Enhancing tropical fruit flavour in Chardonnay and Shiraz through foliar nutrient sprays

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Research in France has shown that foliar vineyard sprays containing nitrogen and sulfur can increase the concentration of thiol compounds responsible for tropical fruit flavours in wine. A trial was conducted in a Barossa Valley vineyard to investigate this technique for Chardonnay and Shiraz under Australian growing conditions. Large chemical and sensory impacts were seen for both varieties.

TROPICAL FRUIT CHARACTERS IN WINE

Tropical fruit-related characters such as passionfruit, grapefruit, pineapple, mango or guava, are an attractive feature of many white wines, and are particularly common in Sauvignon Blanc. The tropical nature of Sauvignon Blanc is driven by the presence of potent compounds commonly known as thiols. Recently these compounds have also been shown to be significant contributors to Australian Chardonnay wines (Capone *et al*. 2017, Capone *et al.* 2018). For Chardonnay, two thiols were found to be important: 3-mercaptohexanol (3MH) and 3-mercaptohexyl acetate (3MHA)[1]. In a set of young unoaked wines made from juices sourced from vineyards across Australia, these compounds were associated with enhanced fruity aroma, and at higher concentration with a 'grapefruit' character or, in some cases, clear 'passionfruit' or 'box hedge' flavour, characters more usually associated with Sauvignon Blanc.

While thiols are generally considered most important in white wines, they can also contribute to the flavour of red wines; for example, thiol concentration has been linked to enhanced 'blackcurrant' aroma in red wine (Rigou *et al*. 2014). The thiols 3MH and 3MHA have been observed in Bordeaux red wines (Bouchilloux *et al*. 1998) and a recent survey of commercial Australian red wines by the AWRI commonly found them above their sensory threshold (Siebert *et al*. 2019).

The generation of thiols in wine is somewhat unusual among wine flavour compounds in that it requires several steps. The first step involves metabolism within the grape; the second step requires the action of grape crushing; and, finally, the third step occurs through yeast metabolism. Non-odorous forms of these thiols are bound to amino acids in crushed grape berries and are broken down and released by yeast enzymes during fermentation.

One well-known way of enhancing the level of thiols in wine is by yeast selection. Not only can choice of yeast strain increase or decrease the overall concentration of thiols but it can also influence the ratio of 3MH to 3MHA (Cordente *et al*. 2017), strongly affecting wine flavour. However, the effect of yeast is limited by the amount of precursors available in the grapes to be broken down. The length of time between machine harvesting or crushing and the start of fermentation can have a large influence on precursor concentrations.

Manipulation of thiol concentrations in wine can also start in the vineyard by taking steps to increase the concentration of precursors in grapes. As the building blocks for the production of these precursors include nitrogen and sulfur compounds, vine fertilisation is one vineyard management option to achieve this. The use of foliar sprays in vineyards is commonplace, although vine nutrients are generally applied to the soil. French studies using foliar applications of nitrogen and sulfur resulted in wines higher in tropical thiols (Lacroux *et al.* 2008, Geffroy *et al*. 2016). However, there is limited information of the relevance of this technique in Australian vineyards, and limited reported sensory data.

TRIAL DESIGN

A vineyard block in the Barossa Valley planted in 1995 with both Chardonnay (mix of clones 76 and 277, own-rooted) and Shiraz (clone BVRC 12, own-rooted) at a vine density of approximately 1400 vines per hectare was used to test foliar applications of nitrogen and sulfur in vintage 2018. Mixtures of wettable sulfur (80% sulfur by weight) and low biuret urea (56% nitrogen by weight) were sprayed onto the canopies at two different dose rates (Figure 1). The foliar applications were made twice during the growing season: at the start and end of veraison (two to three weeks apart) to three separate areas per variety at each

[1]Due to changes in chemical naming convention, these compounds are now known as 3-sulfanyl- rather than 3-mercapto- (3SH and 3SHA); although to avoid confusion and allow comparison with previous works, the old naming convention has been used here.

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dose rate. Non-sprayed vineyard areas (also three per variety) were used as the controls. Each vineyard replicate was treated as an individual parcel which was hand-picked and underwent small-lot winemaking (30-40kg ferments) by WIC Winemaking Services. All wines were fermented to dryness with Maurivin™ PDM yeast. After six months of ageing in bottle the wines underwent chemical and sensory analysis.

RESULTS – THE GRAPES

While the yield per vine, total soluble solids and the titratable acid in the grapes were not significantly altered by the foliar applications (Figure 2), some sulfur burn was apparent on the canopy of the high treatment vines. When sulfur is applied as a fungicide, care needs to be taken to select cooler and dryer days (Emmett *et al*. 2003) to minimise the risk of burn. A strong effect was observed for the nitrogen content of the grapes. In line with previous reports, the foliar applications resulted in significantly higher yeast assimilable nitrogen (YAN) which increased with foliar dose (Figure 2). Importantly for fermentation, not only was there an increase in the inorganic nitrogen (ammonia) portion of YAN (which could be increased by a DAP addition in the winery), but also an increase in the organic nitrogen (alpha-amino nitrogen).

RESULTS – THE WINES

All wines underwent sensory analysis, where the sensory panel assessed the Chardonnay and Shiraz wines as separate sets, with no knowledge of the variety or any background to the study. Sensory results for both varieties showed an increase in the intensity of 'grapefruit' attributes with increasing foliar dose. The Chardonnay wines showed a similar trend for the 'passionfruit' attribute (Figure 3, see page 32).

For the Chardonnay wines the only other aroma attribute that differed among the treatments was 'honey,' which showed decreased ratings with increasing foliar spray dose (Figure 4, see page 32). The results for the Shiraz wines were slightly more complicated, with an increase in the 'drain' aroma attribute (a term used by the sensory panel to refer to unpleasant 'reductive' sulfide-related notes) seen in the foliar

AT A GLANCE

- Thiol compounds 3-mercaptohexanol (3MH) and 3-mercaptohexyl acetate (3MHA) are potent flavour compounds with sensory thresholds of 60 and 4ng/L, respectively, responsible for tropical fruit characters in wine.
- Foliar applications of nitrogen and sulfur to grapevines in France have been shown to boost concentrations of these thiols in wine.
- A mixture of urea and sulfur was sprayed onto Shiraz and Chardonnay vines in a Barossa vineyard during veraison (E-L 35) and three weeks later.
- The resulting wines showed elevated concentrations of 3MH for both varieties and a greater increase in 3MHA in the Chardonnay wines than in the Shiraz wines.
- Sensory analysis showed an increase in 'grapefruit' and 'passionfruit' characters in the wines for both varieties. The Shiraz wines also saw changes in some additional attributes, both positive and negative.
- The role of thiols in red wine flavour is an ongoing area of investigation.

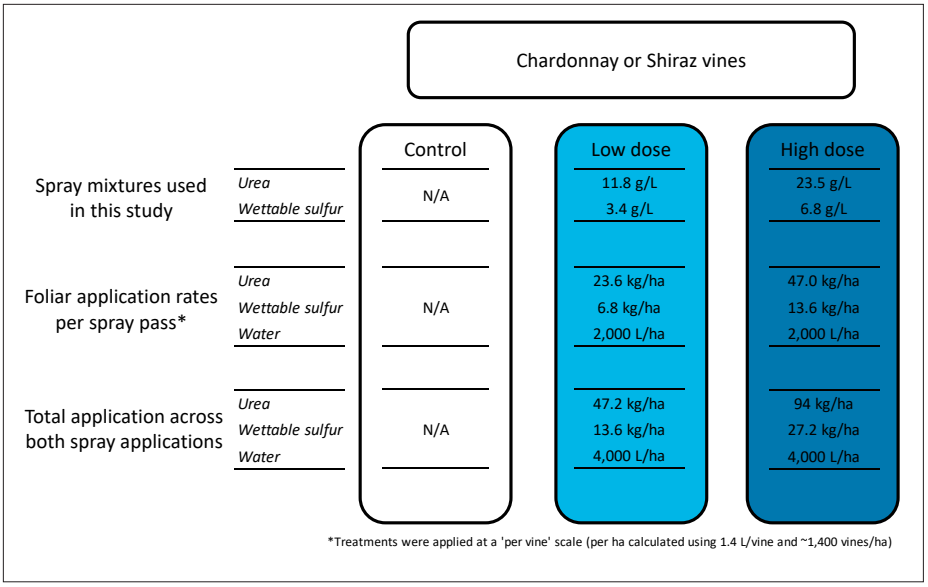

Figure 1. Foliar spray application experimental treatments and rates of sulfur and urea for Chardonnay and Shiraz vines. For each variety and dose (control, low and high), there were three separate vineyard areas in a randomised block design, resulting in a total of 18 vineyard replicates.

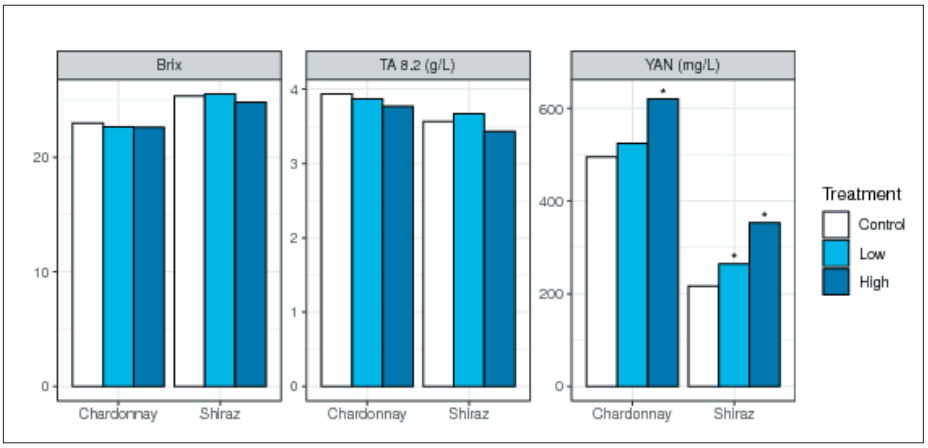

Figure 2. Effect of foliar application of sulfur and urea on grape juice composition (Brix, titratable acidity and YAN). Data are expressed as means of vineyard replicates (n=3). Bars with asterisks are significantly different from control (p=0.05).

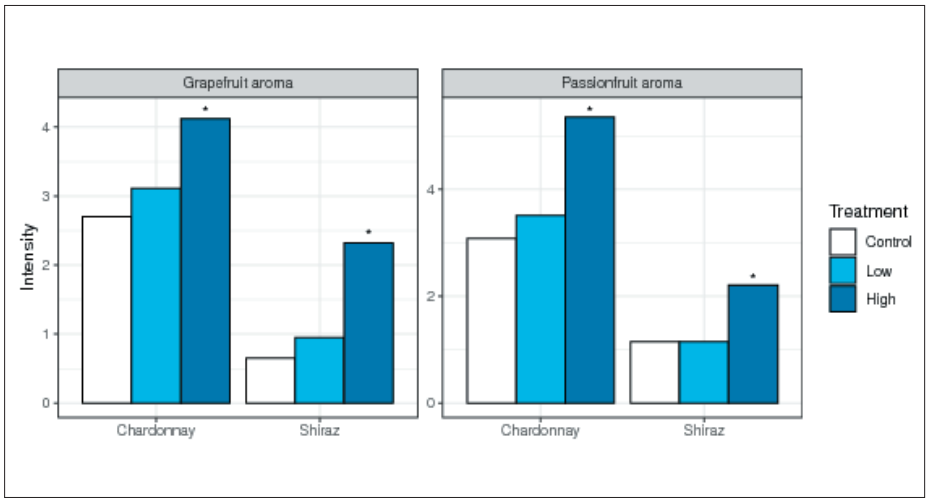

Figure 3. Effect of the foliar application of sulfur and urea on the sensory panel's ratings for 'grapefruit' and 'passionfruit' attributes in the Chardonnay and Shiraz wines. Data are expressed as means of all ratings. Bars with asterisks are significantly different from control (p=0.05).

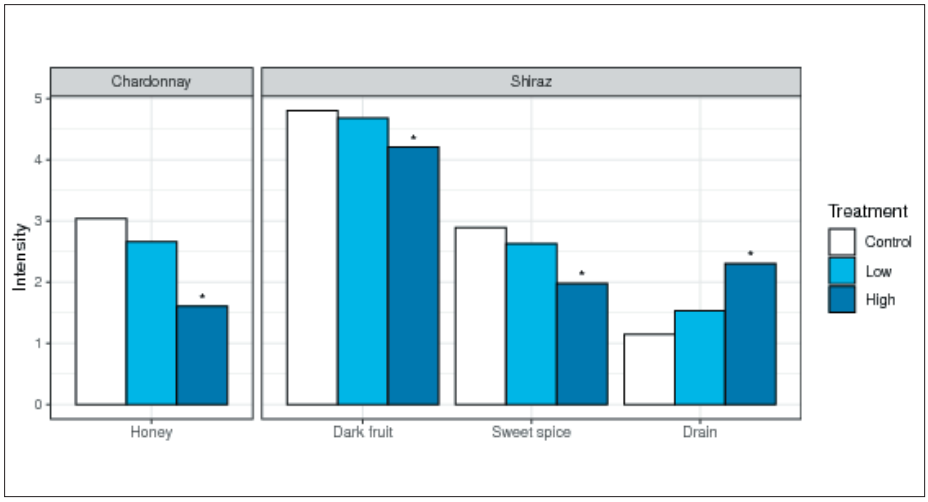

Figure 4. Additional aroma attributes rated as significantly different between foliar spray treatments. Data are expressed as means of all ratings. Bars with asterisks are significantly different from control (p=0.05).

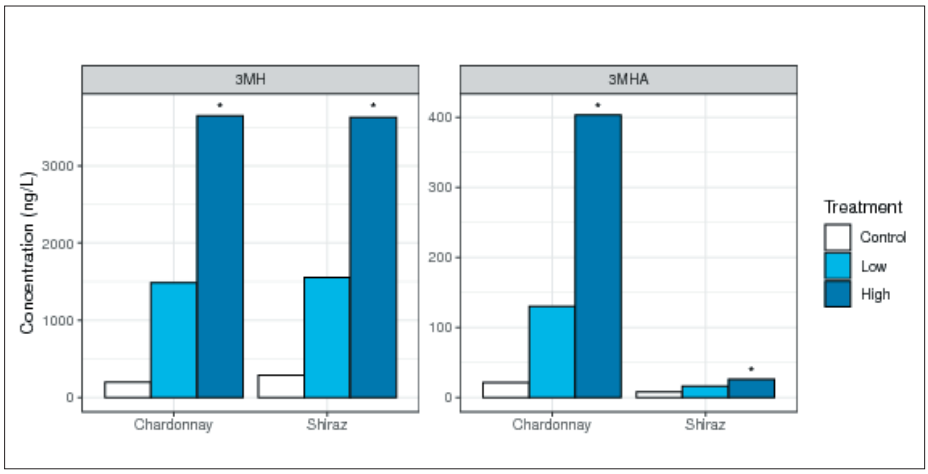

Figure 5. Tropical thiol concentrations in wines made following foliar applications of urea and sulfur. Data are expressed as means of vineyard replicates (n=3). Bars with asterisks are significantly different from control (p=0.05).

spray treatments, along with a small decrease in 'dark fruit' and 'sweet spice' attributes (Figure 4).

In the chemical analysis results, the Chardonnay wines showed a significant dose-response for both thiol compounds 3MH and 3MHA (Figure 5), which reflected the increases in tropical attributes noted by the sensory panel. These concentrations are very high, considering a recent survey of Australian commercial Chardonnay wines reported an average 3MH concentration of 650ng/L (Capone *et al*. 2018). Most of those wines in the survey had 3MH concentrations under 100ng/L, and some extended to around 2500ng/L. Similarly, 3MHA concentrations in the survey wines were capped at 80ng/L, much lower than the 400ng/L in the high treatment in this study. While a similar dose-response was seen in Shiraz for 3MH, the evolution of 3MHA was much lower than in the Chardonnay wines. As 3MHA is the more potent of the two thiols, this may provide some insight as to the more complicated sensory response, and indeed the role of thiols in red wines is an ongoing topic of investigation at the AWRI.

CONCLUSION

This study showed that a double application of both sulfur and nitrogen as a foliar spray over the veraison period resulted in increases in thiols and tropical sensory attributes for the Chardonnay wines. The response in Shiraz was similar to Chardonnay in terms of both the effect on nitrogen grape content and the accumulation of 3MH, but Shiraz wines did not show the magnitude of increases in 3MHA and also exhibited a dose-linked increase in an undesirable 'drain' character.

The use of foliar sprays produced a rapid increase in total grape nitrogen, which incorporated both organic and inorganic nitrogen, different from the increases in inorganic nitrogen that would be achieved by winery applications of DAP. The form of nitrogen present in must is known to affect fermentation vigour and yeast biomass, as well as the accumulation of many important aroma compounds (Bell and Henschke 2005).

While the dose that was used in this study was based on the original French

work (Lacroux *et al*. 2008, Geffroy *et al*. 2016), the vine density and canopy size in Australian viticulture is different from that of the original trial sites used (1400 vines/ha compared with either 8500 or 4200 vines/ha, respectively). The optimum dose and timing is an area of ongoing investigation, including the prevalence of sulfur burn. The results presented here are only from a single season, and from a single Barossa Valley vineyard, and current studies will expand knowledge of how widely applicable this technique may be for Australian vineyards. This study was repeated during the 2019 vintage and preliminary sensory assessment of the wines suggests a similar pattern of thiol response.

Foliar application of nitrogen and sulfur in the vineyard appears to be a promising, relatively easy to implement technique for increasing tropical characters in white wines, adding to other techniques available to winemakers.

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