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Grape Bud Survival in the Midwest Following the Winter of 1993-1994

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Abstract

The winter of 1993-1994 was one of the coldest on record across much of the midwestern U.S. Minimum winter temperatures in January 1994 ranged from -16°F (-27°C) to -39°F (-39°C) across Michigan, Indiana, and Ohio. Temperatures remained below 0°F (-18°C) in most areas for several days during January preceding the coldest temperature events. Primary bud survival was rated on 69 American, French-American hybrid, and *Vitis vinifera* grape cultivars and advanced breeding selections in research blocks and commercial vineyards in Indiana, Michigan, and Ohio. Results generally are in agreement with previous reports in that American cultivars were the most hardy, French-American hybrids were somewhat less hardy, and the *Vitis vinifera* cultivars were the least hardy. However, some French-American hybrids including 'Foch,' 'DeChaunac,' 'Frontenac,' 'LaCrosse,' and 'Ventura' were more hardy than the American cultivars. Many cultivars had better bud survival than expected for the minimum temperatures experienced. These ratings represent a good measure of the maximum winter hardiness of the cultivars surveyed because conditions for winter hardening in the fall of 1993 were ideal, and there were no winter temperature fluctuations or sharp temperature drops leading to the January 1994 episode.

The major limiting factor to grape production the eastern, midwestern, and parts of the western U.S. is cold temperature injury. Cultivars differ significantly in their ability to withstand cold so information on cultivar cold hardiness is essential when planning new plantings. The winter of 1993-1994 was one of the coldest on record across much of the midwestern U.S. and provided an opportunity to evaluate the hardiness of grape cultivars throughout the region. Minimum winter temperature in January 1994 ranged from -16°F (-27°C) to -39F (-39°C) across Michigan, Indiana, and Ohio. In most areas temperature remained below 0°F (-18°C) for several days during January preceding the coldest temperature events.

Cold hardiness in grapes can be affected by a number of environmental, physiological, and pathological factors (1, 4, 5, 11, 12). This survey includes a number of commercial vineyards and research plantings across a wide geographic area so some variability in the data can be expected.

Environmental factors that affect the degree of cold damage include the minimum temperature experienced, level of acclimation when the cold event occurs, duration of the minimum temperature, and temperature that precedes the cold event. There are three different phases of cold hardiness. In New York, acclimation begins in the fall, reaches a maximum in late December, and is maintained through February (8). Cold temperatures early in winter, before vines have reached the maximum level of hardiness, can cause considerable injury. Fluctuations in temperature, especially rapid drops, also cause significant bud damage. Apparently grape buds deacclimate more rapidly than they reacclimate, so in the event of warm temperatures followed closely by cold, more hardiness is lost than it can be gained back, and damage occurs. Wind is also considered to have a negative effect by

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drying tissues, or increasing the rate of cooling, but the role of wind in cold injury is still unresolved (4). Snow cover can lessen the amount of cold damage by insulating the vine from cold temperature.

A number of cultural management practices can lead to differences in cold hardiness. The most important factors are maintenance of maximum leaf area, training systems to insure maximum light exposure, adequate supply of water and fertilizer, and proper crop load (4). Cultural practices that encourage the onset of dormancy and acclimation, such as early harvest, actively growing cover crops, and dry soil conditions, generally improve cold hardiness. Practices that provide maximum exposure of canes and leaves to sunlight also maximize cold hardiness of the tissues near the exposed leaves, regardless of whether exposure results from differences in plant size, training system or severity of pruning (5, 12). Canes grown in shaded conditions seldom harden off properly and are frequently killed during the first freezes of winter. Because of the importance of leaves for cold hardiness, management practices to maintain healthy foliage, such as insect and disease control, are crucial (4). High incidence of leaf diseases, particularly downy and powdery mildews, can markedly reduce cold hardiness. Vines grown in poorly drained soils tend to enter dormancy slowly and often suffer more damage than vines grown on well drained soils. Crop load is another important factor. Excess cropping can reduce cold hardiness in cane and bud tissues (12). All of these factors can lead to variability in cold hardiness ratings of grape genotypes, and should be considered when making evaluations.

Materials and Methods

Grapes were sampled at nine locations; two in Indiana, one in Michigan, and six in Ohio. Extremely cold temperatures occurred across the region for eight days from 15 to 22 January 1994 with the coldest temperatures occurring at most sites on 19 January. Minimum temperatures in Indiana were -25°F (-32°C) in West Lafayette and -26°F (-32°C) at SWPAC. The daily minimum temperature was below 0°F (-17.8°C) for 8 consecutive days at both SWPAC and West Lafayette. During the period of coldest weather from 15 to 22 January, the daily average minimum and maximum temperatures were -15.1°F (-26.2°C) and 4.5°F (-15.3°C) at West Lafayette, and -13.8°F (-25.4°C) and 6.4°F (-14.2°C) at SWPAC, respectively. During the period preceding the cold event, from 1 to 14 January 1996, the daily average minimum and maximum temperatures were 17.4°F (-8.1°C) and 30.1°F (-1.1°C) at West Lafayette, and 19.7°F (-6.8°C) and 33.9°F (1.1°C) at SWPAC, respectively.

The minimum temperature in Michigan of -16.°9F (-27.2°C) occurred on 19 January. Temperatures were below 0°F (-17.8°C) for 5 of 8 days from 15 to 22 January. The daily average minimum and maximum temperatures during that period were -2.8°F (-19.3°C) and 14.6°F (-9.7°C). For the period preceding the cold event, from 1 to 14 January, the daily average minimum and maximum temperatures were 16.1°F (-8.8°C) and 31.1°F (-0.5°C).

Minimum temperatures from -22°F (-30°C) to -24°F (-31°C) occurred at locations in Ohio on 19 January. Information on daily average minimum and maximum temperatures were not available.

In Indiana bud samples were collected from replicated cultivar trials at two locations, and observation plots in one location. For all cultivars and selections tested at least 100 nodes from count positions were evaluated for primary bud damage by making a cross section cut through the bud with a razor blade and checking for necrosis of the primary and secondary buds. In Ohio 1,000 buds from each location

were evaluated by counting the percentage of growing buds on wood that would have been count buds on the training system used. Evaluation in Michigan was based on the percent of 10 basal nodes showing growth in May.

Results

Results of this survey are in agreement with other reports and the generally accepted opinions on grape cold hardiness (1, 2, 3, 6, 7, 8, 9, 10). American cultivars were generally the most hardy, French-American hybrids were somewhat less hardy, and the *Vitis vinifera* cultivars were the least hardy (Tables 1 and 2). However, some overlapping did occur among the groups. Older French hybrids such as 'Foch,' 'Leon Millot,' 'DeChaunac,' and 'Baco noir'; and newer French-American hybrids such as 'Frontenac,' 'Ventura,' and 'LaCrosse' were the hardiest wine grape cultivars. 'Concord' was nearly as hardy as these hybrids. Other American cultivars such as 'Catawba,' 'Delaware,' and 'Niagara' were also relatively hardy. Among the most widely grown French hybrid wine grapes, 'Foch' was the hardiest, and 'Vignoles,' 'Chancellor,' 'Aurore,' and 'Seyval' were moderately hardy. 'Cayuga White' and 'Traminette,' a new release from New York, were moderately hardy. 'Chambourcin,' 'Vidal,' and 'Chardonel' were the least hardy.

'Riesling' proved to be the hardiest of the *Vitis vinifera* wine grapes. 'Cabernet Sauvignon,' 'Cabernet Franc,' 'Chardonnay,' and 'Pinot Gris' had about 10% live buds at locations in Ohio (Table 2). However, most vinifera in Ohio were killed to the snow line, so bud survival may be associated as much with snow depth and training system than genetic cold hardiness. Vinifera cultivars in Indiana were killed to the ground.

Table 1. Percent survival of primary buds at count nodes of 47 grape cultivars following low winter temperatures of January 1994[z]

	Horticulture Research Farm West Lafayette, Indiana	SWPAC Vincennes, Indiana
	Minimum Temperature	
Cultivar	-25°F (-32°C)	-26°F (-32°C)
American		
Concord	64	72
Cynthiana	11	38
Delaware	10	78
Sunbelt	18	
Hybrid Red Wine Types		
Chambourcin	0	14
Chancellor	59	99
Frontenac	95	
Leon Millot	81	98
Marechal Foch	86	92
MN 1095	98	
MN 1141	90	
NY 70.809.10	47	
NY 70.816.5	31	
NY 73.136.17	25	
Villard noir	68	92
Hybrid White Wine Types		
Burdin 4672	20	25
Cayuga White	34	46
Chardonel	0	31
Horizon	20	56
JS 23-416	57	81
LaCrosse	77	96
Melody	11	50
NY 65.403.1	0	8
NY 65.533.13 (Traminette)	39	54
Ravat 34	76	87
Seyval	24	77
Siegfried	11	69
Vidal	0	13
Vignoles	41	78
Villard blanc	7	7
Ventura	88	92
Vinifera		
Cabernet Franc		0
Chardonnay		0
Table Grapes		
Canadice	0	
Einset	12	
Himrod	0	
Lakemont	0	
Mars	22	
NY 64.029.1 (Marquis)	4	4
NY 65.479.1	0	
NY 65.483.2	0	
Reliance	46	
Remaily	0	
Saturn	0	
Suffolk Red	7	
Vanessa	0	
Venus	0	

[z]Percent live nodes determined by cutting 100 buds of each cultivar at each location from the basal ten nodes on a cane.

The table grapes 'Reliance,' 'Mars,' and 'Einset' were the hardiest in Indiana. 'Reliance' and 'Canadice' both survived well at one location in Ohio. Two Elmer Swenson selections and two New York selections proved to be very hardy with less than 10% bud mortality in Michigan (Table 3). 'Einset,' 'Mars,' 'Himrod,' 'Reliance,' 'Romulus,' and 'Canadice' all had less than 50% bud mortality in Michigan.

Discussion

Bud survival was higher than expected on many cultivars considering the very low minimum temperatures reached and the length of the cold event. Expectations were for severe trunk, cordon, and cane injury on most cultivars after several days of average daily minimum temperatures of -15°F (-26°C) and a season low of -25°F (-32°C) such as occurred in Indiana and southern Ohio. However, very little cordon or trunk damage occurred on the hardy and moderately hardy cultivars, and damage has not shown up during the 1995 or 1996 season.

Peterson (7) reported the primary bud survival on wine and juice grapes in New York following the same test winter where low temperatures ranged from -8°F (-22.2°C) to -20°F (-28.9°C) in the Finger Lakes region during mid-January. Our results closely match his observations that 'Concord' was hardiest among the American cultivars, with 'Catawba' and 'Niagara' only slightly less hardy. 'Aurore,' 'Cayuga White,' and 'DeChaunac' were moderately hardy, and 'Seyval' was the least hardy of the French-American hybrids. Brusky-Odneal (1) evaluated bud survival following winter temperatures of -14°F (-25°C) and -16°F (-27°C) that occurred in mid-January 1982 and rated 'Concord,' 'Catawba,' 'Delaware,' and 'Steuben' as very hardy (≤30% primary bud mortality) American cultivars; 'Baco Noir,' 'Foch,' 'DeChaunac,' and 'Leon Millot' very hardy French hybrids; and 'Reliance' as a very hardy table grape. Again, our observations closely match her findings.

Hamman (3) evaluated 32 cultivars for winter hardiness over five years in Colorado and found similar results to those presented here. Though winter temperatures seldom dropped below -15°F (-26°C), winter damage was more apparent with *Vitis vinifera* than French hybrids. 'Rougeon' proved to be the hardiest cultivar tested, surviving -20°F (-29°C) with no apparent damage. Other red hybrids such as 'Foch,' 'DeChaunac,' and 'Chancellor' were ranked hardy, and white hybrids 'Seyval,' 'Aurore,' and 'Vidal' moderately hardy. Though we did not have 'Rougeon' in our survey, 'Foch,' 'DeChaunac,' and 'Chancellor' were hardy at all locations.

The present survey involved both commercial vineyards and research plots across a wide geographic area, so variability in bud survival values can be expected, and is evident in the data. It is difficult to account for variability between locations from the information available. Differences in crop load, disease incidence, cover crop management, soil fertility, and other factors that affect cold hardiness between the different sites likely contributed to the variability seen in bud survival. We were not able to quantify the various factors that may have influenced the amount of cold damage on all cultivars at all sites. However, despite the lack of control of these factors, we feel that this data is of value because the environmental variation across the region was minimal and should have caused little variability in the amount of cold injury. In particular, the temperatures during the period preceding the cold event were very stable and relatively cold, so deacclimation should not have been a factor. In addition, the summer and fall of

Table 2. Percent survival of count nodes of 30 grape cultivars from commercial vineyards in Ohio following low winter temperatures of January 1994[z]

Cultivar	Meier's North Bass -24(-31)	Klingshirn Avon Lake -24(-31)	Willow Hill Johnstown -24(-31)	Debonne Madison -22(-30)	Markko Conneaut -22(-30)	Valley Morrow -24(-31)
			Minimum Temperature °F(°C)			
American						
Blue Eye						31
Catawba	81		37			50
Concord		85	56	84		75
Delaware	83	67				
Niagara			18	86		12
Steuben						22
Hybrid Red Wine Types						
Baco	84					81
Burdin						64
Chambourcin			2		66	
Chancellor	78					9
Chelois				31		18
Colobel				17		7
DeChaunac			38	81		94
Foch			68	9		71
Rosette				58		
Hybrid White Wine Types						
Aurore			72			82
Cayuga				80		9
Rayon d'Or			40			
Seyval	78		55	66		65
Vidal	34	60		33		10
Villard				58		
Vinifera						
Cabernet Franc	15					
Cabernet Sauvignon	22				36	
Chardonnay	10		0	17	13	0
Gewurztraminer	6					
Pinot Gris	11					
Pinot Noir					2	
Riesling	60	3	0	36	39	0
Table Grapes						
Canadice			1	71		
Reliance			1	78		10

[z]Percent live nodes based on the number of nodes showing growth out of 1000 buds of each cultivar from count nodes based on the training system used.

Table 3. Percent live nodes[z] for 15 seedless grape cultivars at the Southwest Michigan Research and Extension Center, Benton Harbor, Michigan following low winter temperatures of January 1994[y]

Cultivar	Percent Live Nodes[z]
ES-3-22-18	95%
ES-3-20-33	93%
NY 65.479.2	93%
NY 65.479.1	92%
Einset	82%
Mars	78%
Himrod	63%
Reliance	58%
Romulus	57%
NY 46.290	57%
Canadice	55%
NY 64.029.1	43%
Vanessa	35%
Lakemont	27%
NY 63.483.2	10%

[z]Percent live nodes based on the number of nodes showing growth per 10 basal nodes on a cane.
[y]Minimum temperature of -17°F (-27°C).

1993 were excellent in regard to vine growth and fruit development.

In Indiana, data were collected from two replicated trials at different locations that were the same age (3 years), had been managed according to standard recommendations, and were free of foliar diseases or other factors that would reduce cold hardiness. We found that bud survival was 25-55% higher at the SWPAC location than the Horticulture Research Farm location, despite the fact that the minimum temperature and duration of cold was essentially the same. One possible explanation for the difference in bud survival is that vineyards at West Lafayette are on somewhat poorly drained silt loam soils whereas those at SWPAC are on well drained sandy loam soils. In addition, the growing season is about 2 weeks shorter, on average, at West Lafayette than SWPAC. In general there was a good agreement in the ranking of cultivars between the locations.

Minimum temperatures reached in January 1994 were lower than the temperatures during test winters previously reported (1, 2, 3, 6). Primary bud damage in this study may have been mitigated somewhat by good conditions for winter hardening during the September, October and November 1993, and lack of temperature fluctuations during December and January. Weather conditions during the weeks preceding the cold event were ideal for maximum winter hardiness, and the cold event occurred late in the winter when vines had achieved maximum hardiness. This has not been the case in some other reports. Clore et al. (2) evaluated European, American and French hybrid cultivars following an early winter temperature of -5°F (-21°C) to -7°F (-22°C) in which vines had not had a chance to fully harden. Among the French hybrid cultivars none had 50% or more primary bud mortality. As in this survey, 'Foch,' 'DeChaunac,' and 'Aurore' were among the hardiest French hybrid cultivars, and 'Concord' and 'Delaware' were among the hardiest American cultivars. Mullins (6) reported on the performance of American and French hybrid cultivars in Tennessee and stated that weather had a catastrophic affect on vineyard performance. Though low temperatures ranged to -25°F (-32°C) during the test period, the author noted that cold temperature events were often preceded by warm weather, and that fluctuating temperature during early winter caused much of the cold injury and resulted in reduced vigor and productivity of the vines over years. In that study, 'Foch,' 'DeChaunac,' 'Baco noir,' and 'Aurore' had 85% or greater winter injury and were rated among the least hardy of the cultivars tested following a freeze in December 1983 in which a low temperature of 0°F (-18°C) occurred. The occurrence of early fall freezes prior to dormancy, and an accumulation of freeze injury over the five year course of the experi-

ment apparently lead to the poor winter hardiness ratings in that study, and mid-winter injury was not the primary cause of damage.

Unlike some previous reports (2, 6) killing temperature during the winter of 1993-1994 occurred when vines were in the deepest state of dormancy and fully acclimated, so these data represent a good measure of maximum winter hardiness for these cultivars. This undoubtedly accounts for the high rate of bud survival compared to previous reports. These data should be of value in planning future studies and making recommendations to growers.

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Apple Breeding in Romania*

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The apple is second only to plum in important fruit crops in Romania. Apples now account for approximately 30 percent of the acreage and output of Romania's fruit production. The most widely grown cultivar is 'Jonathan,' followed by 'Golden Delicious,' 'Red Delicious,' 'Parmain d'Or,' 'Idared,' and a few local cultivars such as 'Cretesc' and 'Patul.' (5)

The production of fruit crops has reached more than 600,000 metric tons annually; thus great importance has been placed on varietal improvement, either by introduction of foreign cultivars or by developing our own apple breeding program.

Apple breeding in Romania began in 1948, when the first formal program was initiated by N. Constantinescu at

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