Technical Note

ARC TRAINING CENTRE FOR INNOVATIVE WINE PRODUCTION

Uncovering the effectiveness of vineyard techniques to delay ripening

Investigators: Pietro Previtali, Christopher Ford

Background and Aims

In a scenario of increasing CO_2 levels and more intense and frequent heat and water stress events, growers are in need of mitigation techniques to maintain yield and quality. When elevated temperature and water deficit occur while grapes are ripening, a critical consequence is that sugar accumulation is accelerated and becomes disconnected from the synthesis of organic acids, phenolic compounds (colour and mouthfeel) and aroma compounds. The resulting wines are then high in alcohol and lack balance with other visual, aromatic and textural components[1–3]. Delaying sugar accumulation, often referred to simply as "delayed ripening", has become a key aspect of viticultural management in view of climate change, to alleviate the decoupling between sugars and specialised metabolites and improve grape and wine quality.

In the past decade, several researchers have attempted to answer the question of which vineyard management practices can be best used to delay ripening, with combined benefits in terms of fruit quality and fruit intake through vintage decompression[4]. A primary objective has been identification of cost-effective techniques, including those whereby growers can leverage already-owned equipment with simple modifications in the timing or intensity of the treatment applied. Techniques to counteract detrimental effects of climate change have been described in previous reviews[5,6], providing a useful tool to summarise information from a range of primary studies reporting the outcomes of in-field experiments. These entirely qualitative reviews fail however to provide an estimated measure of the effect of a treatment, and are even less able to draw links between treatment effects and confounding factors such as variation between sites or vintages, or important parameters that can be controlled directly by growers. In our study, we incorporated the numerical outputs of all publicly-available experiments on delayed ripening into a quantitative analysis, using statistical techniques known as "meta-analysis".

These procedures have often been applied in other research fields, and their use is slowly catching on in viticultural research. Literature searches were performed in the main scientific databases and the results were rigorously screened leading to 43 studies qualifying for further analysis. A dataset for meta-analysis was compiled with 242 "effect size" values, meaning measures of the delaying power of a treatment, each one calculated as the difference between TSS values in the control and treated grapes on the same date. Negative and positive effect size values therefore indicated advanced and delayed ripening respectively (**Figure 1**), whilst null values indicated no treatment effect and increasing absolute values indicated larger or smaller effects in either direction.

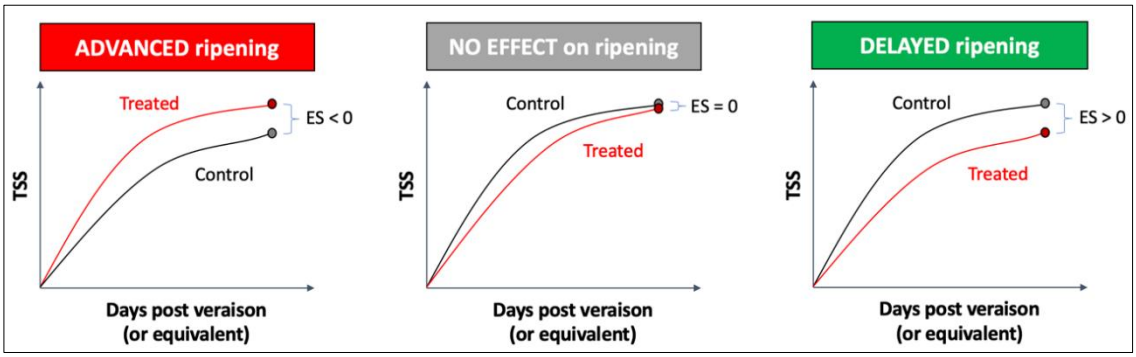


Figure 1. Calculation of a new variable called "effect size" (ES) from TSS data of primary studies.

The focus of our analysis was three treatments that have been studied most intensively and are easy to implement at the commercial scale:

- **Antitranspirants**: these chemical compounds can be easily sprayed on vines
- **Delayed pruning**: pruning operations are simply postponed until after the conventional winter timing
- **Late source limitation techniques**: these involve leaf removal or shoot trimming techniques that are commonly adopted in vineyards.

Key outcomes

The results of our systematic review and meta-analysis of vineyard techniques to delay ripening have been reported in the publication of Previtali et al. (2022)[7], which describes the full steps of data collection, curation, exploratory analysis and meta-analysis. Our analysis was not only able to identify if there is enough evidence for the treatments of interest to cause a ripening delay, but also highlighted aspects that growers can control to make the treatment itself more or less intense. The sections below report the key outcomes for the three treatments investigated.

Antitranspirants. When antitranspirants are sprayed on grapevines, they cause a decline in transpiration and consequently the photosynthesis rate is negatively affected. Less sugar synthesised in the leaves potentially means a lower degree of movement to grapes, which is the foundation of using antitranspirants to delay ripening. The delay caused by antitranspirants was positive and significantly different from zero, with an average effect of 0.74 °Brix. Significant factors that may be leveraged by growers were the choice of the active compounds as well as the timing and number of applications (**Figure 2**). Larger delays to sugar accumulation were found to be achieved when di-1-*p*-menthene (also called pinolene) was used, leading to an increase by 1.2 °Brix over kaolin sprays. Additionally, growers should consider to spray closer to ripening compared to around flowering for antitranspirants to be more effective, or alternatively a combination of an early and late application (such as flowering and veraison) may also make the delaying effect more intense.

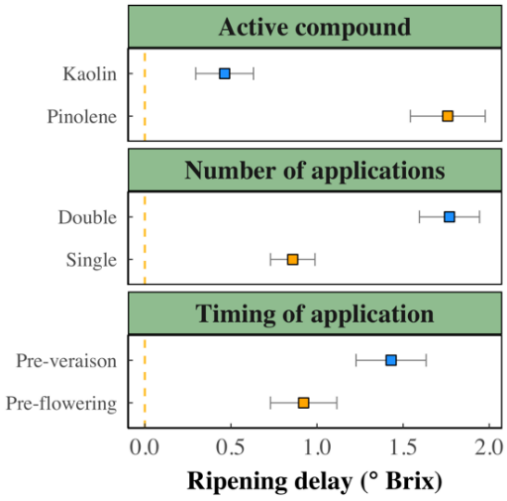


Figure 2. Significant factors affecting the ability of antitranspirants to delay ripening.

Delayed pruning. Compared to the conventional winter pruning, it is possible to postpone pruning operations until after budburst to delay the annual cycle of grapevines. Pruning canes after the apical buds have burst causes the basal buds for production to have less resources, hence their development to be hindered and harvest being achieved potentially later.

The suitability of delayed pruning for this purpose was confirmed and an average delay of 1.5 °Brix. Important factors that growers should take into consideration (**Figure 3**) are the pruning stage, with larger delays achieved the later vines are pruned, and yield, since it was clarified that late pruning is more effective under conditions of low yield.

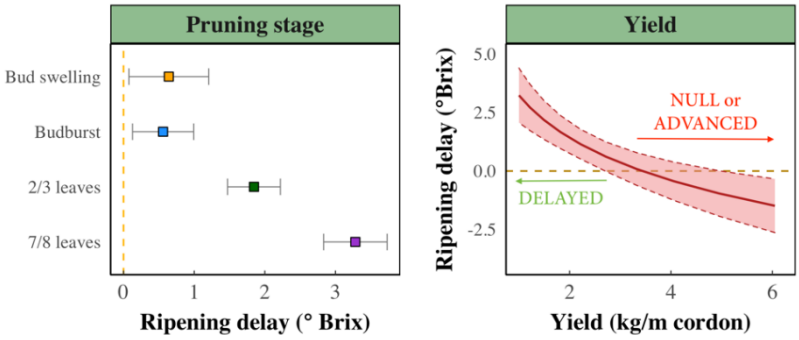
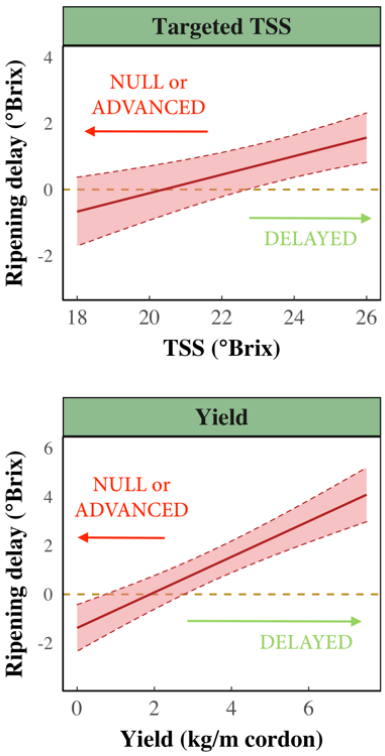


Figure 3 (left). Factors affecting the efficacy of delayed pruning to delay ripening.

Figure 4 (below). Factors affecting the effectiveness of late source limitation techniques to delay ripening.



Late source limitation. Limiting the synthesis of sugars in leaves (the so called "source" organs) is another way to slow down the process of sugar accumulation and can be achieved by late apical defoliation or late shoot trimming. Our analysis found that these techniques are able to significantly delay ripening, with an average delay of 1.2 °Brix. We also identified important factors that are able to affect the outcome of late source limitations (**Figure 4**). Firstly, these techniques are better suited for red or other grapes harvested at 23 °Brix or higher. Additionally, yield is another important consideration, with the best results obtained in high-yielding, slow sugar-accumulating vines.

Recommendations

Our research provides a clear quantitative rationale for the use of three main vineyard techniques to delay ripening: antitranspirants, late pruning and late source limitation. We have highlighted important trends between key aspects that growers can directly control and the outcome of these treatments. Growers may leverage these pieces of information in their decision making in an attempt to achieve the targeted delay in sugar accumulation.

Acknowledgements

We would like to acknowledge Filippo Giorgini, Randall Mullen, Nick Dokoozlian and Kerry Wilkinson for their input and effort in co-authoring the article. The support of Wine Australia's supplementary PhD scholarship to Pietro Previtali (PPA002459) is also acknowledged.

References

1. Sadras V & Moran MA (2012). Elevated temperature decouples anthocyanins and sugars in berries of Shiraz and Cabernet Franc. *Aust. J. Grape Wine Res.* **18**, 115–22.
2. Previtali P, Dokoozlian NK, Pan BS, Wilkinson KL & Ford CM (2021). Crop load and plant water status influence the ripening rate and aroma development in berries of grapevine (*Vitis vinifera* L.) cv. Cabernet Sauvignon. *J. Agric. Food Chem.* **69**, 7709–24.
3. Sweetman C, Sadras V, Hancock RD, Soole KL & Ford CM (2014). Metabolic effects of elevated temperature on organic acid degradation in ripening *Vitis vinifera* fruit. *J. Exp. Bot.* **65**, 5975–88.
4. Petrie PR, Brooke SJ, Moran MA & Sadras V (2017). Pruning after budburst to delay and spread grape maturity. *Aust. J. Grape Wine Res.* **23**, 378–89.
5. Gutiérrez-Gamboa G, Zheng W & Martínez de Toda F (2021). Current viticultural techniques to mitigate the effects of global warming on grape and wine quality: A comprehensive review. *https://doi.org/10.1016/j.foodres.2020.109946*
6. Palliotti A *et al* (2014). Changes in vineyard establishment and canopy management urged by earlier climate-related grape ripening: A review. *Sci. Hortic. (Amsterdam).* **178**, 43–54.
7. Previtali P, *et al* (2022). A systematic review and meta-analysis of vineyard techniques used to delay ripening. *https://doi.org/10.1093/hr/uhac118*

Contact

For further information, please email or visit our website:
Pietro Previtali: pietro.previtali@adelaide.edu.au; **Christopher Ford:** christopher.ford@adelaide.edu.au
ARC Training Centre for Innovative Wine Production; https://www.arcwinecentre.org.au

Australian Government
Australian Research Council

The ARC Training Centre for Innovative Wine Production is funded by the Australian Government (IC170100008) with additional support from Wine Australia and industry partners.

THE UNIVERSITY of ADELAIDE