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Grapes for the future

GRAPES FOR THE FUTURE: Dissecting dormancy and cold tolerance in *Vitis* spp.

Professor Al Kovaleski is helping secure grape (*Vitis* spp.) production into the future through innovative research on grapevine dormancy and cold tolerance. As a Putnam Fellow, Professor Kovaleski did post-doctoral work at the Arnold Arboretum of Harvard University, and is currently faculty at the University of Wisconsin-Madison.

Grapes are economically important to several countries and the majority of global production is made into wine. Like other perennial fruit crops, grapevines face challenges from climate change. In the northern hemisphere, most grapevines grow at latitudes from 30 to 50°N.[1] Despite an overall warming trend, a weakened winter polar jetstream results in shifts of the polar vortex down to reach these latitudes more frequently, rapidly causing unseasonably cold temperatures. Predicting where and how much the polar vortex will meander is a challenge, but there is a good chance northern grapevine growing regions could encounter lethally low temperatures more frequently in the near future, be that in midwinter or during budbreak.[2-4]

Young grape leaves and flowers, like in many other woody perennials, are formed the previous growing season as tiny structures inside buds. The buds enter endodormancy and cold acclimate with decreasing day-length and temperatures, in preparation to overwinter. As temperatures drop below 0°C, the water inside bud tissue supercools, remaining liquid at sub-zero temperatures. The low temperature capacity to supercool depends on the environmental conditions that induce cold acclimation and the species or cultivar of grape. During the dormant season, buds accrue chilling (0 to 10°C) time to transition from endodormancy to ecodormancy. Grape species originating from colder climates, where winter temperatures often remain below freezing (non-chilling) have a shorter chilling requirement than those from warmer climates, possibly reflecting some adaptive advantage.[5] After successful transition to ecodormancy, buds can synchronously break open as they respond to warmer temperatures and moisture from spring rains.[6,7] Grapevine buds could encounter two dangerous scenarios with the combination of warming temperatures and an erratically meandering polar vortex. At lower latitudes, buds could encounter lethally low temperatures from an early fall cold front before they properly enter endodormancy and cold acclimate. At higher latitudes, milder winter temperatures could increase chilling time and transition buds to ecodormancy pre-maturely. False springs in midwinter could initiate de-acclimation and bud break, making buds susceptible to a hard frost and lethal subzero temperatures if supercooling capacity is lost.[1,8]

New grape varieties may be required to safely survive and thrive through these scenarios. Professor Kovaleski is meeting these breeding and engineering challenges head-on by linking the physiology of cold tolerance with a given genetic signature.[6,8-10] In addition, Professor Kovaleski combined x-ray imaging and lethal low temperature assessment techniques to study de-acclimating buds, showing a clear relationship between increasing bud tissue volume and losing cold acclimation. By combining these techniques, Professor Kovaleski is fundamentally increasing our knowledge of cold tolerance and providing novel methods to investigate mechanisms of low temperature lethality in other plants.[11] At Harvard, Professor Kovaleski uses BioChambers low temperature equipment to understand temperature conditions necessary for gaining cold hardiness as a process that occurs against the temperature gradient. This means lower temperatures promote greater acclimation, which in turn suggests active temperature sensing is necessary for this process. Low temperature chambers are also used to provide artificial chilling in order to better understand the effects of different temperatures on overcoming dormancy both in grapevines and in other species collected from the Arnold Arboretum.

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