The Australian Wine Research Institute

Extreme and increasing temperatures: effects on grapes and wine

Dr Peter Dry
Emeritus Fellow, AWRI

What happened in season 2013/14 in SE Australia?

The Australian Wine Research Institute

- Several extreme weather events
- Yield losses due to spring frosts
- Low temperature period coincidental with flowering
  - → poor fruit set of some varieties → yield loss
  - →uneven ripening of some varieties
- Heatwaves around veraison
  - → uneven ripening of some varieties*

* See Feb 2014 Aust Grapegrower & Winemaker

What happened in season 2013/14? More detail for southern SA

The Australian Wine Research Institute

- Sept:
  - warmest on record for both maximum and minimum temperature T
  - earlier than average budburst
- Oct:
  - Well above average max and min T
- Nov:
  - above average max and min T
  - below average rainfall RF
  - early start to flowering
- Dec:
  - above average max and min T
  - much below average RF

What happened in season 2013/14? For southern SA

The Australian Wine Research Institute

- Jan:
  - above average max and min T, below average RF
  - three significant heatwaves → heat damage etc
- Feb:
  - above average max and min T
  - earlier than average start to harvest
- Mar:
  - warmer than average for first half, cooler in second half
  - below average RF
- Apr:
  - above average max and min T

Impact of global warming?

The Australian Wine Research Institute

- Harvest is earlier than it used to be
- **Since early 1980s, harvest advanced by about 8 days per decade in southern Australia, Europe, Calif etc…**
  - Regional differences

Climate warming and earlier harvest

The Australian Wine Research Institute

- Day of year of maturity (DOYm) at sites with long term data: common period 1985-2009

Used same target Brix each year

Location	Variety	Days advanced per decade
Mornington Pen	Pinot Noir	16
Eden Valley	Shiraz	4
Central Vic	Shiraz	8 to 13
Margaret R	Shiraz	8

Source: Webb et al. (2012) Nature Climate Change

Cause of earlier harvest

The Australian Wine Research Institute

- What has caused earlier harvest?
- What are the implications for vineyard management and wine style/quality?

Climate warming and earlier harvest

The Australian Wine Research Institute

- Main drivers
  - **Increased growing season average temperature**
    - Air temperature effect on tissue temperature and phenology
    - Soil temperature effect

Climate warming and earlier harvest

The Australian Wine Research Institute

- Main drivers
  - **Increased growing season average temperature**
    - Air temperature effect on tissue temperature and phenology
    - Soil temperature effect

Springtime rootzone warming*

→ Mobilisation of root carbohydrate

→ Earlier canopy development

→ Earlier budburst, flowering and veraison

→ Berry composition

* Rogiers et al. (2013) AJGWR 20, 123-

Climate warming and earlier harvest

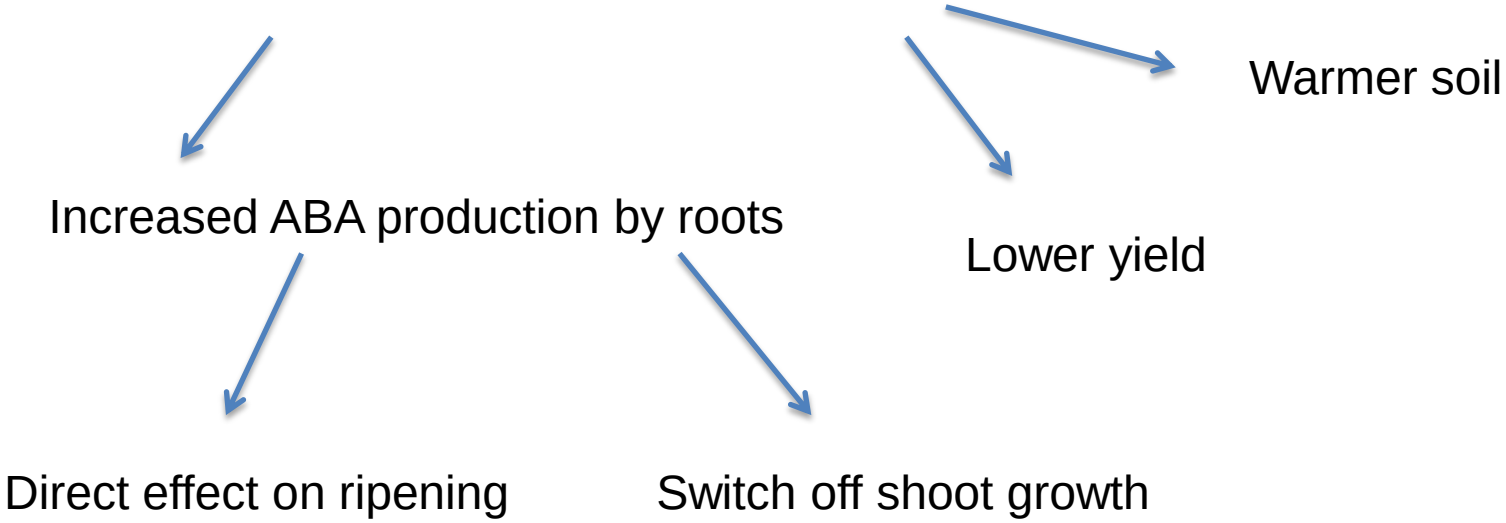
The Australian Wine Research Institute

- Main drivers
  - **Increased growing season average temperature**
  - **Decreased soil water content**

Climate warming and earlier harvest

The Australian Wine Research Institute

- Decreased soil water content



Climate warming and earlier maturity

The Australian Wine Research Institute

- Earlier maturity due to:
  - shorter ripening period?
  - or earlier onset of ripening?
    - with no change in duration of ripening period

Based on what we know about both
a) the **regional effect** and
b) the **seasonal effect**
of temperature on time of maturity
we could predict that it is most likely to be due to
an **earlier onset of ripening**

Climate warming and earlier maturity

The Australian Wine Research Institute

- Earlier maturity due to:
  - ~~shorter ripening period~~
  - **earlier onset of ripening**

- Confirmed for Chard., Cab Sauv and Shiraz in Riverland, Barossa and Coonawarra

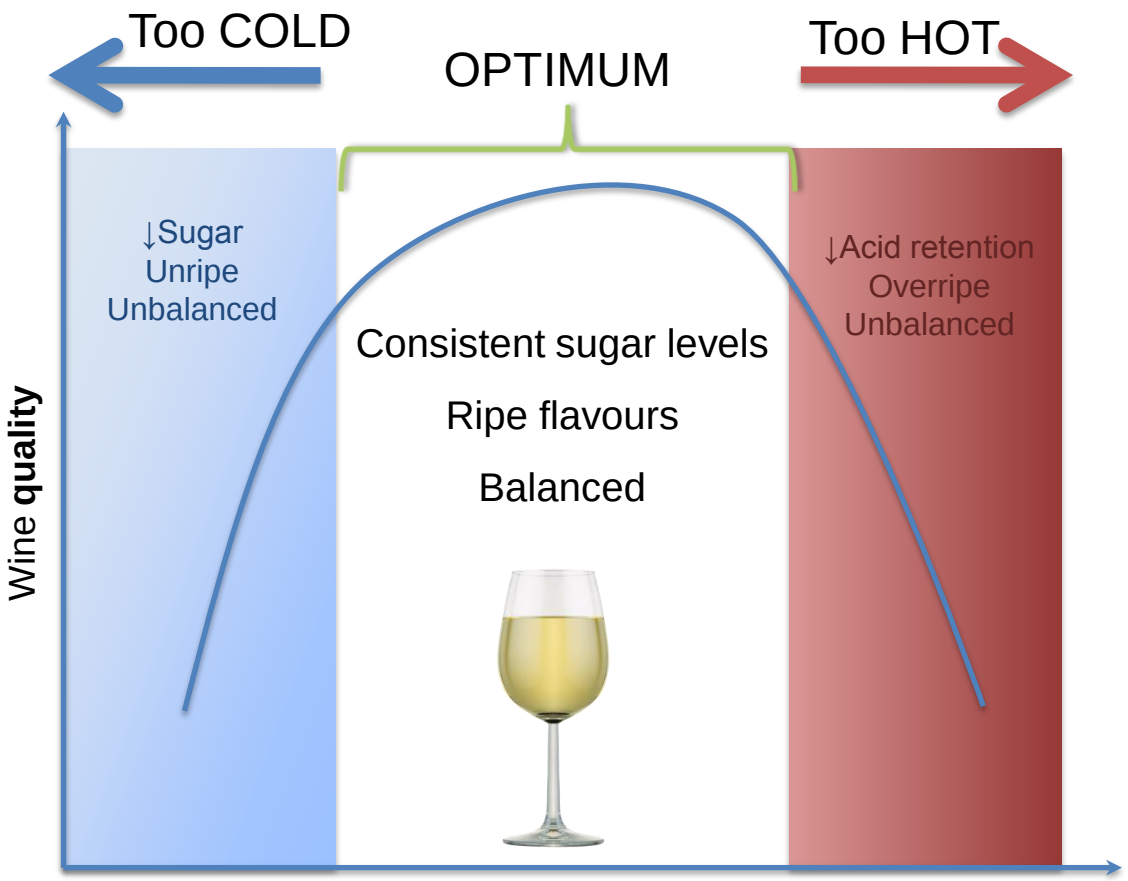
  (Sadras and Petrie 2011 Aust J Grape and Wine Res 17, 199-205)

  - Associated with higher temperature in spring

Temperature and wine quality

The Australian Wine Research Institute

- Balanced composition
- Typical varietal flavours
- Vintage rating



Redrawn from Greg Jones

Grape composition – the critical period

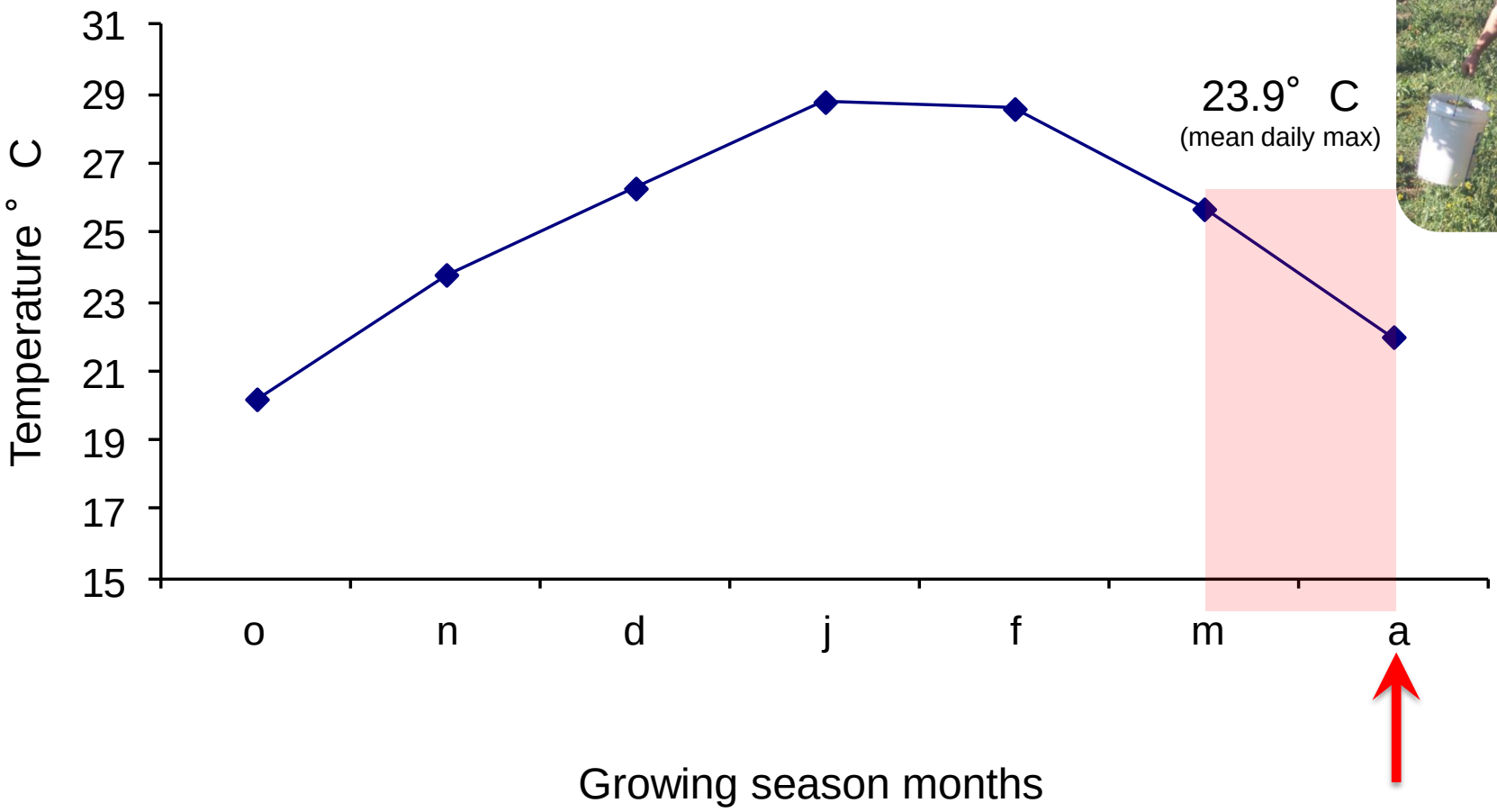
The Australian Wine Research Institute

Temperature in month prior to harvest (= ripening month) is particularly critical for determination of final wine quality

So, what will happen to ripening month temperature in a warming climate?

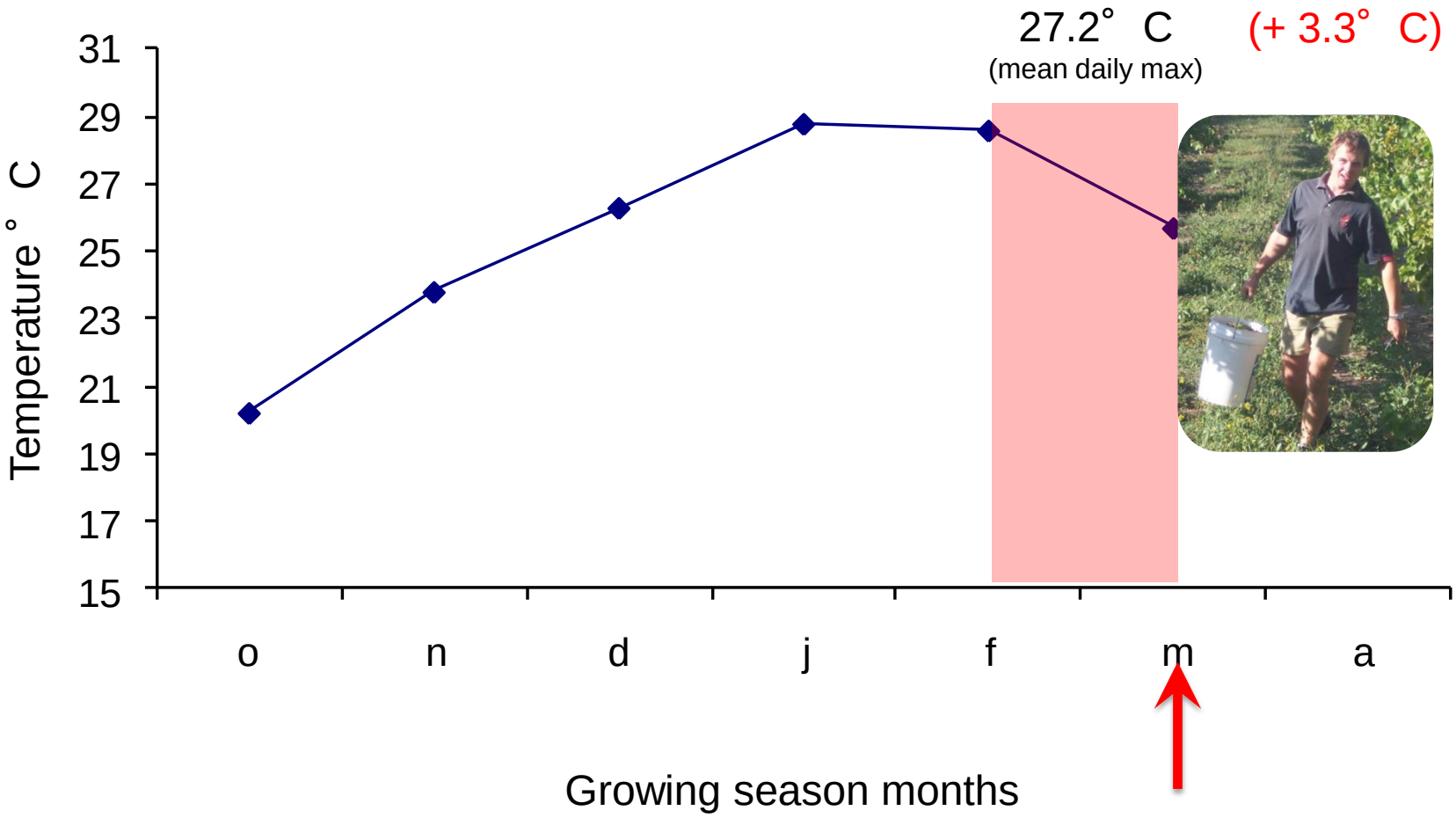
Example: Coonawarra Cabernet Sauvignon

The Australian Wine Research Institute



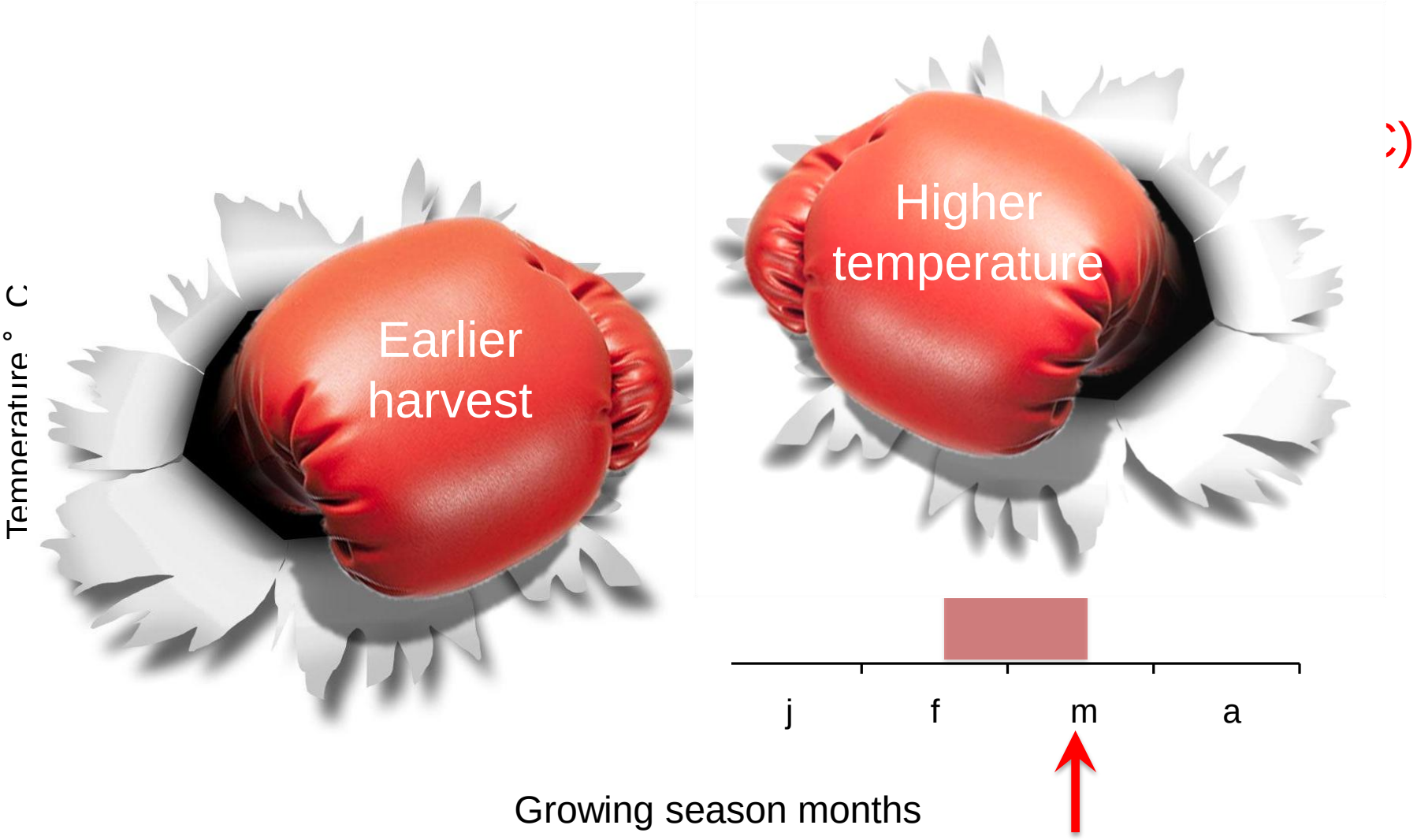
Example: Coonawarra Cabernet Sauvignon

The Australian Wine Research Institute



Example: Coonawarra Cabernet Sauvignon

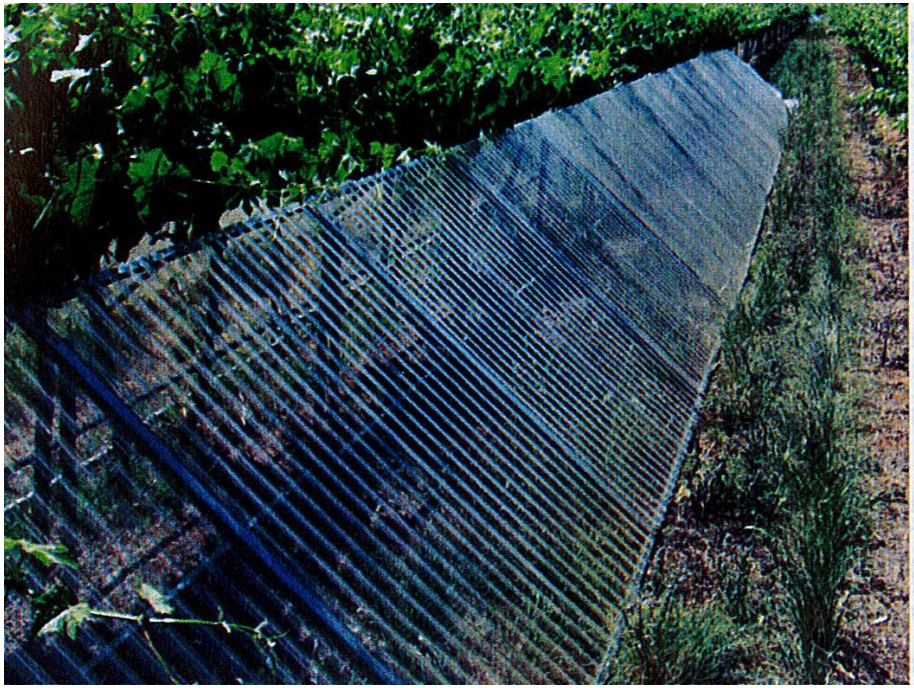
The Australian Wine Research Institute



Research using open-top chambers

The Australian Wine Research Institute

- Temperature increased by 2°C above ambient over whole season, Barossa Valley, several seasons (Sadras et al.)



Source: Krstic and Barlow 2014 WVJ M/A, 54

Research using open-top chambers

The Australian Wine Research Institute

- Thermal effects on phenology are greatest before veraison
- Yield both increased and decreased
  - Varietal response - effect of temp on fruitfulness and bunch number
- Higher temperature → increased stomatal conductance only when conditions suit high conductance
- Higher temperature → delayed anthocyanin accumulation relative to sugar development
- For some varieties higher temperature → lower TA and higher pH as expected (eg Chard, Cab Franc)
  - But for others no effect at all (Shiraz) or just higher pH (Sem)

Refer to AGWA website for further reading

Other impacts of climate change

The Australian Wine Research Institute

- Decreased winter and spring rainfall
- Increased risk of water stress
- Increased risk of spring frost
- Increased salinity
- Impact on nutrition
- Increased risk of high intensity summer rainfall
- Increased disease risk
  - Also new diseases

Photo: Richard Muhlack

Conclusions part 1

The Australian Wine Research Institute

- It is warmer than it was in the past and likely to keep getting warmer
- This has led to earlier harvest
  - mainly due to increased temperature in spring → earlier flowering
- Earlier harvest means a warmer ripening period with implications for fruit composition and wine style
- Also increased risk of heat waves during berry development → **more risk of bunch damage**
- Increased risk of water stress

What can you do about it?

The Australian Wine Research Institute

- **For existing plantings:**
  - Delay flowering?
    - late pruning
  - Irrigation management to offset soil drying
  - Slow down onset of ripening
    - Intervention only likely to be successful if done prior to veraison
  - Cool/protect bunches

What can you do about it?

The Australian Wine Research Institute

- Slow down onset of ripening
  - Reduce leaf area by leaf removal or shoot trimming pre-veraison: up to 20 days delay

Further reading:
Dry, P.R. (2013) Can the production of low alcohol wines start in the vineyard? Wine and Vitic. J., 28(2): 40-43

Pallioti et al. (2013) Aust J Grape Wine Res 19, 369-377

Management strategies to protect bunches from extreme heat

The Australian Wine Research Institute

↓ bunch exposure

↑ cooling

Management strategies to protect bunches from extreme heat

The Australian Wine Research Institute

1. Aim = minimise exposure

- Pruning
- Nutrition
- Irrigation

} increase shoot vigour and promote canopy development

- Canopy management
- Row orientation
- Artificial shading
- Vineyard floor management
- Chemical sprays

} minimise bunch exposure to radiation, particularly in the afternoon

Management strategies to protect bunches from extreme heat

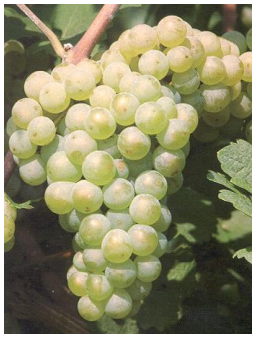
The Australian Wine Research Institute

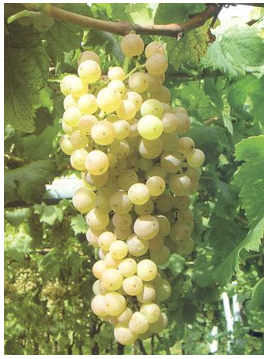
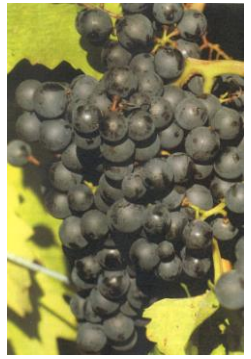
2. Aim = decrease vine and bunch temperature
   - Irrigation
   - Sprinkler cooling
   - Artificial shading

What can you do about it?

The Australian Wine Research Institute

- **New plantings**
  - Varieties better adapted to hotter and drier climate
  - Later ripening varieties
  - Rootstocks with less sensitivity to soil drying

New varieties

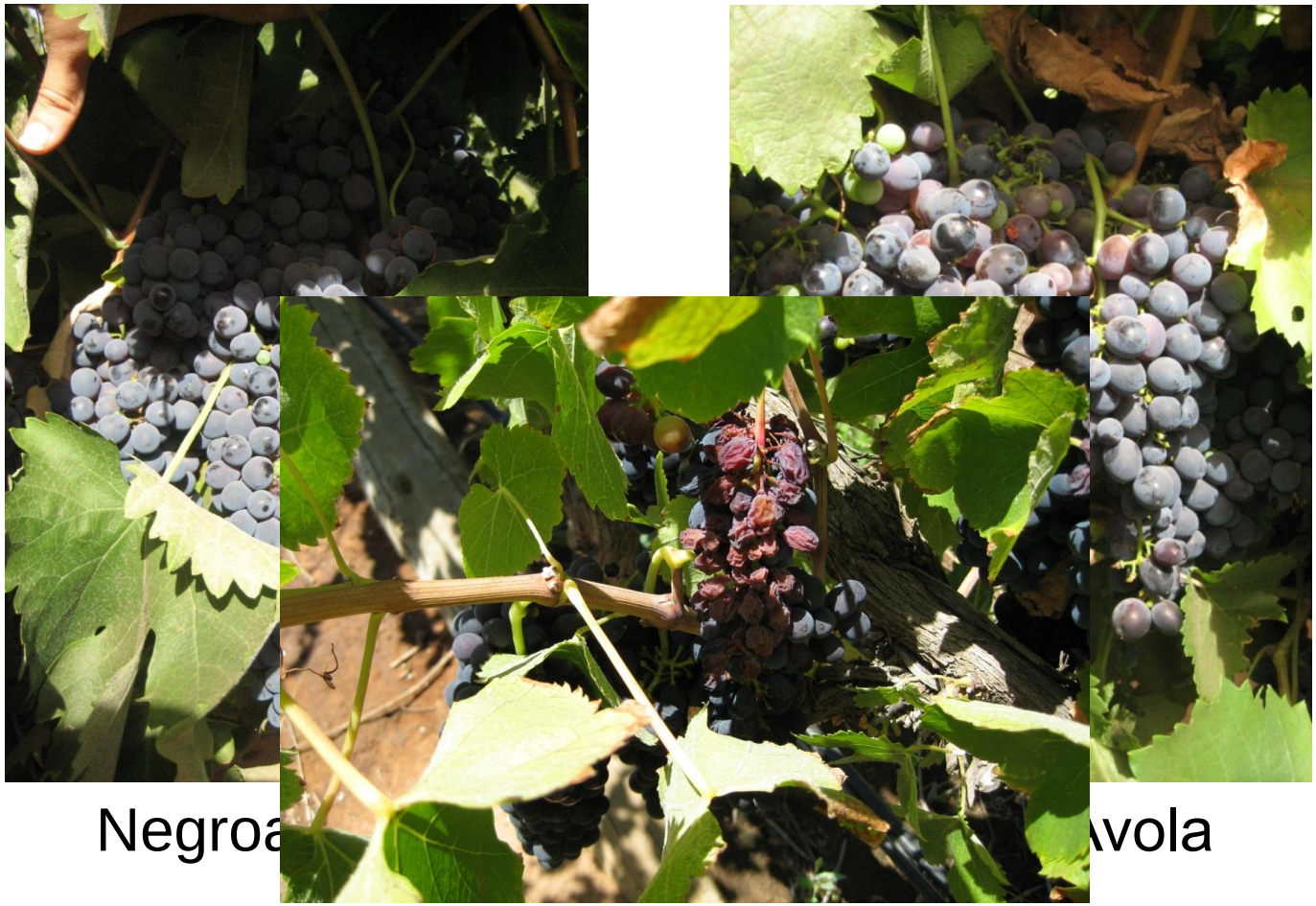
The Australian Wine Research Institute

- Many issues to consider

New varieties

The Australian Wine Research Institute

- Many issues to consider



Negroa vola

Conclusions part 2

The Australian Wine Research Institute

- Excessive bunch exposure has implications for grape composition and wine quality
- Maintain bunches with some degree of shading
- The degree of bunch exposure can be manipulated in both existing and new vineyards
- Many existing winegrape varieties are adaptable

  BUT some ‘new’ varieties can offer greater heat and drought tolerance

New vineyards: Row orientation

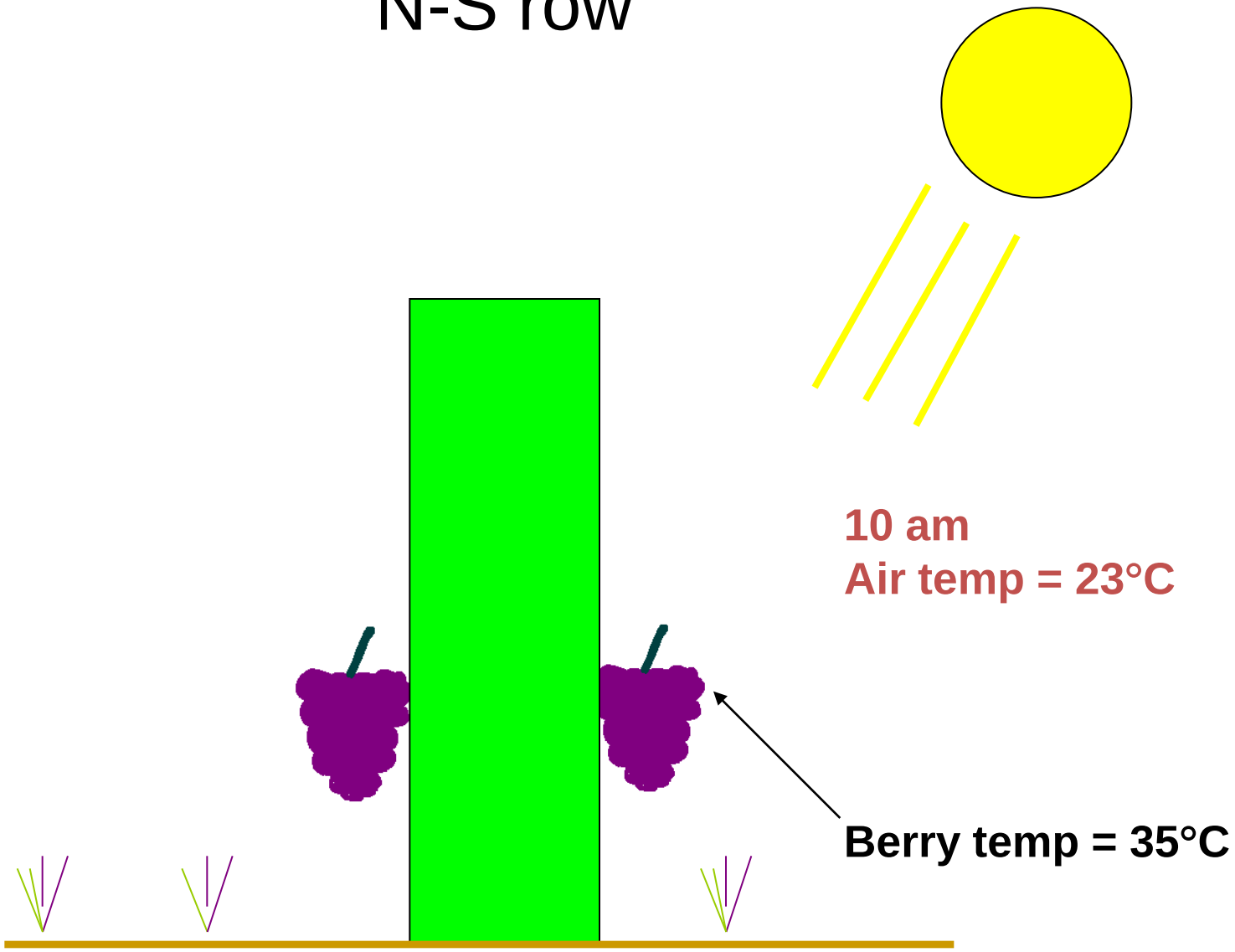
The Australian Wine Research Institute

North-South rows are common in Australia:

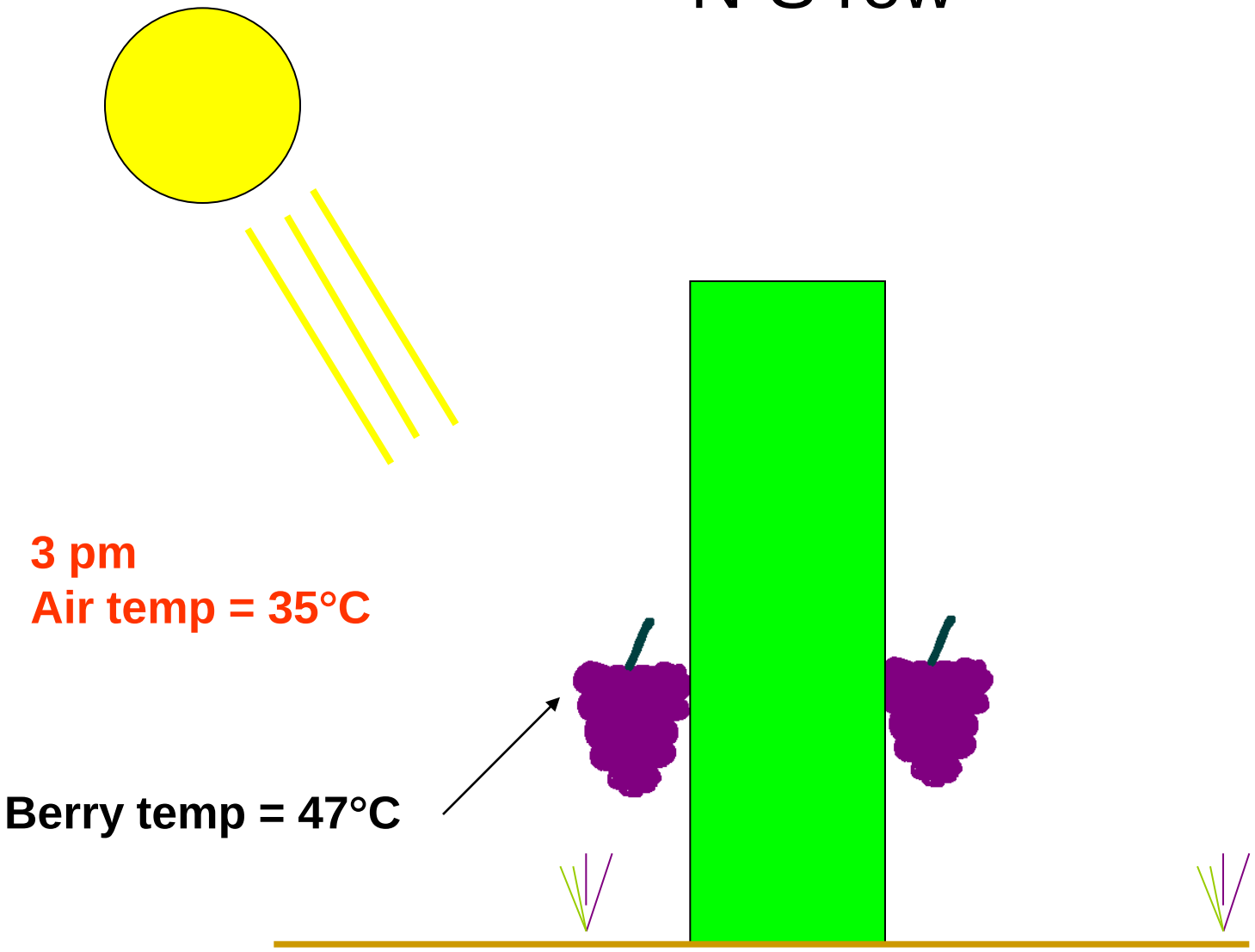
BUT thermal properties of bunches on W side are very different to those on E side

In sunny climates, the choice of row orientation should take into consideration **protection of bunches from over-exposure**

N-S row



N-S row



New vineyards: Row orientation

The Australian Wine Research Institute

In 2009: most bunch damage on N-S rows, particularly with VSP

In a single cool climate vineyard:

- 40% bunch damage on N-S rows,
- only 10% on E-W (Webb et al. 2009)

Row orientation:

The Australian Wine Research Institute

Recommendation:

Protect bunches during the hottest part of the day

- Consider **E-W or NW-SE*** row orientation for VSP and other trellis systems with vertical canopy face

*NE-SW in northern hemisphere

Irrigation management

The Australian Wine Research Institute

Aims:

- Develop strong canopy early in the season
  - Keep in mind potential ↑ demand for water later in the season
- Maintain a good canopy cover until late in the season

Irrigation management

The Australian Wine Research Institute

In 2007 to 2009 most bunch damage occurred where water was limited prior to heatwaves due to:

- drought or
- ‘severe’ deficit irrigation

Negative effects of high temperature event (40-45°C) are more severe for water-stressed vines than well-watered controls (Edwards et al. 2011)

Irrigation management

The Australian Wine Research Institute

Irrigation affects the vineyard microclimate

Transpirational cooling is ***critical***

- Active transpiration must occur ***prior*** to heat event
  (Edwards et al. 2011)

Considerations:

- **Need good water supply**
  - **particularly from set to veraison**
  - **and during heat waves**

Irrigation management

The Australian Wine Research Institute

Recommendations:

- Apply adequate irrigation pre-veraison to achieve good canopy cover
- If heat event forecast, cease deficit irrigation, apply irrigation to refill soil profile

Requires good water supply & appropriate infrastructure

Canopy management: training system

The Australian Wine Research Institute

In 2009 vineyards with sprawling, non-positioned canopies had least heat damage (Webb et al.)

- VSP trellis had most heat damage

  Particularly in cool regions (with a high proportion of VSP trellis and bunchzone leaf removal)

Canopy management: training system

The Australian Wine Research Institute

What do you do if you have VSP and north-south rows in sunny climate?

Canopy management: training system

The Australian Wine Research Institute

Full lift on both W and E sides of N-S row

Foliage wire lift to first position only on W side: both wires lifted on E side

Canopy management: bunchzone leaf removal

The Australian Wine Research Institute

- Either avoid altogether
- Or if necessary, do only on E side of N-S rows

W side

Artificial shading

The Australian Wine Research Institute

Applicable to winegrape vineyards?

Tablegrape vineyard near Mildura

Vineyard floor management

The Australian Wine Research Institute

In 2009 vineyards with bare soil had most heat damage (Webb et al.)

Recommendation:

Permanent sward

Mown sward thrown undervine