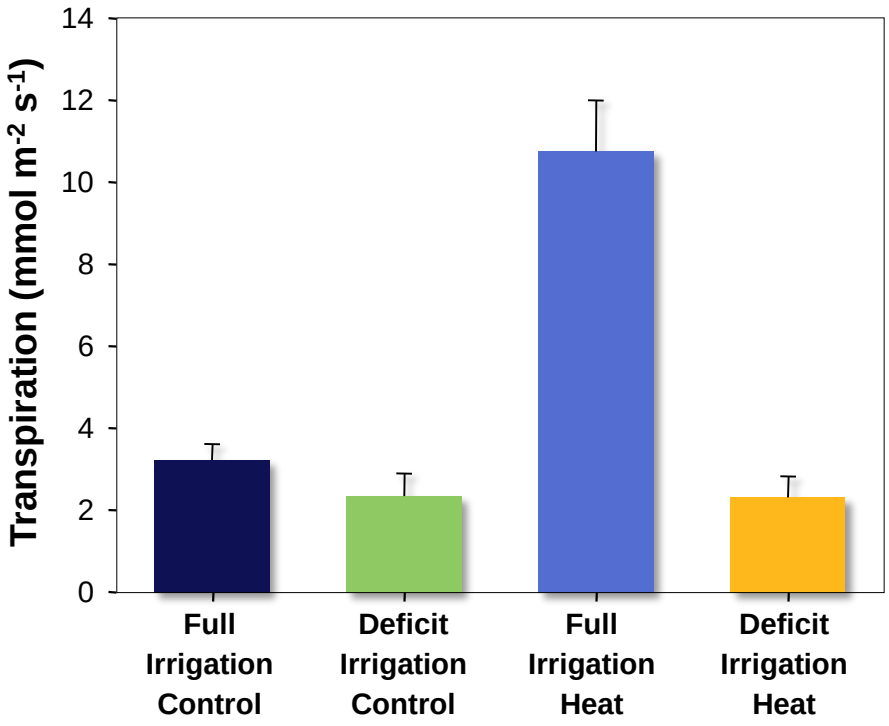
- greater stomatal closure, resulting in higher leaf temperatures,
- reduced vine water status, increasing risk of hydraulic failure and wilting.

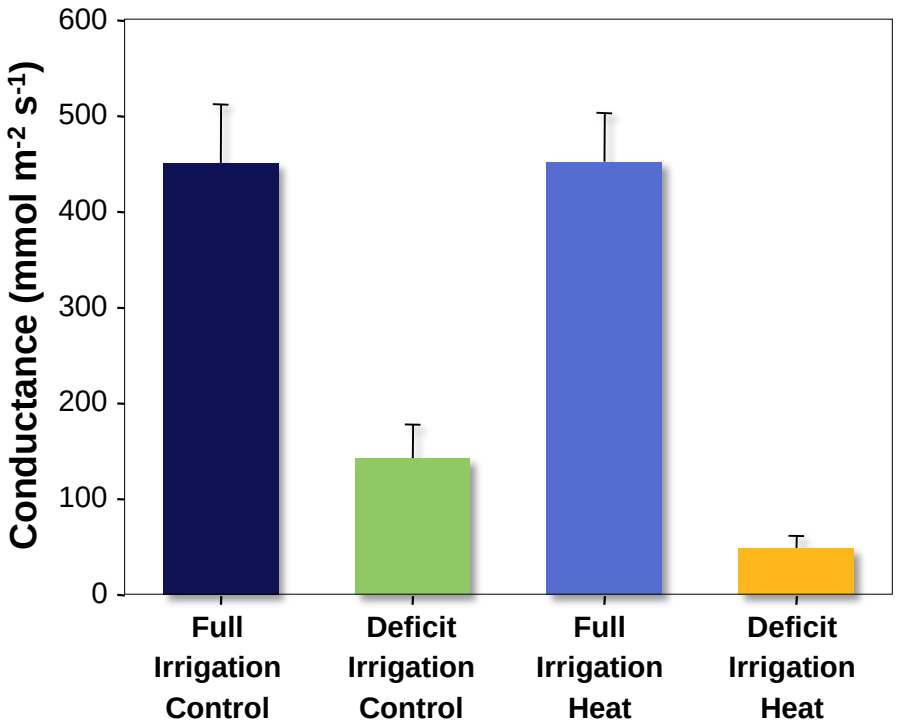
High temperature usually results in high VPD (low %RH), increasing water loss, even with low stomatal conductance.

Wilting of canopy increases fruit exposure and temperature.

Heatwaves and water deficit – conductance & transpiration

Difficult to study in the field, CSIRO has run a number of glasshouse experiments.

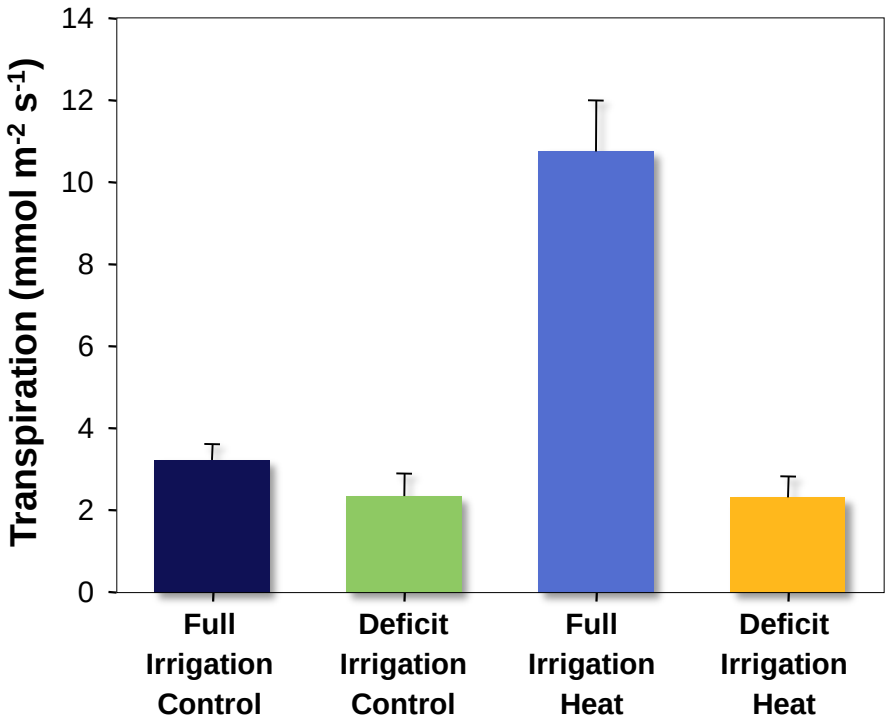


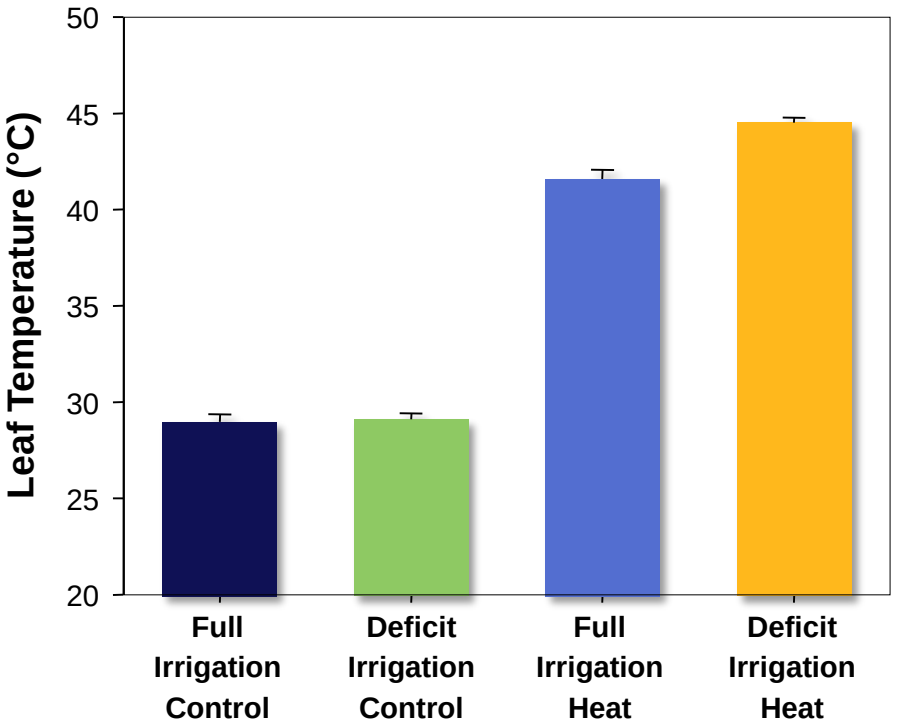


Edwards et al. *(2011), AJGWR.*

Heatwaves and water deficit – leaf temperature

Difficult to study in the field, CSIRO has run a number of glasshouse experiments.

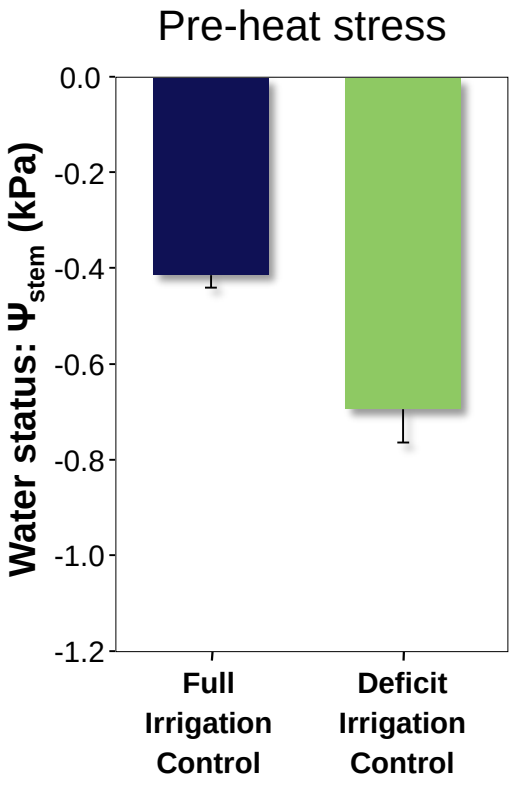


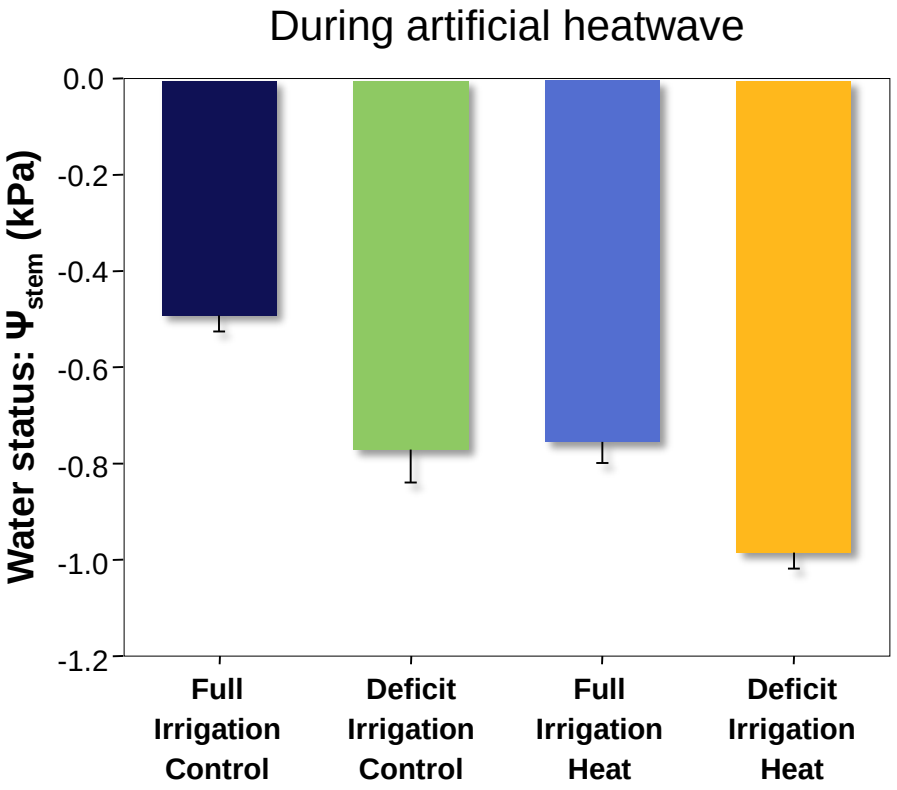


Edwards et al. *(2011), AJGWR.*

Heatwaves and water deficit – water status

Difficult to study in the field, CSIRO has run a number of glasshouse experiments.

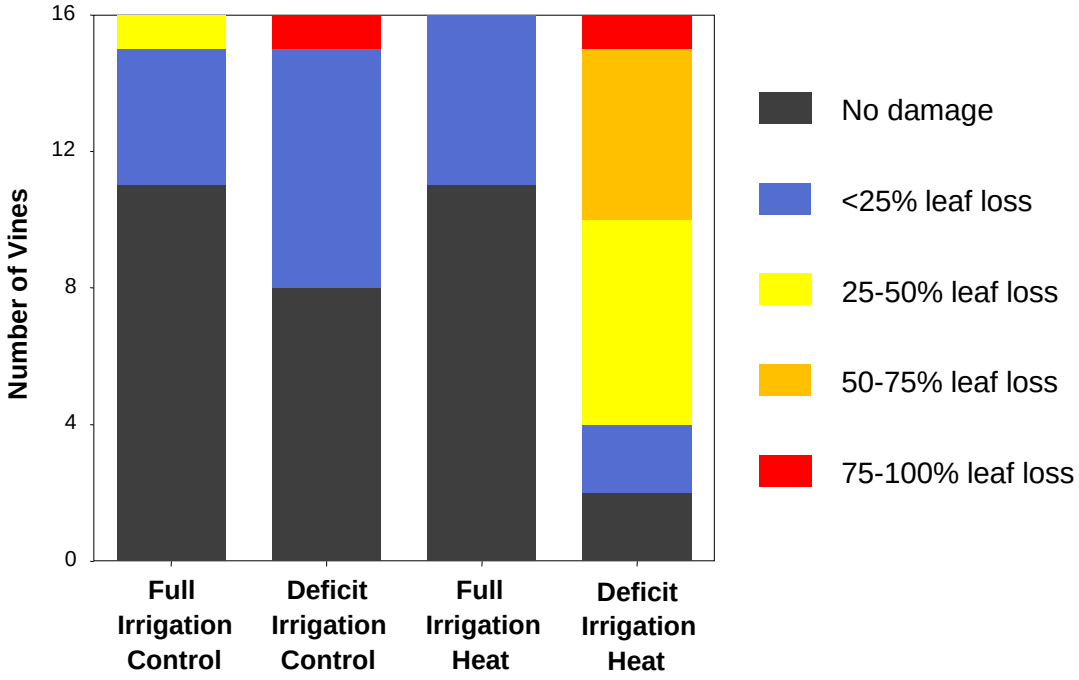


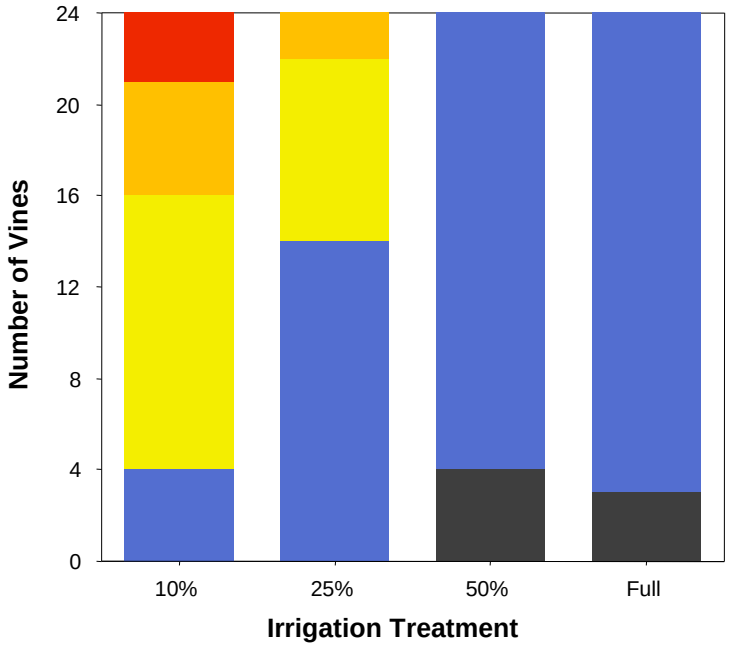


Tesfamicael, Edwards, Rodriguez (2017), unpublished.

Heatwaves and water deficit - damage

The vine's ability to cope with heatwaves is proportional to the water stress present.





Leaf loss in vines heated to >45°C.

Edwards et al. *(2011), AJGWR.*

Summary of biology

Damage to tissues by heat stress likely due to lack of water supply rather than heat per se.

Therefore, water status of canopy is key to heat stress tolerance in short-term.

VPD (%RH) is the primary driver of day-to-day changes in vine water use.

Maintaining open stomata/high transpiration (cooling) during heatwave can require four-fold increase in water uptake.

Protect canopy to protect fruit.

Longer-term solutions may also include considering solar radiation load.

Acknowledgements

Past and current staff and students of grapevine physiology team at CSIRO.

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Wine Australia for Australian Wine

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