Jack Frost Nipping at Your Nodes:
Grapevine Cold Hardiness and Strategies to Handle Winter Cold

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Grape production in the northeastern United States was long considered a risky endeavor, due in large part to issues with plant damage from cold events. Being perennial plants, grapevines must face all of the weather conditions that occur in their environment, and successful plantings will reflect a combination of: site selection; physiological plant characteristics; and grower management practices which prevent, minimize, or mitigate damage from cold temperatures.

Selecting the proper site is the first step to avoiding cold damage problems in the vineyard. Cold temperatures experienced in vineyards can be tempered to some degree. If there is sufficient elevation drop from the vineyard to allow cold air to drain away from the planting, removal of barriers such as tree lines can help improve airflow. On sites where the topography is not sufficient to drain away cold air or obstructions cannot be removed, frost fans may be used on the coldest nights (or when vines are most tender, such as after budbreak) to pull warmer air from above, but only if an inversion layer exists. Soil drainage is an important but less considered site component of grapevine hardiness. Vines that grow in saturated soils experience poor overall vigor, and therefore are more prone to cold damage. Improving soil drainage in a vineyard through tile drainage, berms, or swales can therefore reduce the vines' susceptibility to damage from cold.

Cultivar selection is critically important to ensure that a hardy enough grape is chosen for the site. Within the cultivar categories commonly planted in New England, e.g. *vinifera*; French-American hybrid; and cold hardy hybrid; differences appear in the relative hardiness of specific varieties. For example, *vinifera* are not generally considered hardy enough for all but the best sites in Northern New England, but growers have had varying success with Riesling and Pinot Noir in exceptional sites (that's not to say that those varieties perform as they do in more mild regions, however, and their use is not generally recommended). Most northern vineyards use hybrid varieties that contain genetic material from North American species that impart cold hardiness, as well as other characteristics including disease resistance, predominant growth habit, season of budbreak, and juice quality parameters. Many of the older French-American hybrids are less cold hardy than varieties bred in Minnesota and other upper Midwest states (referred to here as 'Minnesota hybrids'), although they may be considered with caution for warmer areas such as the Champlain and lower Connecticut Valleys. The Minnesota hybrids generally can be grown throughout northern New England, as far as midwinter cold hardiness is concerned. This does not mean, however, these cultivars, some of which break bud early in the season, can avoid spring frost damage on every site, nor that the growing season is sufficiently warm or long enough to adequately ripen the crop.

Cold damage occurs in grapevines when water within plant cells freezes and expands, thereby rupturing the cell wall or components within it. Grapevines have evolved a number of

characteristics that help minimize damage from freezing temperatures. Woody tissues such as trunks and canes withstand cold temperatures when the plant exports cellular water into the intercellular spaces so that, when frozen, it does not rupture the cell walls in plant tissues. This migration of water from within the cells also increases solute concentrations within the cells, thereby lowering the freezing point within, a phenomenon known as supercooling. Gradual temperature shifts in late fall to winter promote maximum acclimation in grapevines, while gradual warming in the spring leads to good deacclimation conditions. Deacclimation is simply the reverse of the hardening process under which vines prepare for spring growth, and deacclimating vines are more susceptible to cold injury than fully dormant vines.

Grapes have a unique strategy to ensure growth of the vine even in the event of cold injury. The compound buds present on one-year canes contain three separate bud primordial which can each develop into a shoot the following season. The largest primary bud is generally the most fruitful, vigorous, and *least hardy* of the three buds. Ideally, a grower wants to produce a crop from these buds exclusively, since crop quantity, quality, and consistency will benefit. In the event of damage to the primary bud through cold or other injury, and in some varieties even without damage to the primary, the secondary or tertiary buds may emerge and produce growth for that season. Midwinter cold damage to buds can be visually assessed after warming canes for 24 hours and slicing through the buds to look for visual browning which indicates bud death.

Vines begin the acclimation process in late summer in response to a change in day length. This occurs around veraison, which is one component of the hardening off process. The goal of the vine during this period is to ripen fruit so that it may spread seeds and maintain the species, and then to store nutrient reserves with which to harden off tissues and supply the vine during budbreak and early growth in the following year. Cold hardiness acclimation is an active process in grapevines. Shoot lignification (hardening off), nutrient storage, and even leaf fall all require energy derived from photosynthesis to occur. Because fruit act as a sink for photosynthate produced by the vine, vines with fruit hanging late in the season (e.g. high acid *riparia* varieties, long season *vinifera*, or ice winegrapes) may experience greater winter damage than those which have had a few weeks or more before a killing frost to harden off without the stress associated with fruit ripening.

The best way to ensure optimum cold hardiness for a particular vineyard is to practice balanced viticulture. This refers to a theoretical, but achievable, state where fruit production and vine growth are balanced so that the quality of each is optimized. Several factors will affect this relationship. Vines should be well pruned, shoot thinned early, and canopies managed using best practices such as shoot thinning, cane positioning, and modest leaf removal. Well-ripened fruit, harvested at the optimum time, generally indicate that the vine is in good shape to go through a typical winter. Where fruit ripening is delayed or inconsistent throughout the canopy, vines are likely stressed and cold hardiness reduced. Nutritional balance is also critical in maintaining cold hardiness. Although research has shown limited effect from increasing nitrogen or potassium fertilization on cold hardiness, overall vine nutrition does affect the plant's ability to handle winter cold. Therefore, growers should have petioles and soils analyzed and maintain an adequate nutrition program to ensure good vineyard performance. In addition to sound

viticultural management, vineyards that receive adequate pest management programs in the prior season will be more cold hardy than those that experience damage and defoliation from disease and insect pests. If these all sound like the same recommendations typically given for best managing your vineyard during the growing season, they are- healthy vines with a well-ripened crop of fruit and wood will withstand cold temperatures better than poorly managed or overcropped vines, because the vine can maximize photosynthate production and partition sugars and starches into stored tissues.

The deacclimation process is especially important for minimizing spring frost damage in vines. Gradual warming, with no significant dips into sub-freezing territory after the vines have begun to prepare for spring growth, helps to minimize damage to tender buds and shoots. Cultivars deacclimate differently to one another, which can lead to variable hardiness in the vineyard at certain times of the year. For example, Marquette, which is one of the cold hardy Minnesota hybrids, deacclimates before *vinifera* vines such as Riesling, and thus, for a few critical weeks in the spring, it is the less hardy of the two. Methods for delaying budbreak or managing temperatures after deacclimation has occurred are limited. Planting cultivars with early budbreak on north-facing sites may delay deacclimation, while planting those same cultivars higher on a slope may avoid the coldest temperatures experienced on a site when they have resumed growth in the spring. Delaying pruning until after expected spring frosts have passed, or 'double pruning', i.e. pruning to long spurs and following with adjustment of final bud count after frosts are no longer expected, can delay budbreak to some degree. Also, application of soybean oil to dormant vines in spring can delay budbreak by two days to around two weeks, but this strategy is recommended only for experimentation by growers until its performance can be fully tested. Vine training systems can also help minimize damage from spring frosts. During radiation frost events, the coldest air is located near the ground surface, so elevating the region where productive buds reside (i.e. high wire cordon systems) can help minimize cold damage after budbreak. However, this system should only be used on varieties that are fully hardy to expected midwinter lows, since the fruiting zone of the vine is held above any insulating snow cover or other material.

The use of snow cover (if it can be relied on) or other insulating materials is common in many vineyards, particularly on grafted vines, where the scion cultivar must be protected in the event that trunks are damaged. By protecting above the graft with snow, mulch, or mounded soil, the temperatures experienced can be 25°F or more above ambient temperature. Training systems such as Guyot (low-wire cordon), low head (fan), and 'J-style' allow for growers to cover vines with soil or mulch in fall to protect fruiting buds. These systems however are very labor intensive, require careful canopy management, and may produce poor-quality fruit due to problems with light interception on fruit located low in the canopy. For those reasons, it is recommended to select varieties that are hardy to expected midwinter in the vineyard, rather than to adapt and apply management strategies to protect tender vines.

Recommended resource: Winter Injury to Grapevines and Methods of Protection. Zabadal, T. (ed.) http://www.emdc.msue.msu.edu/product/winter-injury-to-grapevines-and-methods-of-protection-685.cfm