Reviewed Research Paper

An Analysis of Winter Injury to Grapevines as a Result of Two Severe Winters in Washington

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I. Introduction

In eastern Washington, critically low temperatures occur often enough to make growing certain varieties of European grapes (*Vitis vinifera*) hazardous (Table 1). For the past 51 years, about 1 year in 3 winter temperatures have been −21°C or colder; and about 1 year in 6, minimum temperatures have ranged from −24 to −29°C (3, 4). Two recent winters which have caused severe damage to grapes occurred in 1978-79 and 1983-84. These have formed the basis of analysis of winter damage in this article.

Winter hardiness is the ability of the grapevine to withstand cold winter temperatures which is normally judged by the vine's capacity to fruit normally after such exposure.

II. Nature of Damage

Buds: Winter injury can occur in all parts of the vine. However the most commonly observed form of injury in most years has been to grape buds. The grape bud is a compound bud having 3 growing points, called primary, secondary and tertiary. When dissected with a razor blade, the dead growing points appear as dark brown to black areas under a magnifying lens. If the primary bud is killed due to severe winter temperatures, the secondary bud often gives rise to a shoot which could bear fewer clusters than the shoot from the primary bud. The reduction in crop on secondary shoot compared to the primary depends upon the variety (10).

Canes: Some injury to canes due to low winter temperatures has been noticed in most years. The dead and/or damaged canes lack the green color when cut with a pruning shear or razor blade. The apical portion of the cane is often killed due to low temperature injury with the basal portion remaining alive. In winters where the minimum temperature was −24 to −26°C (2) the entire cane has been killed especially in cold tender varieties like Grenache.

Cordon: Injury to the cordon is less common than cane injury. Damaged or dead cordons lack the green color and appear dessicated when cut. Injury to cordon occurs in a random fashion.

Table 1. Years and months —18 C or colder minimum temperatures 1949-1983 at the Irrigated Agriculture Research and Extension Center, Prosser, WA.

Year	Jan	Feb	Nov	Dec
1949	−22	—	—	—
1950	−27	−29	—	—
1954	−26	—	—	—
1955	—	—	−18	—
1956	−19	−24	—	—
1957	−28	—	—	—
1959	−18	—	—	—
1960	−18	—	—	—
1963	−18	—	—	—
1964	—	—	—	−22
1969	−21	—	—	—
1972	−18	—	—	−22
1974	−21	—	—	—
1978	−21	—	—	−22
1979	−22	−22	—	—
1980	−20	—	—	—
1982	−22	—	—	—
1983	—	—	—	−26

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Trunk: Trunk damage, visually similar to that in cordons, was seen on some of the vinifera varieties during the 1978-79 winter. More injury to the trunk is usually seen on the northeast side which may be due to greater temperature fluctuations compared to south side. During the 1978-79 winter trunk damage was seen on Grenache, Cabernet Sauvignon and other cold tender varieties. Another form of winter injury seen in the 1978-79 winter on the trunk is the splitting of the trunk. This is not very common but has been seen in certain years. Paroschy and Meiring (1) attributed trunk splitting to dehydration stress.

Roots: Root injury is the least common form of winter injury experienced by vines in Washington. In most winters, there is snow on the ground during the winter months which prevents the soil temperature from going too low. However during the 1978-79 winter, the snow had melted in December and subzero temperatures (−22°C at IAREC, Prosser) continued. The result of this cold spell was deep soil freezing. The lack of moisture in the soil due to unusually low amounts of rainfall the preceding fall and winter contributed to the root damage.

In many years, the injury is not limited to a single location on the vine but is a combination of bud, cane, cordon, trunk and root injury. Depending upon the severity of the injury, the damage could range from stunting of shoots in the spring to total collapse of the vine either in the early spring or during the summer, if high temperatures are experienced.

III. Factors Responsible for Winter Injury

Genetic: There are genetic differences among the Vitis species and varieties within each species for winter hardiness. *Vitis labrusca* is hardier than *Vitis vinifera*. In northern and central parts of northeastern China, *Vitis amurensis* is the most cold hardy species which can endure −40° to −50°C below zero without injury. *Vitis amurensis* has been crossed with *Vitis vinifera* to breed cold hardy cultivars. Beichan released by the Botanical Gardens of Peking and Gongniang released by Julian Academy of Agricultural Sciences at Gongzhuling China are two such cultivars which are very hardy. *Vitis thunbergii* and *Vitis riparia* are 2 other species which have been used in cross breeding for cold resistance in China (7). Among the vinifera varieties commercially grown in Washington, White Riesling is the most winter hardy and Grenache (Table 2) least hardy. Among the American hybrids, Diamond, Niagara and Buffalo are considered hardy, and Isabella and Seneca have low winter hardiness.

Vine Factors (Non-genetic)

The important non-genetic factors in influencing hardiness are vine size and age, crop load, shoot exposure to sunlight and node position on a given shoot.

Other conditions being the same, the young vines (1-2 yrs. old) are more susceptible to winter injury than old

Table 2. Bud injury to grape varieties as a result of 1983-84 winter freeze.

Variety	Primary	Secondary	Tertiary
	% Bud Kill		
Cabernet Franc	8.7	10.7	9.7
Cabernet Sauvignon	37.6	25.7	26.7
Chardonnay	6.9	0.0	0.0
Chenin Blanc	20.0	16.2	20.9
Concord	1.0	0.0	0.0
Gewurztraminer	14.6	15.5	15.5
Grenache	99.0	99.0	99.0
Merlot	14.1	17.8	16.0
Pinot Noir	12.1	7.1	10.1
Sauvignon Blanc	24.3	15.5	17.5
Semillon	32.4	9.0	7.2
Sylvaner	36.5	25.9	33.8
Thompson Seedless	84.2	11.9	1.0
White Riesling	7.1	1.2	0.0
Zinfandel	25.2	12.6	21.4

Data from the Irrigated Agriculture and Extension Center, Prosser, WA. Minimum temp. recorded was −27°C on December 24, 1983.

well established vines. This was true in 1978-79 and in 1983-84 (1, 2). Over cropped vinifera vines yielding 18.0 to 22.0 metric tons/hectare in general had suffered greater winter damage than vines yielding 4.5 to 11.2 m. tons per hectare in the year or years preceding the severe winter with some exceptions. In 1978-79 a vinifera vineyard on a sandy soil north of Prosser, WA with a history of 4-5 to 11.5 tons/hectare for the last four years had less than 10 percent primary bud and vine damage whereas several high yielding Concord, Niagara and vinifera vineyards showed 40-70 percent primary bud and/or vine damage (1). These differences could be due to greater carbohydrate reserves in the canes, trunks and roots of low yielding vines.

Concord buds and canes on shoots at the canopy exterior, well exposed to sunlight, were 6.0 to 8.0° and 6.0°C hardier, respectively, than similar tissue from poorly exposed shoots from the canopy interior. Buds from basal positions were 5.3°C hardier compared to those from apical portions and basal canes were 4.5°C hardier than apical canes (8). The hardiness differences due to node position and sunlight exposure were inversely related to water content of tissues (8).

Acclimation of Vine Parts

During the winter there is no top growth but the physiological processes continue. If the vine is acclimated i.e. has developed the ability to resist low temperature stress, its chances of surviving under low winter temperatures are better. As the photoperiod shortens, and temperature drops, acclimation of vine begins.

Cold acclimation of grape canes begins as early as the third week in August in Washington and growth cessation is not a prerequisite for the shoot to begin acclimating. There is a close relationship between water content and tissue hardiness during acclimation but not past acclimation. Concord grapevines do not have a typical two-stage acclimation pattern and hardiness of cane and bud tissue more closely follows shoot maturation (9) than other observable phenomenon.

Proebsting et al. (13) studied the acclimation of primary buds of Concord, White Riesling, and Cabernet Sauvignon over a seven-year period. Concord had a stable T-50 value of −20°C and White Riesling and Cabernet Sauvignon −23°C. Cold weather preceding testing resulted in increased cold resistance during the acclimation period. Either physiological or morphological changes occur in the roots which cause changes in root permeability to water (9). More research is needed on winter hardiness of roots.

IV. How to Minimize Winter Injury

The cold tender vinifera varieties will suffer some cold injury if temperatures of −23°C or below occur. However the injury can be minimized by adapting the following measures.

1. Vineyard location:

Locating vineyards on sloping grounds is advantageous because cold air could drain into adjacent low lying areas. In eastern Washington wide, uniform southeastern slopes are preferred because they receive greater sunlight in late season which helps ripening of grapes compared to northern slopes. The slope should be at least 3% to be effective for air drainage. Such favorable sites can have minimum temperatures 3 to 4°C higher during the winter (6).

2. Type of planting material:

Vines started from mist propagated greenhouse grown plants suffered greater root damage than the vines planted with one or two-year old rooted hardwood cuttings in 1978-79 winter (1). This is largely due to the fact that mist propagated plants have a small and shallow root system. To minimize winter injury deeper rooting should be encouraged.

3. Cultural practices:

Cultural practices important for minimizing winter damage include decreasing the frequency of irrigation from August to September, providing a post-harvest irrigation, maintaining lower fertility levels, providing cover crop competition to vine, maintaining moderate cropping levels and hilling (1).

4. Irrigation:

Vinifera varieties continue to grow vegetatively in late season and could be damaged by frost in October and November. Forcing cane maturity by controlling vegetative growth is desirable, and is achieved by controlling the late season irrigations. Depending upon the weather, irrigations are either completely stopped by mid-August till harvest, or a light irrigation is given if hot weather prevails. While this practice is not backed by experimental evidence, it helps to achieve the desired cane maturity.

Filling in the soil reservoir with water before the vines go into dormancy is recommended for minimizing winter damage. Late season post harvest irrigation prevents dessication of the vine and the moist soil provides some insulation for the roots from the cold winter temperatures.

5. Cover crops:

Growing an annual or permanent perennial cover crop as means of providing competition for the vines has gained acceptance in Washington's viticulture. Creeping red fescue and perennial Elka rye grass are commonly planted between the rows 45 to 60 cm from the vines. Several other perennial cover crops like Durar Red Fescue, Fairway crested wheat grass can also be tried. Water requirements of cover crops and the effect of cover crop competition on vine growth and quality of grapes have not been assessed. Although some recent work has shown that perennial cover crops can use as much water as the vines (9).

6. Soil fertility:

Maintaining low to moderate soil fertility levels in vineyards is important for controlling late season vegetative growth and for winter hardiness. Growing a cover crop as a scavenger crop helps to take the extra nitrogen out of the soil.

7. Hilling:

Hilling refers to placing soil or any other cheap and easily available material around the trunk to protect the root system of own rooted plants from freezing. The most common method of hilling is to use a tractor mounted ridger to pile soil from the row middles on to the trunk and under the vine canopy. Hilling after the third year when the vines have a deep enough root system may not be necessary. Care should be taken not to expose the roots in the row middle while hilling.

8. Modifying the microclimate of vineyards:

In winter months when inversion conditions prevail, the temperature of the vineyard floor is colder than the air a few feet above it. By using the wind machines, the temperature of the vine's microclimate could be raised by a few degrees just before the occurrence of frost or colder spells. This offers the grower an opportunity to minimize winter damage to buds and/or canes. Since the price of wine grapes is high, such an approach is economically justifiable. During the 1983-84 winter, some growers have used the wind machines with beneficial results. Research is needed in this area in Washington.

9. Varietal selection:

Winter damage to Vinifera varieties can be minimized by selecting only winter hardy early-to medium-maturing varieties. Of the eleven vinifera grape varieties commercially grown in the state, White Riesling, Gewurztraminer and Chardonnay are considered hardy in that order. Grenache is the most cold tender variety. The other varieties have low- to medium-hardiness (Table 2). The grower should try to plant only the most hardy varieties. However because of the demand for certain varieties by the wineries, the grower chooses to grow less hardy varieties. Hardiness of a variety is dependent upon the cultural practices adopted for inducing hardiness (withholding late season irrigation, growing a cover crop, control of crop load, etc.). The hardy White Riesling if overcropped and not properly hardened is likely to get more winter damage compared to another variety of medium hardiness which has been properly hardened.

Within a variety, there is a great amount of variation in the amount of cold injury. The differences could be in the extent of cane dieback, bud injury, cane, cordon and trunk injury. These differences could be due to location of a vine within a vineyard, vine vigor, the presence of shaded and not well matured canes, and the build up of carbohydrate reserves within the cane and permanent parts of the vine. Canes depleted of photosynthetic reserves have less chance of being cold hardy than those which have abundant reserves. Vine characteristics which are important in cold hardiness are the amount of foliage and its exposure to sun, cessation of shoot growth early in the season after sufficient canopy has developed to support the amount of fruit carried by the vine, size of the crop and fruit maturity.

10. Use of rootstocks:

Another approach to growing less hardy vinifera varieties in cold climates of Pacific Northwest is by grafting them on less vigorous and hardy rootstocks (16, 17). Vinifera varieties on rootstocks have withstood cold winters better than own-rooted vines in New York. Fuchigami et al. (5) have indicated that a translocatable cold hardiness promoter may exist. If this is true, the use of rootstocks may offer greater possibilities of increasing the hardiness of cold tender varieties.

11. Use of chemicals for increasing hardiness:

Ethephon which releases ethylene within tissues following absorption has been used for increasing mid-winter hardiness of flower buds of fruit trees (14). Ethephon applied to wine grapes for advanced ripening and color enhancement also retarded vegetative growth with no effect on winter hardiness (12). Research with grapes and fruit trees elsewhere has shown that ethephon can help achieve increased hardiness (15).

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