Texas A&M AgriLife Extension Service

Grapevine Cold Hardiness

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Cold hardiness

Cold hardiness is the ability of dormant grapevine tissues to survive cold temperatures during autumn and winter. It is often expressed as the temperature that causes mortality of 50% of primary buds in midwinter, termed "lethal temperature 50" (LT_{50}).

During dormancy, vines gradually acquire tolerance to cold in response to exposure to low temperatures, to reach a maximum tolerance level that is dependent on the grape variety, the environment and cultural practices (Table 1).

Cold hardiness class	Range of critical temperatures	Species	Example of varieties
Very tender	5 to -5°F	Most *Vitis vinifera*	Chenin blanc, Merlot, Semillon, Syrah, Sauvignon blanc, Zinfandel
Tender	0 to -8°F	Most *Vitis vinifera*	Chardonnay, Cabernet-Sauvignon, Gewurztraminer, Pinot gris, Pinot noir, Sangiovese, Viognier
Moderately tender	-5 to -15°F	Some *Vitis vinifera* and some hybrids	White Riesling, Cabernet franc, Gamay noir, Chambourcin
Moderately hardy	-10 to -15°F	Most hybrids	Chardonel, Traminette, Norton, Vignoles
Hardy	-15 to -20°F	Most *Vitis labrusca*	Concord, Niagara
Very hardy	-20 to -30°F	Some hybrids	Frontenac, Foch

Table 1. Relative cold hardiness of various grape genotypes. *Adapted from Dami (2007), Freezing and Survival Mechanisms of Grapevines. Workshop Proceeding.*

The cycle of cold hardiness is U-shaped pattern and contains an acclimation period (transition from cold-tender to cold-hardy state) and a deacclimation period (transition from a cold-hardy to a cold-tender state) with maximum hardiness during winter months (Figure 1).

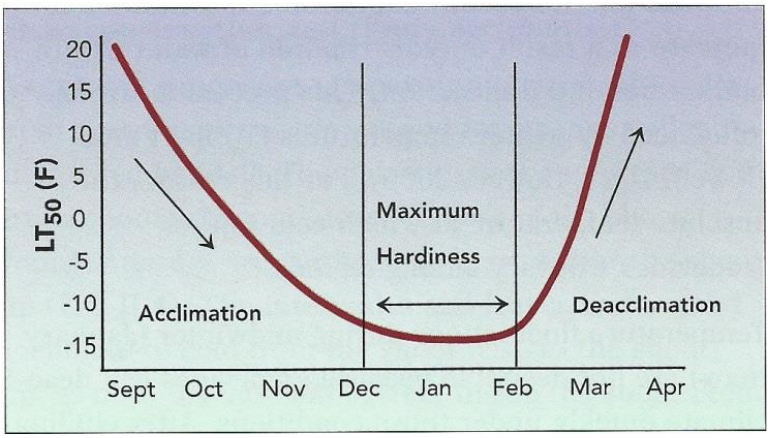

Figure 1. Cold hardiness in grapevines. *Figure from Zabadal et al. (2007).*

Factors that influence cold hardiness

- **Temperature fluctuations during mid-winter**: vines gradually acquire tolerance to cold as a result of exposure to cold temperatures. Exposure to warm temperatures for even just a few days can cause deacclimation which is more rapid than the acclimation process. Thus, grapes are more likely to sustain winter injury if cold temperatures are preceded by a period of warm weather.
- **Rapid temperatures drop:** this phenomenon can cause trunk splitting which serve as an entry point for pathogens and can trigger crown gall.
- **Duration of low temperature period** can affect mainly the extent of trunk damage, especially in big old trunks where it may take longer for the core to reach ambient temperatures.
- **Plant genetics**: *Vitis vinifera* cultivars are generally the most sensitive to cold winter temperature extremes, French hybrids are generally hardier, and native cultivars are often the toughest.
- **All sources of stress** such as diseases, mineral deficiencies, inappropriate water status, virus infections... All sources of stress can reduce grapevine cold hardiness during the winter.
- **Vines out of balance:** over-cropped or under-cropped vines are more susceptible to cold damage than balanced and healthy vines.
- **Limited canopy management and sunlight exposure**: practices and training systems that enhance photosynthesis also enhance wood maturation and tissue cold hardiness. A poor managed canopy that increase shading and limit sunlight exposure increase vine susceptibility to injuries due to unripe wood.
- **Site mesoclimate and site topography**: vines in frost pockets that accumulate cold air are more prone to cold injuries.

Cold damage on buds and trunks

A grapevine bud is a compound bud consisting of three growing buds: a primary bud that will emerge first and gives the largest clusters, and a secondary and tertiary buds which are smaller and less fruitful. Cold

injury in response to low temperatures typically affects the primary bud first. If the primary bud is killed, the other two buds, which are often hardier, may have survived and will take over instead. Bud injuries can be evaluated after cold damage. Guidelines for determining bud injury can be found online from Cornell University.

Cold damage to trunk can cause splitting which forms an excellent gateway for diseases such Crown gal caused by *Agrobacterium vitis* (Figure 2B). Trunk damage will manifest itself in spring by generating excessive sucker growth (Figure 2A). Vineyards heavily affected by cold can die immediately or weaken and die 2-4 years later.

Figure 2. Syrah vine damaged by winter low temperatures in West Texas.

Strategies to mitigate cold damage

- Wisely match variety with site in order to minimize or eliminate losses to winter damage: cold-sensitive cultivars should be planted only on sites that ensure good cold air drainage.
- Prune cold-hardy cultivars first and finish with the least hardy in order to adjust pruning level: for bud adjustment and according to Zabadal et al. (2007), if less than 15% bud injuries occurred, no need for adjustment. If bud mortality is between 15-35%, retain 35% more buds, if between 35-50%, retain 100% more buds. If bud mortality is more than 50% it may not be cost effective to do any dormant pruning or at least very minimal pruning.
- Good vineyard management that maximizes vine cold hardiness (adequate irrigation and fertilization, optimal crop load, good disease and weed management…).
- Vines with multiple trunks: if one of the trunks collapse, there may still be another trunk that produces a crop and provides some income until new trunks can be established to replace the damaged one (Figure 3).

- In sites where trunk injury is expected, hilling-up soil over graft unions can protect scion buds for re-establishing trunks following a cold event that damages buds. Another suggestion is to have the graft union as close to the ground as possible where it is warmer.
- Wind machines can be used during temperature inversions to mix warmer above-ground air with cold air, thus raising temperatures above bud-injuring levels at the trellis.

Figure 3. Syrah vine with two trunks, one damaged by cold temperatures and one growing normally.

Recovering after cold damage

After winter injury, a collapsed vine with healthy roots will throw new shoots that will emerge at the base of the plant. Shoots will also often emerge higher on the vine from the most sunlight-exposed nodes on the trellis, or from the basal buds at the base of canes. Many of the shoots will emerge later than normal because they develop from secondary, tertiary or basal buds.

On an own-rooted vine, shoots that emerge at the base, known as suckers, can be used to make new trunks and restore the plant to productive status. However, this cannot be done if renewal shoots are emerging from below the graft union of a grafted vine. In this case, growers may have to start over with new vines, unless a bud just above the union remains viable and emerges.

It is recommended to retain several suckers (3 or 4 suckers) because some may be damaged during the season or eventually develop into large, vigorous bull canes. Moreover, more suckers equal more leaf area essential for recovery and for root system. It is also recommended to not to add any nitrogen fertilizer as this will largely increase the growth of remaining shoots. After training the new trunk, extra suckers can be pruned next season.

As mentioned earlier, damage trunks are prone to Crown gal. If Crown gall develops, galled trunks can be nursed through the season to produce at least a partial crop while suckers from below the galls are trained

up as renewal trunks. Old trunk and fruiting canes can only be pruned when the total complement of buds needed for the vine can be obtained on new trunks.

In addition, on severely winter-injured vines, delaying or eliminating pruning is recommended. It allows the adjustment of bud numbers later in the season, reduces vigor of remaining canes and provides greater leaf areas for vine recovery.

Replant decision

Following winter injury, growers have the option of replanting missing vines, or abandoning part or all the vineyard. Replanting vines is costly but replanting also offers the opportunity to make strategic changes to improve overall vineyard profitability and viability.

Factors to consider when deciding to replant after winter injury: site mesoclimate, frequency of cold injury, soil characteristics of the site, performance of variety/rootstock combination, vineyard design and profitability and history of yield and fruit quality.

Cold hardiness is largely dependent on vine environment, health and genetics and it may be an important consideration when selecting varieties for the High Plains and West Texas.

For further reading:

Dami (2007), Freezing and Survival Mechanisms of Grapevines. Workshop Proceeding.

Kamas, Identifying and Managing Winter Injury, Texas Winegrower Volume II, Issue 1

Strik et al. Winter Cold Injury; Oregon Viticulture.

Zabadal et al. (2007). Winter Injury to Grapevines and Methods of Protection. Michigan State University, Extension Bulletin E2930.