SUSTAINING GRAPE PRODUCTION UNDER CHALLENGING CLIMATE CHANGE CIRCUMSTANCES

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Abstract:

Context and purpose of the study - Grapevines are an important economic crop grown in temperate climates of both hemispheres characterized by short-term heat spells and heat waves due to the distinct seasonality. However, these events have worsened during the late 20th and early 21st centuries due to accelerated climate change and is expected to exacerbate with even more intensity and frequency in the foreseeable future. This unprecedented speed in climate change has spawned major scientific and viticultural challenges as grape berries particularly exhibit high sensitivities to heat waves during ripening, the key phenophase determining fruit quality, time of harvest, and eventually the economic viability of wine industry. Given that the projections of worsening heat wave events are an immediate concern to the high socio-economic value of grapes, it is imperative that heat stress be curbed to ensure sustainability of grape production in a challenging environment. Therefore, the objective of this study was to mitigate the impact of heat waves by understanding the response of different grapevine cultivars to heat stress and various protective measures.

Material and methods – The experiment was conducted with field-grown own-rooted red and white cultivars. Individual clusters of these cultivars were enclosed using white paper bags and cheese cloth before veraison. Close to harvest, enclosed clusters as well as clusters that developed under ambient growing conditions (heat waves) were sampled and analyzed for primary and secondary metabolites.

Results – The berries of exposed clusters developed typical symptoms of sunburn, which included loss of crystalline structure of epicuticular wax resulting in a shiny surface. Such morphology was due to degradation and transitioning of wax platelets into amorphous masses creating a rough surface with poor development of color. However, the quercetin levels were higher than the enclosed clusters. The juice composition entailing Brix, pH, titratable acidity, content of malic and tartaric acids, sugars, and the levels of predominant mineral nutrient potassium, were compromised in sunburned berries. Furthermore, the response of various secondary metabolites such as tannins, polymeric anthocyanins, methoxypyrazines, guaiacal, and 4-methylguaiacal varied among exposed (sunburn) and enclosed (protected by bags and cheese cloth) berries. Overall, the enclosed clusters developed with better fruit quality attributes suggesting that cluster enclosure could be an effective strategy to mitigate the ill effects of heat waves.

Keywords: Climate change, Heat wave, Phenolics, Sugars, Sunburn

1. Introduction

Global climate changes are of major concern, especially to grapes, the world's most valuable horticultural crop (White et al., 20016). One of the key aspects of climate change is heat waves, which causes acute heat stress to grapevines at all phenological stages. In particular, grape berries exhibit high sensitivities to heat waves during ripening (Schar et al., 2004; White et al., 2006; Greer and Weston, 2010; Marx et al., 2017), the key phenophase determining fruit quality, time of harvest, and eventually the economic viability of wine industry (Bondada et al., 2017). At the cluster level, the effects of heatwaves are manifested as sunburn caused by over exposure of UV radiation (intense insolation) and high temperature (Shrader et al., 2003; Bondada and Keller, 2012). Given thatclimatechange forecasts predict an increase in the severity and frequency of heat waves (Schar et al., 2004; White et al., 2006; Bondada and Keller, 2012), it is imperative that sunburn be curbed to ensure sustainability of grape production in this era of tremendous global climate change. Possible means of tackling sunburn in grapevines include shifting grape growing regions to higher altitudes or latitudes (Hannah et al., 2013), improving the current germplasm (Zha et al., 2018), and adopting plant improvement techniques such as genetic engineering or traditional breeding to develop/identify new cultivars that are able to withstand heat stress.

Of all these means, the most viable option is the use of strategies that buffer the effects of heat waves such as evaporative cooling, kaolin-based particle film technology (Surround® WP) and shade net (Parchomchuk and Meheriuk, 1996;Schupp et al., 2002;Glenn et al., 2002; Gindaba and Wand, 2007). Each has its own pros and cons, yet the particle film technology is more practical and economical and hence used frequently to reduce fruit temperature in a wide variety of crops (Dry, 2009). In this study, instead of spraying the protective compounds, clusters were enclosed using white paper bags and cheese cloth before veraison. Close to harvest, enclosed clusters as well as clusters that developed under ambient growing conditions (heat waves) were sampled and analyzed for fruit composition to determine if the enclosures improve fruit quality.

2. Material and methods

A commercial vineyard with mature own-rooted *Vitis vinifera* cultivars of red and white wine grapes located in Red Mountain and HHH AVA's were chosen for determining the effect of protective coverings (Fig. 1) against sunburn by analyzing various fruit quality attributes desired for making wine. All cultivars were trained to VSP system and spur-pruned to equate the shoot density to 20 shoots/m. The vineyard with north-south oriented rows had vine by row spacing of 6 x 9 feet on a uniformlydeep loamy fine sand. All vines were drip-irrigated and standard cultural practices were performed to maintain healthy vines. Close to harvest, enclosed clusters as well as clusters that developed under ambient growing conditions (heat waves) were sampled and analyzed for primary and secondary metabolites.Microscopy technique was used to examine cell viability of flesh cells in healthy and sunburned berries. Cell viability was determined by the method suggested by Bondada et al. (2017).

3. Results and discussion

The berries of exposed clusters developed typical symptoms of sunburn, which included loss of crystalline structure of epicuticular wax resulting in a shiny surface. Such morphology was due to degradation and transitioning of wax platelets into amorphous masses creating a rough surface with poor development of color (Bondada and Keller, 2012). However, the symptomatology of sunburn between red and white cultivars varied; in red cultivars, color development was poor whereas brown lesions appeared on the skins of white cultivars (Fig.2). Furthermore, the sunburned berries incurred losses in cell viability whereas the healthy berries showed viable cells (Fig. 2). Regardless of cultivar types, the quercetin levels were higher in the sun-exposed berries (Bondada et al., 2017). Also, the juice composition entailing Brix, pH, titratable acidity, content of malic and tartaric acids, sugars, and the levels of predominant mineral nutrient potassium, were compromised in sunburned berries. Furthermore, the response of various secondary metabolites such as tannins, polymeric anthocyanins, methoxypyrazines, guaiacal, and 4-methylguaiacal varied among exposed (sunburn) and enclosed (protected by bags and cheese cloth) berries. Overall, the enclosed clusters developed with better fruit quality attributes suggesting that cluster enclosure could be an effective strategy to mitigate the ill effects of heat waves.

4. Conclusions

Both red and white varieties succumbed to sunburn; however, the symptomatology varied between the two types. The sun protective flavonol, quercetin increased in the sunburned berries despite a significant loss in cell vitality. Also, other primary and secondary metabolites were altered in sunburned berries. Enclosing the clusters with cloth and paper bags appeared to mitigate the effects of sunburn.

5. Litterature cited

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Figure 1:(Left)A cluster enclosed with cheese cloth and white paper bag (right) before veraison to protect them against heatwaves.

Figure 2: Sunburned Chardonnay (left) and Cabernet Sauvignon (Middle) clusters. Viable cells in healthy (green fluorescent upper part) and dead cells (faint fluorescent lower part) in sunburned berries (Right).