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Do wine grape cultivars respond differently to equally applied water deficits?

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Just over 15 years ago, Schultz (2003) reported the first evidence of potential differences between wine grape cultivars in their response to water deficits. The author – comparing Syrah and Grenache – concluded that the latter cultivar tightly controlled its water status (i.e. how relatively wet or dry the plant was) by closing its stomates early in response to water deficits, whereas the former did not. The cultivars were subsequently classified into two groups that describe theoretical plant stomatal behavior – isohydric and anisohydric. The tight stomatal control of water status by the isohydric cultivar Grenache was contrasted with the relatively poor stomatal control of water status by the anisohydric cultivar Syrah.

Plant ecophysiologists (those who study plant responses to their natural environment) often describe these response types, or strategies, as 'optimistic' versus 'pessimistic' (Lambers et al. 2008). In theory, isohydric plants are pessimistic (more conservative) such that they close their stomates early, reducing photosynthetic gas exchange in order to save water. In contrast, anisohydric plants are optimistic (less conservative) in that they keep their stomates open, maintain photosynthetic gas exchange at the expense of losing water. There is no free lunch in nature, so while the isohydric pessimists risk starving themselves of carbon in order to save water, the anisohydric optimists risk dying of thirst in order to gain carbon. Vast differences have been observed across plant (and crop) species, and indeed exist within crop species as well. For those of us concerned with controlling plant water status in a vineyard, the implications of wine grape cultivars having different responses are great and could make the difference between a successful vintage and significant crop loss.

Since Schultz (2003) published his results comparing Syrah and Grenache, there has been a flurry of research activity over the last decade examining the purportedly large differences among wine grape cultivars' stomatal behavior. Although a review of literature not the purpose of this article, I can summarize by writing that the results have often been contradictory – one study might show evidence for a particular cultivar being isohydric, while another might show the opposite. One reason is simply that replicated multi-year field trials with multiple cultivars are hard to do, so researchers are forced into potted-vine experiments or are limited in terms of cultivars. Believe it or not, there aren't too many replicated and randomized 20-cultivar vineyards planted out there! Another reason is that results can be confounded by somewhat expected factors such as rootstock, environment, and instruments/operator (Levin 2019). In fact, a recent meta-analysis of the literature on wine grape stomatal responses showed that 35% of the variability in the published data could be attributed to differences in study site and rootstocks (Lavoie-Lamoureux et al. 2017). Finally, much of the inconsistency in the literature could also be due to the fact that we egghead scientists simply have trouble even agreeing on terminology (Hochberg et al. 2018).

A recent paper from my lab reports on a study that was designed to control for many of the troublesome factors outlined above, and attempts to answer the titular question (published open-source, so it is freely available here: https://www.publish.csiro.au/fp/FP19073; Levin et al. 2019). We

utilized an existing, replicated cultivar trial with 20 cultivars grafted onto the same rootstock, and collected data over multiple years. The vines were subjected to water deficits by cutting off irrigation at different times of the year, and we compared how the cultivars controlled their stomates at various levels of equally applied water stress. In the end, we showed that cultivars do indeed respond differently to equally applied water stress, but that there were no clear distinctions among them in terms of isohydricity (no clear optimists or pessimists). In other words, there was a continuum of responses across all of the cultivars in the study.

The 17 red wine grape cultivars we evaluated were all grown in warm-climate viticultural regions, and included may common types, such as Cabernet Sauvignon, Tempranillo, Grenache, and Syrah. Observed cultivar differences in stomatal behavior were greatest at moderate water stress levels, whereas there were few differences at high or low water status. To put it another way, when water was plentiful, all cultivars had their stomates open and didn't show any differences in maximum stomatal conductance, while when water deficits were severe, all cultivars had their stomates pretty much closed. However, it was the transition between these levels that elicited the greatest differences. The mechanisms underlying this transition were hypothesized to be differences in osmotic adjustment in leaves and/or anatomical differences in vascular tissues that conduct water.

As is often the case, research results answer a few questions but lead to many more. It turns out that cultivars respond uniquely to water stress, but cannot be put into boxes of one type or another. This suggests that a one-size-fits-all irrigation management strategy is not the best. Growing conditions are changing across our state's viticultural regions and throwing new challenges at our managers. Thus, more work is required to evaluate responses to water deficits among the cool-climate cultivars that predominate our vineyards. It appears likely that different clones of Pinot noir or Chardonnay would respond differently to equally applied water stress as well. Understanding these differences will allow us to more precisely manage our vineyards while conserving our state's precious freshwater resources.

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