Grapevine Cold Hardiness

Cold Damage Tips

	Vineyard	Variety & Vine
Identify	At risk cold blocks.	Cold tolerance, crop potential and appropriate canopy density.
Monitor	Temperature of at risk cold blocks.	Bud and trunk damage, shoot density.
Respond	Implement new training systems. Replant with Cold Hardy varieties.	Leave additional shoots and trunks, delay pruning.

Grapevine cold hardiness is dependent on multiple independent variables such as variety and clone, shoot vigor, previous season's crop load, vineyard weather conditions, weather conditions prior to the cold event, duration of the cold event and the overall health of the vine entering the dormant season. Together these variables make predicting bud cold hardiness and cold injury difficult; however, with proper knowledge of these variables and application of the information and resources contained in this report, there are ways to manage cold hardiness to achieve positive outcomes in the vineyard.

Best Practices

Wait 24 hours after cold event to evaluate for damage.

Delay winter pruning, leave additional buds, prune again between bud break and 3-4 leaves per shoot.

Avoid excessive crop load (correct shoot density).

Provide water stress after verasion to encourage periderm formation (cold hardening).

Cold Damage Quick Facts

Phloem damage can be 100% recovered.

General sample size is 100 buds per vineyard block.

Under 25% primary bud damage - prune normally.

Over 25% primary bud damage - adjust bud number to reach crop potential.

Dormant buds of grapevines can sustain cold injury under low temperature conditions. Cold injury events may occur at different times and at different stages in bud dormancy. In general terms, warm temperatures tend to reduce bud hardiness while cold temperatures tend to induce more hardiness (within limits). In practical terms, this means that the specific weather conditions at each site will influence the ability of buds to withstand cold temperatures and thus the extent of cold injury on the grapevine. Locations that offer protection or buffer from the extremes, such as cold air drainage, are ideal and play an important role in the feasibility of growing grapevines in many parts of Colorado.

Generally, cold injury observed following 1) very low temperatures in mid-winter when dormant buds have reached maximum hardiness 2) moderately cold temperatures in the fall before buds have reached maximum hardiness 3) in the spring when dormant buds are waning down from maximum hardiness as the growing season approaches. Often, the most damaging events occur during clam nights following storms in the winter and spring.

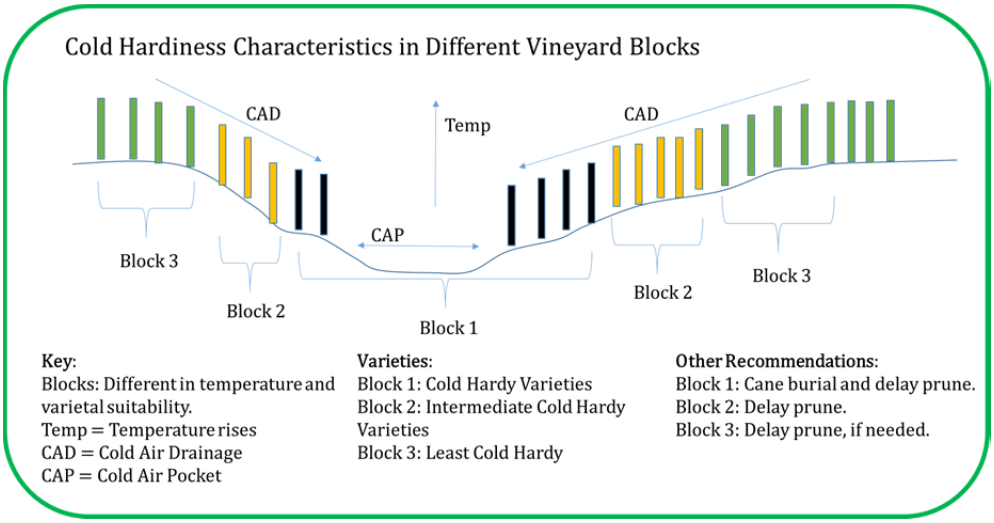
Cold temperature injury can damage of the fruitful (primary and secondary) buds and if severe enough, lead to the loss of cordons/canes, trunks, or the entire vine. Each variety of grapevine is unique and has a genetically determined cold hardiness limit and will differ in rates of acclimation from fall to winter and de-acclimation from winter to spring.

Grapevine Cold Hardiness in Colorado

From the 2015 Colorado Grape Growers Survey, vineyards continued the general trend of starting new plantings with cold hardy varieties as well as replacing cold tender grapevines. Cold hardy varieties now account for approximately 20% of the state's vineyard acreage and account for 54% of the state's new plantings. Currently, Colorado's industry struggles to maintain stable yields from year to year, in large part due to winter damage on cold tender varieties. Adding additional vineyard blocks and/or substituting failing plantings with cold hardy varieties should stabilize yield and make vineyard operations sustainable.

Cold Hardy (American/Hybrids)	Intermediate Cold Hardy (Hybrids/French)	Cold Sensitive (French/European)
Aromella, LaCresent, Frontenac, Vignole, Marquette, Noiret, Vidal Blanc, Norton, Marechal Foch, Concord, Traminette, American Root stocks.	Chambourcin, Albarino, Souzao, Riesling, Merlot, Baco Noir, Malbec, Cabernet Franc.	Rkatsiteli, Chardonnay, Syrah, Cabernet Sauvignon, Gewurztraminer.

Vineyard/Site Identification – The sustainability of a vineyard and the occurrence of cold injury will depend largely on the frequency of large temperature changes. Weather conditions can and will vary from vineyard to vineyard and often throughout the vineyard itself. The best way to approach sites with cold injury concerns is to record temperatures from fall through the spring season. Temperature data loggers are affordable and available from multiple manufacturers, they are simple to use and place in the vineyard. Additionally, there are multiple resources online to help predict climatic conditions such as CAVE and the USDA's Plant Hardiness Zone Map. Knowing how a vineyard or particular site in a vineyard will behave over winter will allow you to assess which variety will grow best at that location.



[USDA Agricultural Research Service – Plant Hardiness Interactive Map]

[Colorado Association for Viticulture & Enology (CAVE) – Weather Station Network]

Matching Vineyard/Block with Variety - The Western Colorado Research Center produces cold hardiness and cold injury information on the common varieties grown in Colorado and similar information can be found from other research institutions. Colorado State's Cold hardiness and Bud Evaluation provide tools to help growers best assess the potential of different varieties in their vineyards.

[Colorado State University – Cold Hardiness and Bud Evaluation]

[Washington State University - Grapevine Cold Hardiness]

[Washington State University - Cold Hardiness Model]

Figure 1 is a sample taken from the Western Colorado Research Center and illustrates the general behavior of cold hardiness throughout the dormant season by variety (Chardonnay and Syrah). Similar results are achievable in vineyard blocks with temperature monitors and bud damage evaluation.

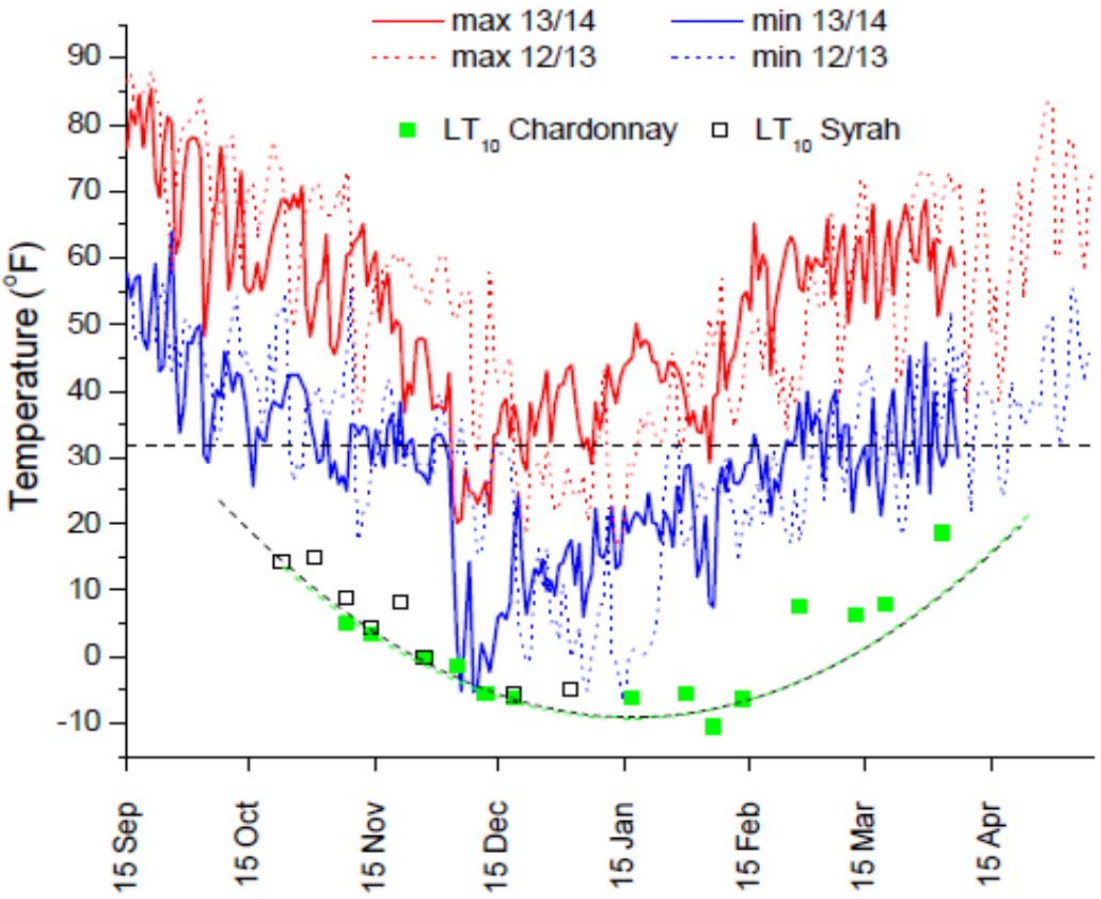


Figure. 1: Daily maximum and minimum temperatures recorded at the Western Colorado Research Center – Orchard Mesa near Grand Junction, Colorado, 201/13 & 20131/14, and critical temperatures for a 10% bud kill (LT10) estimated from Table 2. The dashed lines represent predicted values for LT10 based on curves fitted to previous years' data. Temperature data for various locations within the Grand Valley can found at http://www.winecolorado.org/colorado-grape-growing/weater-station-network/

Meteorological data from other locations throughout Colorado may also be available from the Colorado Agricultural Meteorological nETwork – COAGMET.

Preventing Cold Injury – Oregon State University publication *Protecting Grapevines from Cold Injury* describes three different training systems, V trench, J-system and Spur-pruned rose system (fan system) all which provide trunk protection from winter injury. These systems require additional labor, are not suitable for all varieties and may reduce fruit and wine yield.

Oregon State University – Protecting Grapevines from Winter Injury

Species / Cold Hardiness	Spring	Summer	Fall	Winter
Cold Hardy (American/Hybrids)	Train and leave additional trunks. Use bilateral cordon VSP. Late season prune to delay bud break, leave additional buds.	Treat: Nutrient deficiencies, water stress. Perform: Shoot/cluster thinning to reach desired canopy density.	Perform late season irrigation (soil recharge). Use of wind machine.	Assess bud damage. Monitor cold events. Avoid aggressively pruning.
Intermediate Cold Hardy (Hybrids/French)	Train and leave additional trunks. Use bilateral VSP or quadrilateral cordon. Alternative training: V-trench, J-system or spur-pruned rose or fan system. Remove cane from burial. Late season prune to delay bud break, leave additional buds.	Treat: Nutrient deficiencies, water stress. Perform: Shoot/cluster thinning to reach desired canopy density.	Perform late season irrigation (soil recharge), cane burial. Use of wind machine.	Assess bud damage. Monitor cold events. Avoid aggressively pruning.
Cold Sensitive (French/European)	Train and leave additional trunks. Use bilateral VSP or quadrilateral cordon. Alternative training: V-trench, J-system or spur-pruned rose or fan system. Remove cane from burial. Late season prune to delay bud break, leave additional buds.	Treat: Nutrient deficiencies, water stress. Perform: Shoot/cluster thinning to reach desired canopy density.	Perform late season irrigation (soil recharge), cane burial. Use of wind machine.	Assess bud damage. Monitor cold events. Avoid aggressively pruning.

Assessing and Responding to Cold Damage – Colorado State provides multiple resources on how to evaluate bud damage and when to respond to winter damage. Monitoring temperature, identifying blocks with cold risks and testing for bud damage are vital steps in mitigating cold injury. The resources below provide information on how cold temperatures damage grapevine tissues, instructions on how to evaluate buds and winter prune.

Many growers in Colorado have adopted the quadrilateral training system in response to death of fruitful buds from cold injury, to increase shoot density (bud/shoot number per vine), bunch number and yield per vine. This system can be easily implemented by adding a second (higher) cordon wire to the row. Trails have been conducted with Syrah, Cabernet Franc, Tempranillo, and Gewurztraminer on Colorado's western slope. Additional information can be found at (Quadrilateral vs bilateral VSP – An alternative option to maintain yield?)

Colorado State University – Evaluating Bud Damage Prior to Winter Pruning

Washington State University - Grapevine Cold Hardiness

Assessing and Managing Cold Damage in Washington Vineyards

Cornell University – Anatomy of Grapevine Winter Injury and Recovery

Washington State University – Winter Cold Damage and Vine Fruitfulness

Effect of Pruning on Recovery and Productivity of Cold-Injured Merlot Grapevines

Cold Injury Experiments and Vineyard Trials in Colorado

Cold Hardiness and Bud Evaluation – Orchard Mesa and Rogers Mesa

Additional Resources and Tools

http://webdoc.agsci.colostate.edu/aes/WCRC/TechBulletins/EvaluatingBudDamage.pdf

http://aes-wcrc.agsci.colostate.edu/viticulture/cold-hardiness-and-bud-evaluation/

http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/20803/pnw603-e.pdf

http://planthardiness.ars.usda.gov/PHZMWeb/InteractiveMap.aspx

http://wine.wsu.edu/research-extension/weather/cold-hardiness/

http://www.winecolorado.org/colorado-grape-growing/weather-station-network/

http://wine.wsu.edu/research-extension/files/2010/07/Winter-Freeze-Damage-and-Vine-Fruitfulness.pdf

http://cru.cahe.wsu.edu/CEPublications/EM042E/EM042E.pdf

http://www.hort.cornell.edu/goffinet/Anatomy_of_Winter_Injury_hi_res.pdf

http://www.ajevonline.org/content/ajev/58/3/351.full.pdf

http://wine.wsu.edu/research-extension/weather/cold-hardiness/model/