The use of a freezing bud technique to determine the hardiness of 20 grape genotypes

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Abstract

Pencil thick canes from 20 different grape genotypes were harvested at 2 different dates in the fall (October and November). The genotypes had previously been classified as hardy (group A), semi-hardy (group B) or tender (group C). Individual bud sections of the canes were placed in a refrigeration unit and subjected to sequential freezing temperatures (-7 °C, -15 °C, -22 °C and -30 °C) for 24 hours for each temperature.
Samples were removed each day to evaluate the survival of buds. Results for the samples taken in October showed that almost 100 % of the buds were killed once they were subjected to -22 °C or colder. The critical temperature appeared to be -15 °C where there was a marked difference in survival between the 3 groups of genotypes: percent mortality was 46%, 68% and 94% for groups A, B, and C, respectively.

Introduction:

Cold susceptibility and lack in winter hardiness is one of the most important constraints for grape production, particularly in Quebec (Dubois and Deshaies, 1997). In the areas where the majority of the commercial vineyards are concentrated between 45° and 47° of northern latitude; the winter minimal temperatures can reach -30 °C and exceptionally -35 °C for several hours. In this area and under these extremes conditions, injury is known to occur early in the fall and in late spring season when there is not enough snow cover. The dormant bud is usually the most susceptible part of the grape vine, frequently exhibiting injury when other tissues of vine survive (Ahmedullah 1985).
Significant differences in cold hardiness were observed among the Vitis species and varieties within each species. The tolerance of American and French hybrids spreads out between -15 °C and -35 °C (Galet, 1988). It has been shown that almost all varieties of Vitis vinifera freeze between -15 and -20 °C (Galet, 1993) whereas the rustic hybrids derived from Vitis riparia can tolerate temperatures up to -35 °C (Vandal, 1986). Grape production specially for processing (wine) is a young industry in Quebec and many information is lacking on cultural practices performance and hardiness of some new cultivars introduced to Quebec.
The aim of this study was to evaluate the hardiness of primary buds of 20 grape cultivars that are commonly used or that have potential in Quebec using a visual expression of necrosis method.

Table 1. **Effect of freezing temperature exposure in the laboratory on primary buds mortality of twenty grape cultivars, and winter hardiness of the cultivars in the literature.**

Cultivar	October 2000	November 2000	Ranking for freezing test	Literature Winter Hardiness
Sabrevois (ES-219)	2.76	1.03	Hardy	Hardy [z]
Prairie Star (ES-3247)	2.43	1.23	Hardy	Hardy [z]
ES-4725	5.00	1.23	Hardy	Hardy [z]
Delisle (ES-7541)	3.36	1.43	Hardy	Hardy [y]
Michurinetz	2.30	1.23	Hardy	Hardy [z]
St. Croix	3.31	1.83	Hardy	Hardy [z]
St. Pepin	2.36	1.10	Hardy	Hardy [z y]
Vandal-Cliche	2.70	1.50	Hardy	Hardy [z]
Kay Gray	2.96	1.23	Hardy	Hardy [z y]
Mean	3.03	1.31	-	-
ES-6-12-28	2.36	1.51	Semi-hardy	-
GR-7 (Geneva red)	2.90	1.76	Semi-hardy	Hardy [u]
Lucie-Kuhlmann	3.03	1.43	Semi-hardy	Semi-hardy [y]
Seyval noir	3.30	1.63	Semi-hardy	Semi-hardy [x]
Okanagan Riesling	3.10	1.90	Semi-hardy	-
Mean	2.94	1.64	-	-
GM322 (Geisenheim)	3.36	2.74	Tender	Tender [z]
Sieggerrebe	3.70	3.63	Tender	Tender [v]
Seyval blanc	3.50	2.23	Tender	Semi-hardy [x]
Chancellor	3.43	2.36	Tender	Semi-hardy [x z]
SV-18307	3.30	3.10	Tender	Tender [x]
Vidal	3.56	2.63	Tender	Tender [w] / Semi-hardy [x]
Mean	3.47	2.78	-	-
LSD (5%)	0.54	0.59	-	-

[u] Brusky-Odneal (1983), [v] Reish et al. (1979) ; [w] Bordelon *et al.* (1997) ; [x] Dubois et Deshaies (1997) ; [y] Vignes du Québec ; (http://vignesduquebec.com); [z] Plocher and Parke (2001). The values in this table are the rank or average of the rank, rather then the arc-sin transformed values that we use in analysis of variance.

Materials and methods

This study was conducted on twenty American (V. riparia Michx., V. rupestris Scheele , V. labrusca L., V. aestivalis Michx, V.berlandieri Planch and V. cinerea Engelm.), European (V. vinifera L.) and French-American hybrid grape cultivars, growing on the Agriculture Canada Research Experimental sub-station at Frelighsburg, Quebec (latitude 45oN, longitude 72oW). The twenty grape cultivars had previously been tested for cold climate and classified as: hardy, semi-hardy and tender cultivars in literature (Tab 1). Pencil thick 1-year old canes were collected at 2 different dates in the fall (12 October, and 14 November 2000). Individual bud sections of the canes were placed in a refrigeration unit (Neslab, model LT-50DD) at 1 °C for 48 hr, the temperature was then programmed to decrease gradually, by 2 °C/hr until the next temperature is reached at -7 °C, -15 °C, -22 °C and -30 °C respectively for 24 hours at each temperature.
Samples were removed each day to evaluate the survival of the buds and five buds were harvested randomly for each cultivar at each temperature. Individual buds were sectioned through the tip of the meristem with a razor blade under a binocular microscope and checked for necrosis of the primary bud (Stergios and Howell, 1977). The experiment was repeated 3 times for each sampling date.

Statistical analysis. **The arc-sin transformed data on survival of primary bud were used to perform the analysis of variance by SAS (SAS, 1989). LSD (least significant difference) test (5%) was used to separate means.**

Results and discussion:

The analysis of variance indicated that significant sources of variation were: cultivars, temperature and the interactions of cultivars and temperature for the 2 sampling date. Significant differences in survival of primary buds are observed among cultivars within each sampling date. Hardiness of the buds increased during the sampling period (Fig 1), with overall average killed buds among all cultivars of 3.03, 2.94 and 3.47 for October and 1.31, 1.64 and 2.63 for November, respectively for hardy, semi-hardy and tender cultivars. Table 1 shows the average number of dead primary buds of tested Vitis cultivars. For October, the highest overall survival levels were seen for 'Mitchurinetz', ES-6-12-28 and 'St. Pepin', while 'ES-4725' suffered the most injury followed by 'Sieggerrebe' and 'Vidal' cultivars. November reflects an increase in hardiness of all cultivars. 'Sieggerrebe' and 'SV-18307', already characterized as cold susceptible (Reish et al. 1979), were found to have the lowest primary buds survival rates.
Results for the samples taken in October showed that almost 100% of the buds of all cultivars were killed once they were subjected to -22 °C or lower temperature, no matter the cultivar were rank as hardy ('Mitchurinetz' and 'St. Pepin') or tender ('Sieggerrebe', 'Chancellor' and 'SV-18307') (Fig 1). In contrast, the high survival of primary buds was observed for those exhibiting high levels of cold resistance such as 'Sabrevois', 'Mitchurinetz', 'St. Pepin', 'Prairie Star' and 'ES-4725'. The cultivars 'Lucie-Kuhlmann' and 'GR-7' were intermediate compared to the others cultivars in both, October and November, sampling. The critical temperature appeared to be -15 °C where there was a marked difference in survival between the 3 groups of cultivars. This is explained by the fact that the cultivars were not fully hardened in October.
In November, most of the hardy cultivars were relatively little affected by the cold treatment (-22 °C), with survival primary buds remaining high between 0.10 and 2.76 dead buds out of five tested (percent mortality was 25%). In contrast, the tender cultivars were more affected, with percent mortality of primary buds being close to 83% at -22 °C. Our data agree with previous finding of winter hardiness test from field observations (Hemstad and Luby 1998). They evaluated 15 cultivars for winter hardiness in Minnesota and found that 'Mitchurinetz', 'St. croix' and 'Kay Gray' to be among the hardier cultivars with high percentage of live nodes at -38 °C, whereas 'St. Pepin' showed the most damage. Bordelon et al. (1997) evaluated percent survival of primary buds following winter temperature of -32 °C to -31°C that occurred in January 1994 at two location in Indiana and six location in Ohio, respectively and rated 'St. Pepin' as very hardy (98%), 'Chancellor' as moderately hardy (59% and 99%, respectively for the two locations of Indiana) and 'Vidal' as the most susceptible (0% and 13%). Great differences were also observed for the same cultivars planted in different location and all the authors believe that the variability in bud survival could be due to differences in microclimate, location, crop load, disease incidence, cover crop management and soil fertility.
In general our results are in agreement with others reported on cold hardiness (Vandal, 1986; Galet, 1988; Hamman, 1993 and Stergio and Howell, 1977). It is very clear that American hybrids such as 'Sabrevois', 'Prairie Star', 'St. Pepin', 'St. Croix' and 'Kay Gray' derived from V. riparia, V. rupestris, V. labrusca and V. aestivalis were generally the most hardy, and have a higher tolerance to low temperature . 'Mitchurinetz' was nearly as hardy as these hybrids, it derived from V. amurensis which is specifically selected for its cold tolerance in Russia. French-American hybrids such as 'Seyval blanc', 'SV-18307' 'Vidal' and 'Chancellor' were less hardy respectively, and Vitis vinifera, 'Sieggerrebe' was by far the least hardy.
However, various climatic and cultural practices other than species and cultivar influence grapevine hardiness such as location, microclimate, age, crop load, shoot exposure to sunlight, slop and node position on a given shoot (Ahmedullah, 1985).
In spite of the average tolerance at the low temperatures of the primary buds of the French-American hybrids obtained in this test their use in Quebec might justified because of their better win quality compare to American type (unpublished data). It is not uncommon to have a good fruit yield form the secondary or tertiary buds when the primary is damaged during the winter. Furthermore, the increase in their bud survival while ensuring a satisfactory production is manipulated by cultural practices like traditional covering of the vine by soil during the winter or the use of novel technique like geotextile to cover the rows (un published data).

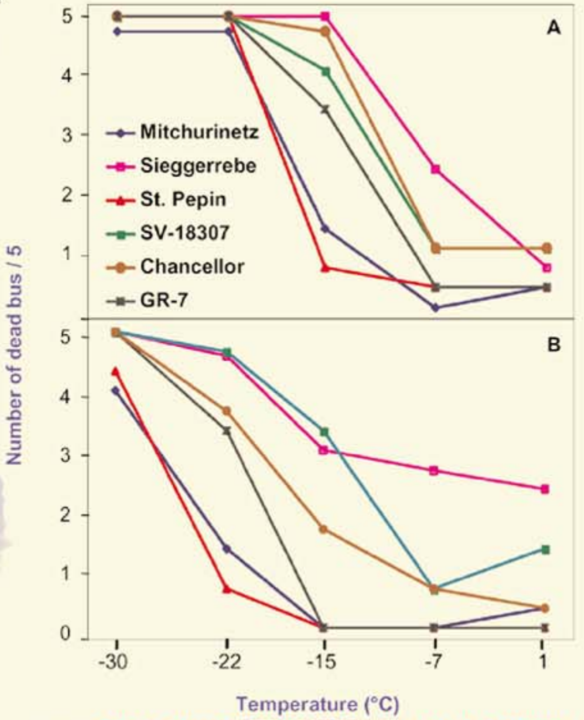

Figure 1. **Effect of freezing temperature on survival of primary buds of selected grape cultivars harvested at 2 different dates in October (A) and November (B).**

References
Ahmedullah M 1985. An analysis of winter injury to grapevines as a result of two severe winters in Washington. Fruit Varieties Journal 39 (4):29-34.
Bordelon B.P., Ferree D.C., and T.J. Zabadal. 1997 Grape bud survival in the Midwest following the winter of 1993-1994. Fruit Varieties Journal 51 (1):53-59.
Brusky-Odneal M. 1983. Winter bud injury of grapevine 1981-1982. Fruit Varieties Journal 31 (2):45-51.
Clore W.J., Wallace M.A., and R.D. Fay. 1974. Bud survival of grape varieties at sub-zero temperature in Washington. Amer. J. Enol. Vitic. 25 (1):24-29.
Dubois J.M.M., and L. Deshaies. 1997. Guide des vignobles du Québec. Les presses de l'Université Laval, Sainte-Foy, 297 p.
Galet P. 1988. Précis de viticulture. 4e éd., Déhan, Montpellier, 586 p.
Galet P. 1993. Précis de viticulture. 6e éd, Déhan, Montpellier, 575 p.
Hamman R.A. Jr. 1993. Wine grape performance of 32 cultivars in western Colorado 1982-1986. Fruit Varieties Journal 47 (1):59-63.
Hemstad P.R., and J.J. Luby 1998. Utilization of Vitis riparia for the development of new wine varieties with resistance to disease and extreme cold, p. 487-490. In. A. Bouquet and J.M. Boursiquot (eds.). Proceeding of the Seventh International Symposium on Grapevine Genetics and Breeding. Vol.2, N° 528. Hacta horticulturae, Belgium.
Plocher T.A. and B. Parke. 2001. Growing grapes and making wine in cold climates. In T.A. Plocher and R.J. Parke (eds.). Northern Winework, Winework Inc. Minnesota, USA, 178 p.
Reish B.I., Pool R.M., Peterson D.V., and M.H. Martens. 1979. Grape varieties for New York State. New York Food and Life Science. Bulletin N° 80. A Cornell Cooperative Extension Publication.
Stergio B.G. and G.S. Howell. 1977. Effect of site on cold acclimation and deacclimation of concord grapevines. Am.J.Enol. Vitic. 28 (1): 43-48.
Vandal J.O. 1986. La culture de la vigne au Québec. À compte d'auteur, Sainte-Foy. 143 p.

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Bud Injury Image: Curtesy of Dr. Robert M. Pool, Professor of Viticulture, Department of Horticultural Sciences, New York State Agricultural Experiment Station, Cornell University Geneva, NY 14456
www.nysaes.cornell.edu/hort/faculty/pool/budcoldinjury/Assessingbudcoldinjury.html
Assessing and Responding to Winter Cold Injury to Grapevine Buds