EXOGENOUS ABSCISIC ACID INCREASES FREEZING TOLERANCE AND INDUCES SUGAR ACCUMULATION IN GRAPEVINES

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Introduction

Grapes are the most valuable horticultural crop in the U.S., and its acreage has been expanding rapidly in the cold regions of eastern and Midwestern states. However, the economic sustainability of the grape industry is limited by climatic constraints, in particular freezing temperatures. In order to mitigate freezing damage, various protection methods have been developed, with the purpose of either changing the environmental conditions in the vineyard or improving the freezing tolerance (FT) of grapevines. To address this issue, we have developed a novel method consisting of foliar application of abscisic acid (ABA) that increased FT of both greenhouse- and field-grown grapevines in various grape cultivars. However, it is currently unclear how exogenous application of ABA mediates the acquisition of FT in grapevines. In addition to increasing FT, application of ABA was also observed to increase the accumulations of soluble sugars in many plant species (wheat, cucumber, alfalfa). Therefore, it has been hypothesized that the effect of ABA on grape FT is mediated by the accumulation of sugars, and that sugar accumulation in grape will be up-regulated by exogenous ABA application. However, the degree to which ABA application regulates sugar acclimation in cold-sensitive grapevines remains unknown. It is the purpose of this study to understand the role of ABA on early plant responses by evaluating the effect of exogenous ABA application on two grape cultivars, *Vitis vinifera* 'Cabernet franc' (cold sensitive) and *Vitis spp.* 'Chambourcin' (moderately cold sensitive).

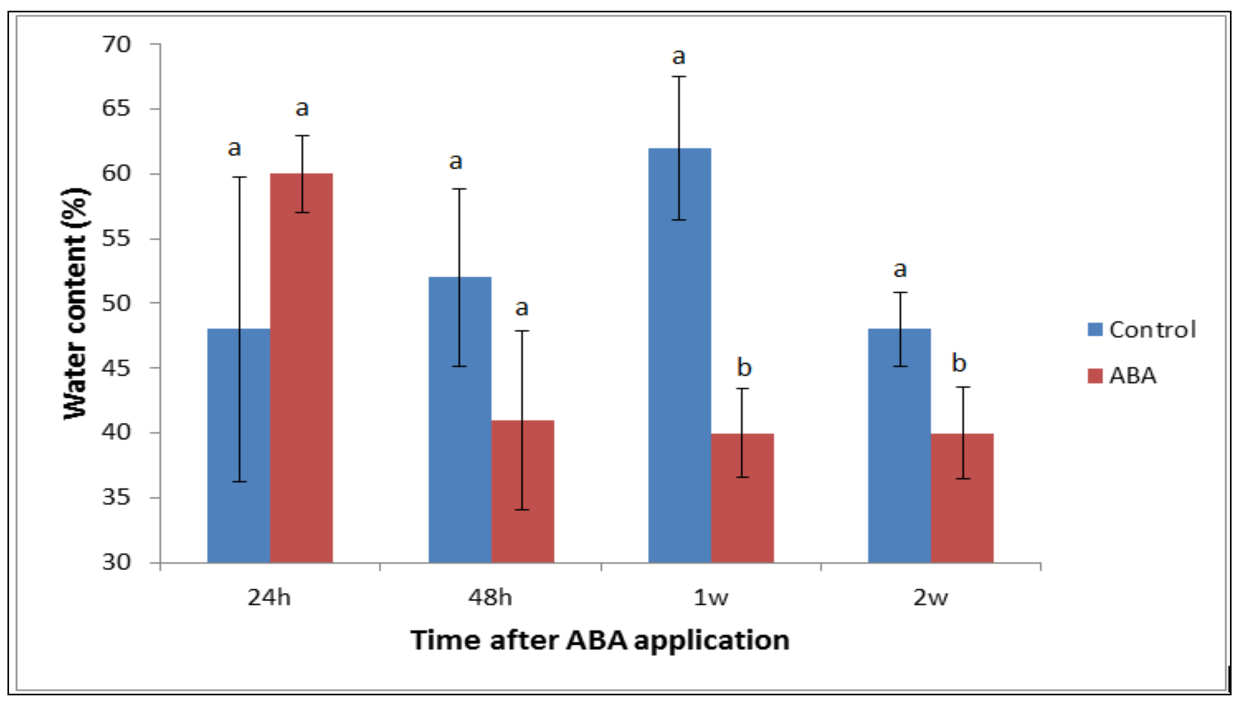

Figure 1. Temporal progression of bud water content in Cabernet franc grapevines post ABA application.

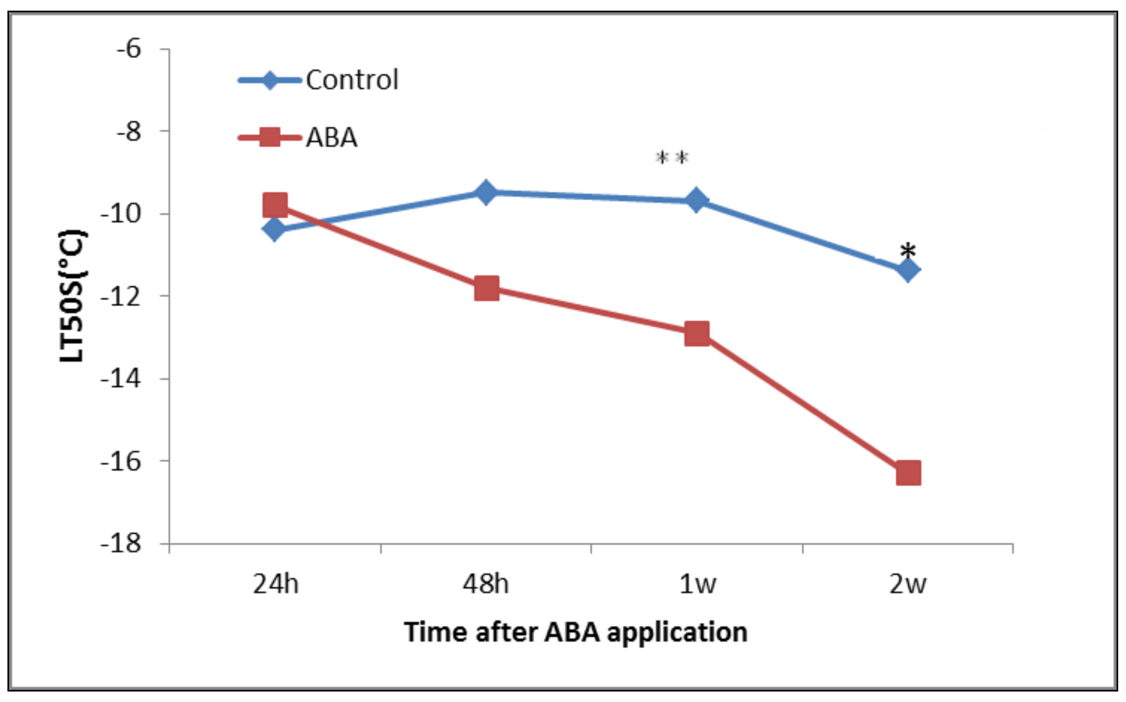

Figure 2. Temporal progression of bud freezing tolerance in Cabernet franc grapevines post ABA application.

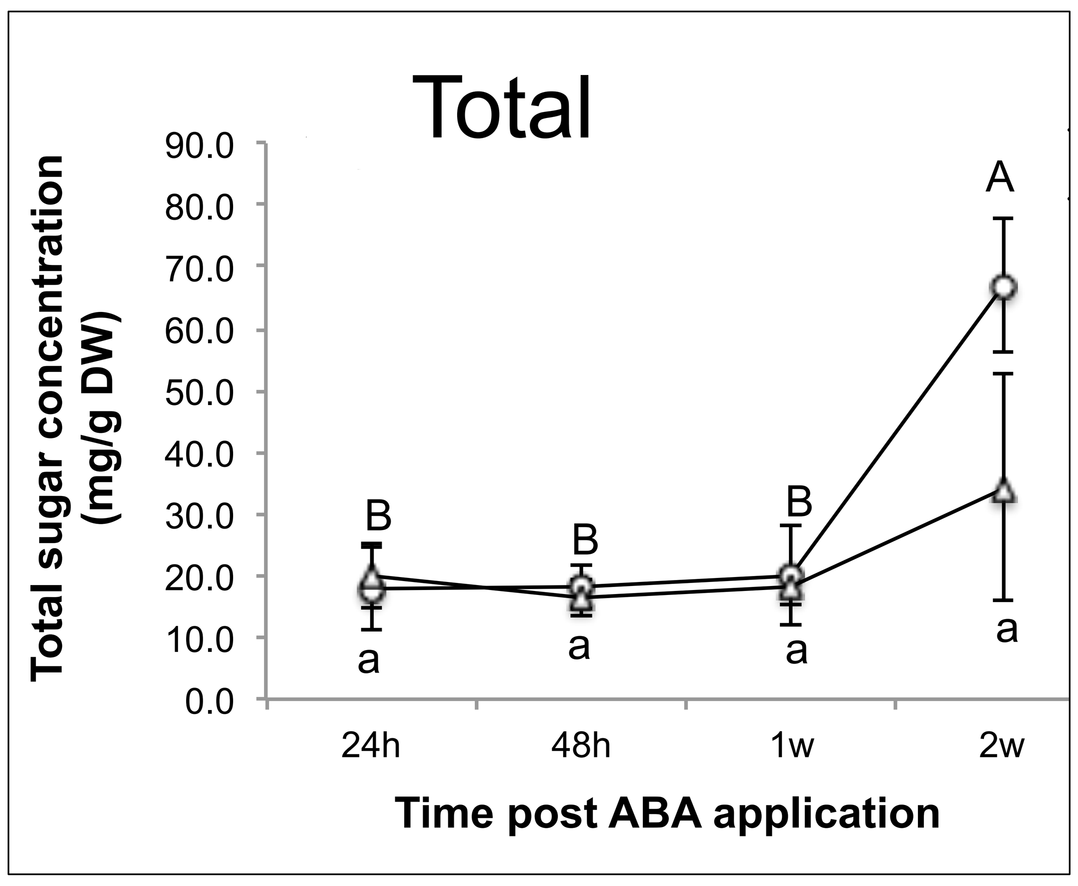

Figure 3. Temporal progression of bud total sugar concentration in Cabernet franc grapevines post ABA application.

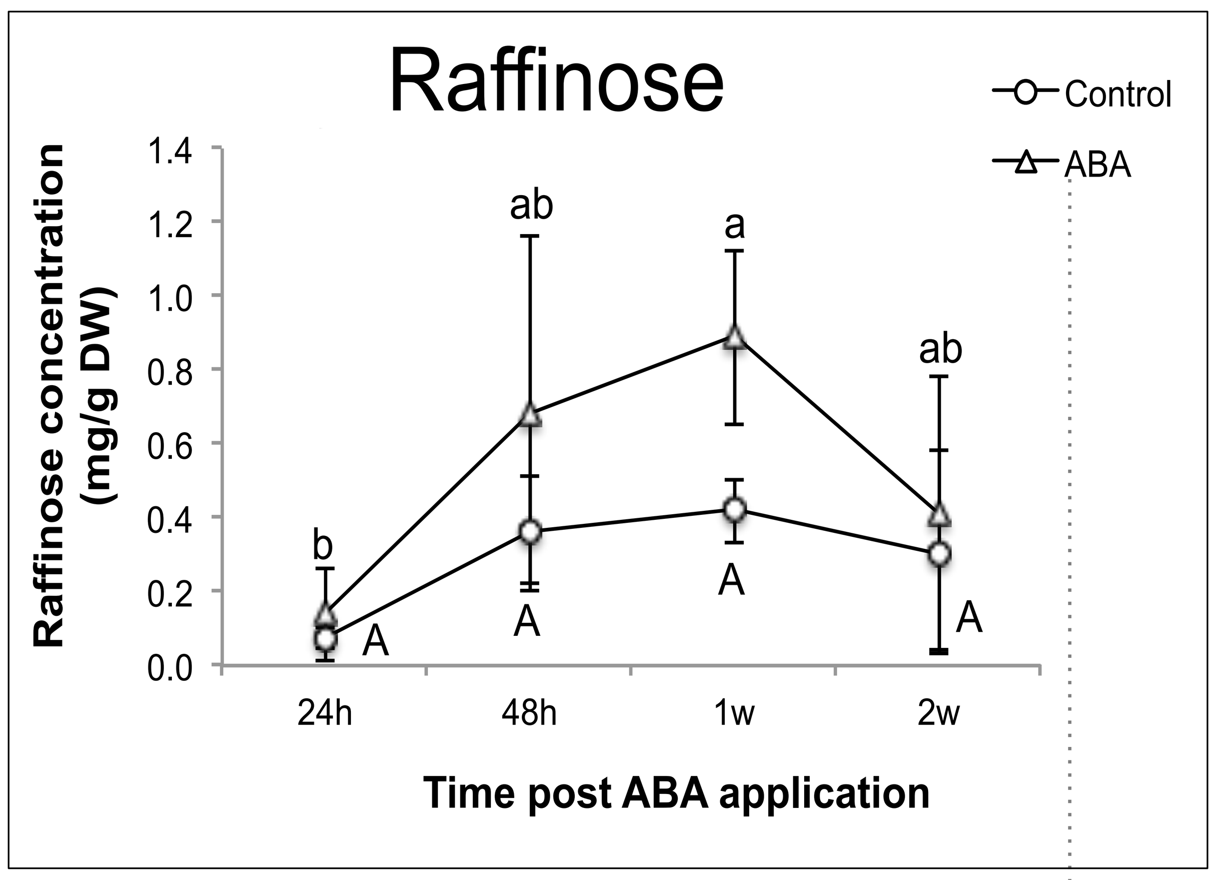

Figure 4. Temporal progression of bud raffinose concentration in Cabernet franc grapevines post ABA application.

Materials & Methods

Greenhouse-grown *Vitis vinifera* 'Cabernet franc' grafted on *Vitis riparia* × *Vitis rupestris* 'Couderc 3309' and *Vitis spp* 'Chambourcin' grapevines were used in this study. Treated vines were sprayed with a foliar application of ABA (400 mg. L^{-1}) and compared to untreated (control) vines, which were sprayed with deionized water. ABA was applied to 'Cabernet franc' and 'Chambourcin' at leaf ages between 90 and 120 days, respectively. Sample collection was conducted over time at 24h, 48h, 1w, and 2w post ABA treatment. At each sample collection time, buds from node positions two to six on each shoot were used for FT and water determinations and sugar quantification.

Results

- Bud water content generally decreased over time and was lower in ABA-treated than control vines at 1w and 2w post ABA application (Figure 1).
- Bud FT consistently increased (LT_{50} decreased) over time and was higher (lower LT_{50}) in ABA-treated than control vines as early as 1w post ABA application (Figure 2).
- Total sugars increased over time and were higher in ABA-treated than in control vines in 'Chambourcin', but not in 'Cabernet franc' (Figure 3).
- Only raffinose was higher in treated than control vines in both cultivars. In 'Cabernet franc', its concentration peaked then decreased one week post ABA application (Figure 4). In 'Chambourcin', maximum raffinose levels were reached 2w post ABA application.

Conclusion

Early responses to ABA is genotype – dependent and generally occurred 1w to 2w post ABA application and led to decreased water content, increased FT, and increased sugar levels in buds. The new knowledge of understanding how ABA mediates early cold acclimation responses would help develop new strategies to mitigate freezing damage. Ultimately, the findings from this research will enhance the economic and environmental sustainability of grape production in cold regions.

Acknowledgements

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