Research in Plain English

Deconstructing cold hardiness: variation in supercooling ability and chilling requirements in the wild grapevine *Vitis riparia*

Research in Plain English provides brief, non-technical summaries of journal articles by Cornell faculty, students, and staff.

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Summary by Janet van Zoeren.

The Takeaway.

- Maximum mid-winter cold hardiness varies among *Vitis* species, and also among V. *riparia* genotypes.
- Chilling requirement and deacclimation rates of V. *riparia* vines are affected by both environmental conditions and genotype of the vine.
- This study identified several V. *riparia* genotypes that show both deep mid-winter cold hardiness, high chilling requirements, and reduced deacclimation rates, which are considered adaptive traits to reduce winter damage.
- This information will be used to identify genetic markers for these traits, and is now available to grape breeders.

Background.

Vitis vinifera grape varieties were originally bred to survive in a Mediterranean climate; however, grapes increasingly need to withstand colder and more variable temperatures, on account of both the expanding range of grape production as well as environmental unpredictability due to climate change. Crossing V. *vinifera* with a more cold-hardy species can create hybrid cultivars with both cold hardiness and desirable fruit characteristics. A commonly-used species for these crosses is the North American *Vitis riparia*. The process of breeding new grapes would be more efficient with a better understanding of how genotype and environmental factors affect cold-hardiness within *Vitis riparia* lineages.

This article explores three aspects of winter survival: maximum cold hardiness (the lowest temperature a plant can survive during the middle of the winter), the chilling requirement (how many hours of non-freezing, cool temperatures a plant needs to

be able to break bud in the spring), and deacclimation rate (how quickly the plant breaks bud following the chilling requirement). Specifically, a goal of this research was to identify genotypes with deep maximum cold hardiness, high chilling requirements, and low deacclimation rates, and which therefore are likely to be able to survive better in future growing seasons.


Budburst experiment: buds at left are just beginning to break whereas those on the right have fully burst.

Experiment.

Forty-three V. *riparia* lineages (genotypes) were used, which came from much of the native geographic range of the species (from Texas to Manitoba). Each vine was quantified based on the USDA hardiness value and latitude from where the vine originated. The season-long temperature at the Cornell USDA germplasm in Geneva, NY (where all vines are being grown) was recorded for both winters of the experiment (2013 and 2014).

The maximum mid-winter cold hardiness, chilling requirement, and deacclimation rate of these 43 clones was tested regularly throughout both winters.

Maximum cold hardiness: Although many tissues of a plant acclimate to cold temperature and deacclimate when exposed to warm temperatures, buds are a convenient tissue to study because they use a mechanism for survival called “supercooling”. Tissues which use supercooling are able to suppress freezing well below 32°F, but when they do freeze it happens quickly giving off a large amount of heat in the process, which we are able to measure. This is a commonly used technique to quantify cold hardiness in plant species which use supercooling. Buds were collected from the field every two weeks from the first frost until budbreak, and frozen in a machine that recognizes the heat peaks given off when the buds

froze, allowing scientists to determine the temperature at which buds froze (the maximum cold hardiness of the bud at that time).

Chilling requirement and deacclimation rate: On the same collection dates, one-bud segments of cane were collected and kept in water in a cool, dark incubator to accumulate chilling hours. They were left in the dark incubator for 250, 500, 750, 1000, 1500, or 2000 chilling hours, and then kept in a growth room at 72°F until woolly bud (Eichhorn-Lorenz stage 3).

Results.

Different genotypes have different maximum mid-winter cold hardiness, but the rate of acclimation is apparently consistent. This seems to suggest that maximum cold hardiness is strongly related to the date when buds begin to gain cold hardiness, with those that begin to acclimate earlier in the season being able to withstand colder temperatures in the middle of the winter. To be clear, this is not true for other *Vitis* species, and is only true for the rate of acclimation, while the rate of deacclimation following mid-winter maximum cold hardiness is different between different *V. riparia* genotypes.

Chilling requirement and deacclimation rates varied across genotypes. Deacclimation was divided into three sections. Early-on an increase in chill accumulation led to a quick decline in time to budburst. Then, for each genotype, there was a transition period (presumably following 100% completion of chilling requirement), after which time to budburst was much less dependent on the hours of chill accumulation. A final transition zone in some varieties was followed by a period where additional hours of chill accumulation had an insignificant effect on time to budburst (presumably once both chilling requirement and deacclimation have both been completed). The specific chilling requirement and deacclimation rates were dependent on both genetic and environmental factors.

Conclusions and practical considerations.

The study showed evidence of genetic variability in mid-winter cold hardiness, chilling requirements, and deacclimation rates of *V. riparia* grapes. These results can be used by grape breeders to breed new cultivars with the desirable characteristics of deep midwinter cold hardiness, high chilling requirements, and low deacclimation rates. Future work looking at the specific genes associated with these traits could further increase the efficiency of breeding more cold-hardy grapes able to withstand changing/variable weather patterns.

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