Use of differential thermal analysis to quantify bud cold hardiness of grape selections and clones [1]

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Summary: Differential thermal analysis (DTA) was used to characterize primary bud mid-winter cold hardiness of *Vitis* spp. Bud hardiness reached a maximum and was rather stable during the months of January and February at Geneva, New York. Because cold tolerance increases during periods of prolonged cold, observed freezing temperature was adjusted on the basis of the freezing temperature of cv. Concord on the day of observation. DTA gives reproducible and meaningful estimates of bud freezing temperature. Such data account for at least 50 % of the among-cultivar variance in overall vine cold hardiness.

Key words: cold resistance, analysis, bud, variety of vine, clone, USA.

Introduction

Winter cold establishes the northern limit of wild grapes as well as that of many other genera (Burke and Stushnoff 1979). The northern limit is approximately coincident with the latitude at which the homogeneous ice nucleation temperature can be expected (George *et al.* 1974). Genera which have this northern limit frequently share a freeze avoidance mechanism to endure winter cold. In such species, when critical tissues freeze, they die. Differential thermal analysis (DTA) detects the temperature at which tissues freeze by detecting the heat of fusion which is released when liquid water becomes ice. DTA has been used to measure the killing temperature of *Vitis*. Various claims have been made regarding the relevance of DTA signals to cold damage of cane tissues (Pierquet and Stushnoff 1980; Barney 1987), but there is general agreement that DTA can accurately estimate the temperature at which dormant grape buds are killed. We have developed a micro-computer assisted DTA apparatus to estimate the freezing temperature of excised grape buds (Wolf and Pool 1986).

With grapes as with other perennial fruits, progress in breeding for polygenetically controlled traits becomes more certain when the trait in question can be accurately and objectively measured. This is especially true of winter cold hardiness. Traditionally vine hardiness is evaluated by noting the damage sustained in the field during the winter. Such estimates are difficult to interpret because field survival is subject to many influences. The 'dosage' of winter cold is not uniform from year to year nor is it uniform within a given site. Cold hardiness is influenced by both viticultural and meteorologic factors. Field hardiness may differ greatly from potential hardiness because of differences in yield or growth during the previous summer or because of the impact of mid-winter climate. Prolonged sub-freezing temperature increases cold hardiness while mid-winter thaws sometimes reduces it. DTA reduces the impact of at least some of these variables. Impact of vine-to-vine variation can be reduced by sampling mature wood within the vine (Howell and Shaulis 1980) and meteorologic influences can be accounted for because hardiness is measured on a specific day rather than observing the impact of an entire winter.

To test the usefulness of DTA for grape breeding programs, we have used the technique to study the killing temperature of a wide variety of grape germplasm.

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Materials and methods

Differential thermal analysis

The basic apparatus has been described (Wolf and Pool 1986). Heat of fusion is detected by mounting excised buds containing a small amount of attached cane tissue on a thermoelectric (TE) module (Melcor^{TM}, Trenton, New Jersey). TE modules are attached to an analogue to digital acquisition board through a digital relay device which allows multiple plates to be connected. The plates are placed in a freezer and cooled at a constant rate using the micro-computer to control the temperature of a heat sink. For our standard tests, 6 replicate buds were excised from nodes 4-6 of well matured canes. They were mounted on dampened paper which in turn was placed on a TE module. After 1 h at −2 °C, the temperature was lowered at 3 °C/h. Exotherms were detected by plotting the TE signal against the heat sink temperature. The high temperature exotherm (HTE), which was caused by extracellular ice, was induced between −3 and −7 °C by seeding a moist cotton string in contact with the paper mount with ice. Low temperature exotherms (LTE's) caused by primary buds were 2-10 times larger than other LTE's. The temperature at which the median primary bud LTE per plate was recorded (if an even number of LTE's were found, the mean of the temperature of the two central LTE's was used). Most often three replicate modules were used per test, but sometimes only duplicates were run and four replicates were used to derive the seasonal curves.

Seasonal changes in cold hardiness

DTA was done at least bi-weekly during the months of September to April for 3 consecutive years (1976/78, 1977/78 and 1978/79) on three cultivars: Concord, White Riesling and Cabernet Sauvignon. Median LTE's were obtained and the data plotted. These data were used to determine the period of maximum hardiness. The data for Concord was used to standardize observed LTE temperature values in other experiments so as to account for variations cause by continuous freezing (Proebsting and Andrews 1982).

DTA of grape cultivars and species accessions

A test of American hybrid table grape cultivars has been underway at Geneva, New York, since 1978. It consists of both named cultivars of North American origin and selections from the

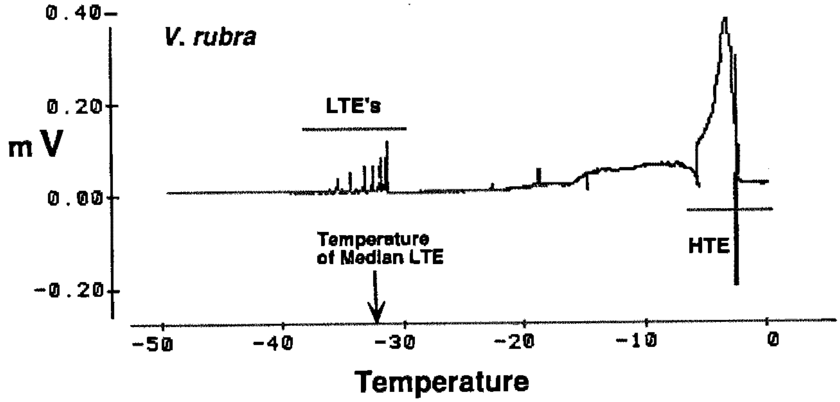

Fig. 1: DTA data for six replicate buds of *Vitis rubra* mounted on a TE module.

Geneva grape breeding program. During the months of January and February 1987 three replicate samples of 6 buds were subjected to DTA. Concord was used as a standard, winter hardy cultivar.

During January and February of 1978 median LTE temperature of cultivars and clones of cultivars of *V. vinifera* L. growing at the New York State Agricultural Experiment Station vineyards were estimated using three replicate 6 bud samples. These data were compared with an overall hardiness rating for these varieties growing at Geneva. Estimates for Pinot noir clone LTE temperatures were compared to data on field survival following the winters of 1987/88 (little cold stress) and 1988/89 (severe cold injury to Pinot noir). During January and February of 1980 duplicate samples of wine and table grape interspecific hybrid cultivars and accessions of *Vitis* species which are part of the collection of the National Apple and Grape Clonal Repository at Geneva, New York, were measured.

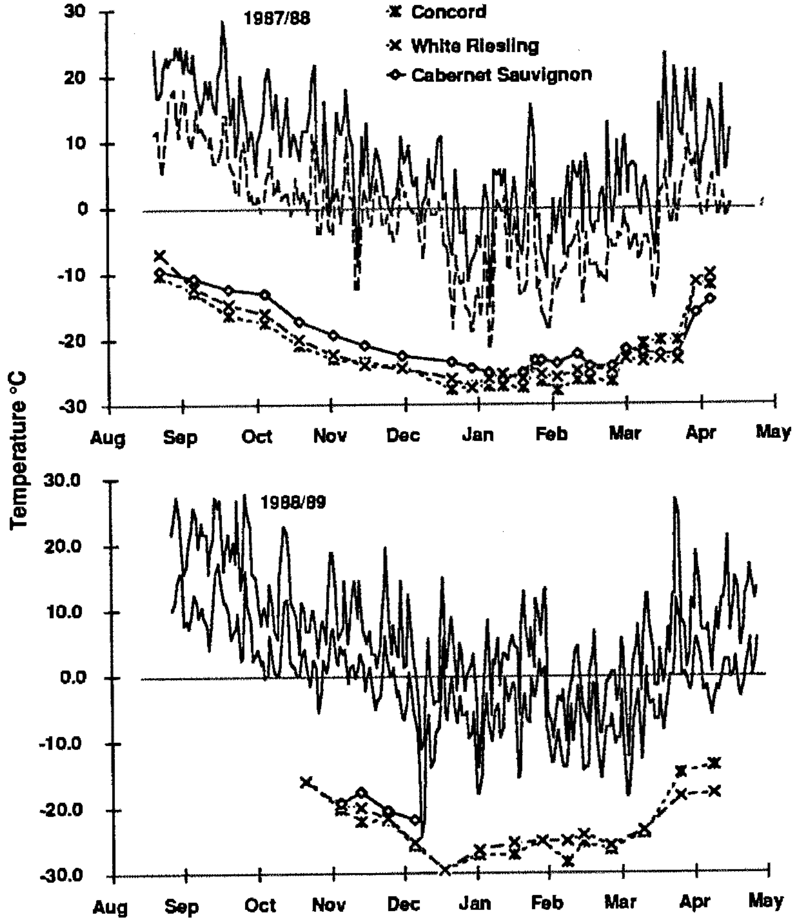

Fig. 2: Daily maximum and minimum temperatures and median LTE temperatures for three cultivars, Cabernet Sauvignon, White Riesling and Concord, growing at Geneva, New York, for the winter seasons 1987/88 and 1988/89.

Results

Seasonal changes in cold hardiness

Fig. 1 shows a DTA profile of 6 nodes from a selection of *V. rubra*. The median LTE of this sample is −32.5 °C. The occasional spikes found at higher temperatures are thought to be due to drops of water on the plate or to the freezing of previously killed buds.

The seasonal cold hardiness of the cultivars Concord, White Riesling and Cabernet Sauvignon for the years 1987/88 and 1988/89 are shown in Fig. 2. The data for Cabernet Sauvignon hardiness for 1988/89 stop after December 12, 1989. At that time the curve of minimum temperature intersected the cold hardiness curve for Cabernet Sauvignon. As a result primary bud kill exceeded 95 % and no further data were collected for that cultivar that year. The observed pattern of hardiness was not only found in 3 years of sampling at Geneva, but also with samples obtained in other states using the same cultivars and protocol. Three stages of hardiness can be seen. Acclimation begins at about the time visible periderm forms and continues until late December when maximum hardiness is reached. January and February is a period of hardiness maintenance. During this time hardiness, especially that of the cultivar Concord, is increased when the maximum daily temperatures do not exceed 0 °C for more than a few days. This has been observed before (Andrews *et al.* 1984), and for that reason data for other cultivars are reported in two ways, observed and adjusted. Adjustments are based on the deviation of Concord hardiness from the period mean median LTE for the year. At the end of February all cultivars begin to de-acclimate. Shortly before bud burst the buds lose their ability to form LTE's. In every year identical differences were noted among cultivars. White Riesling and Concord begin to acclimate early and reach maximum hardiness before Cabernet Sauvignon does. Concord de-acclimates earlier and more rapidly than do White Riesling and Cabernet Sauvignon.

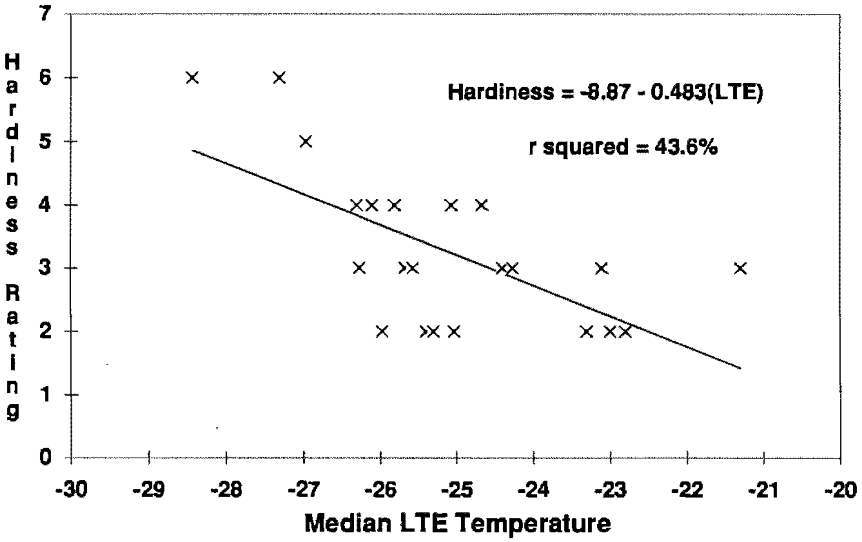

Fig. 3: Relationship between median LTE temperature and field cold hardiness ratings for *Vitis vinifera* and 2 *V. labruscana* cultivars. Each point is a different cultivar. Hardiness ratings range from 1 = very cold tender to 6 = very cold hardy at Geneva, New York.

Table 1: Hardiness of 22 *Vitis vinifera* and 2 *V. labruscana* cultivars as measured by DTA or field evaluation

Variety	Date Sampled	Mean LTE	Adjusted LTE[y]	Field Hardiness Rating[z]
Muscat Ottonel	22-Jan	-21.3	-21.9	3
Portugieser Blau	27-Jan	-22.8	-23.5	2
Reichensteiner	9-Feb	-22.8	-22.1	2
Merlot	13-Jan	-23.0	-22.9	2
Ehrenfelser	22-Jan	-23.1	-23.8	3
Sauvignon blanc	9-Feb	-23.3	-22.6	2
Pinot gris	27-Jan	-24.3	-25.0	3
Gewurztraminer	15-Jan	-24.4	-24.3	3
Nobelssa	27-Jan	-24.4	-25.1	3
Comtessa	15-Jan	-24.7	-24.6	4
Metternich	15-Jan	-25.0	-24.9	2
Limberger	22-Jan	-25.1	-25.8	3
Optima	13-Jan	-25.3	-25.2	2
Sylvaner	13-Jan	-25.4	-25.3	2
Scheurebe	9-Feb	-25.6	-24.7	3
Baccus	9-Feb	-25.7	-24.8	3
Siegerrebe	29-Jan	-25.8	-25.4	4
Perle	15-Jan	-26.0	-25.9	2
Rieslaner	29-Jan	-26.1	-25.7	4
Morio Muscat	22-Jan	-26.3	-27.1	3
Melon	13-Jan	-26.3	-26.2	4
Cabernet franc	29-Jan	-27.0	-26.6	5
Niagara	27-Jan	-27.3	-28.1	6
Delaware	13-Jan	-28.4	-28.3	6

[y] Adjusted by standardizing to the LTE for Concord on the date of sampling.

[z] Hardiness field ratings 1 = very tender 6 = very cold hardy

Evaluation of *Vitis vinifera* cultivars

Table 1 lists the observed and adjusted temperature of the median LTE of 22 cultivars of *V. vinifera* and 2 *V. labruscana* cultivars. An evaluation of overall field hardiness is also given. The 2 *V. labruscana* cultivars had the lowest observed and adjusted LTE temperatures and the highest hardiness rating. The LTE temperature data were regressed against the hardiness rating (Fig. 3). A highly significant relationship was obtained ($P = 0.01$) but the relationship explained only 43.6 % of the variance. Field survival data and 1987/88 estimates of the LTE temperatures were obtained for 8 Pinot noir clones (Fig. 4). In 1987/88 the low temperatures did not approach that of the median LTE. There was severe primary bud injury on December 12, 1988, when temperatures ranged from −24.5 to −25.3 °C in the vineyard. At this time the vines were not fully acclimated and field injury ranged from 32 to 85 % barren nodes in 1989. Generally the observed injury related well with the LTE estimates. A major exception was the Clevner Mariafeld clone which had the lowest LTE temperature and the greatest bud injury.

Table 2: Observed and adjusted median LTE temperatures for interspecific American table grape selections and cultivars

	Observed Temperature of the LTE	Adjusted Temperature of the LTE[z]
Seedless Selections[y] and cultivars		
NY 65.479.1	-23.5	-22.7
NY 46290	-23.0	-23.1
Suffolk Red	-23.3	-23.1
NY 65.143.1	-23.2	-23.3
Lakemont	-24.1	-23.9
NY 65.483.2	-25.2	-24.3
Canadice	-24.6	-24.5
Interlaken	-24.8	-24.6
Reliance	-24.9	-24.8
Remaily Seedless	-24.6	-25.2
Einset Seedless	-25.2	-25.6
Mars	-25.7	-25.8
NY 65.077.2	-25.1	-26.0
Himrod	-25.5	-26.1
NY 63.878.6	-25.3	-26.2
Seeded Selections[y] and cultivars		
Alden	-23.6	-23.7
Yates	-25.4	-24.5
Buffalo	-25.6	-24.7
Steuben	-24.8	-24.9
NY Muscat	-25.6	-25.0
NY 65.112.1	-25.3	-25.4
Concord	-25.5	-25.5
Seneca	-25.2	-25.5
Price	-27.4	-26.5
Swenson Red	-27.7	-27.0
Alwood	-28.4	-27.4
Bath	-28.7	-27.7
Sheridan	-29.0	-28.0

[y] Parentage

NY 46290	(Buffalo X Himrod)
NY 63.878.6	(Fredonia X Canner)
NY 65.077.2	(Vineland 52084 X Ruby Seedless)
NY 65.112.1	Vineland 52082 X Flame Tokay
NY 65.143.1	(Dunstan 210 X NY 45945 (Athens X NY 33873)
NY 65.479.1	((Muscat Hamburg X Hubbard) X (Ontario X Black Monukka))
NY 65.483.2	((NY 10782 X Muscat Hamburg) X (Suffolk Red(Ontario X Black Monukka))

[z]. LTE temperature adjusted to reflect value of Concord on day of measurement.

Evaluation of table grape cultivars and selections

Seedless cultivars and selections LTE temperatures generally were no higher than those of seeded cultivars (Table 2). 6 of the seedless cultivars (NY 65.479.1, Suffolk Red, NY 6290, NY65.143.1, Lakemont and NY65.483) were more than 1 °C less hardy than the standard, Concord. The others had LTE temperatures within 1 °C of Concord. Seeded cultivars, Yates and Alden, which are rated as only moderately hardy were more than 1 °C less cold hardy than Concord. Price, Swenson Red, Alwood, Bath and Sheridan were all 1 °C or more hardy than Concord. Sheridan and Bath were more than 2 °C hardier than Concord.

Germplasm evaluation

Germplasm tested from the repository was divided into 6 categories (Table 3). In order of increasing mean hardiness they were: American *(V. labruscana)* seedless cultivars, American wine cultivars, American seeded table cultivars, interspecific wine cultivars, species selections and rootstock cultivars. The order of mean hardiness by category is not very important as the samples do not necessarily represent the range of germplasm in a category and because differences within category, which ranged from 1.4 to 12.9 °C, greatly exceeded the range of means among the categories which was only 1.6 °C. There were 5 American wine selections which ranged from −24.0 for cv. Wine King to −25.5 °C for cv. Concord. Most of the American seeded table cultivars had median LTE's within one degree of that of Concord. The exceptions were Yates and Alwood which were less hardy and Bath, Century I and Price which were more hardy than Concord. Century I and Price have been rated as only moderately cold hardy in field tests at Geneva. With the exception of the cultivar of southern origin, Venus, the American seedless cultivars were close to the value for Concord, more recently released cultivars were more cold tolerant than older ones. Only a few interspecific wine cultivars were tested. The most widely planted of these in New York state is Seyval (S. V. 5-276) which had the highest median LTE temperature of the group, 1.5 °C higher than that of Concord. The other cultivars, including the wine cultivar most recently released by the New York State Agricultural Experiment Station - Melody (Reisch *et al.* 1986) - were equal to or more hardy than Concord.

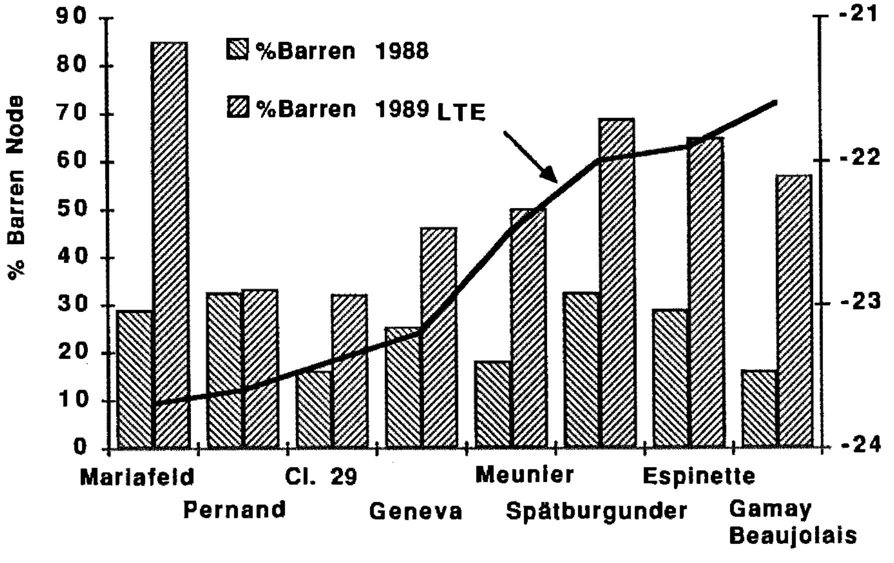

Fig. 4: Observed median LTE temperature and observed 1988 and 1989 barren node percentage for Pinot noir clones growing at Geneva, New York.

Table 3: Temperature of the median LTE of cultivars and species accessions growing in the collection of the National Apple and Grape Repository, Geneva, New York

Category	Plant Name	Repository Designation	Temperature of the Median LTE	Adjusted Temperature of the Median LTE^z
American Wine or Juice	Wine King	131	-23.2	-24.0
	Carmen	588	-23.3	-24.1
	Diamond	124	-24.0	-24.8
	Delaware	52	-26.6	-25.0
	Concord	51	-25.6	-25.5
	Mean		-24.5	-24.6
American Table	Yates	113	-24.6	-22.9
	Alwood	*	-22.2	-24.0
	Swenson Red	439	-25.9	-24.2
	Stueben	111	-26.7	-25.1
	Ontario	45	-24.6	-25.4
	Golden Muscat	*	-24.0	-25.8
	McCampbell	44	-24.4	-26.3
	Bath	109	-24.9	-26.7
	Century 1	985	-26.3	-27.1
	Price	98	-26.7	-28.6
	Mean		-24.8	-25.6
American Seedless	Venus	573	-22.4	-20.8
	Himrod	*	-24.1	-24.0
	Glenora	*	-22.7	-24.5
	Einset Seedless	470	-24.9	-26.7
	Mean		-23.5	-24.0
Interspecific Wine	Seyval	534	-21.3	-23.0
	Seibel 2583	339	-21.3	-23.1
	Seibel 1077	535	-22.0	-23.8
	Melody	581	-27.5	-25.8
	Ravat 34	354	-24.0	-25.8
	Seibel 880	559	-24.3	-26.1
	Chancellor	43	-25.4	-27.1
	Mean		-23.7	-24.9
Rootstock	C157-11	979	-24.1	-21.8
	Mill. et Grasset 219A	598	-24.3	-22.0
	Rup. du Lot	592	-22.7	-22.5
	Mill. et Grasset 125-1	606	-23.0	-23.3
	Teleki 5C	79	-23.2	-23.7
	Richter 110	266	-23.5	-23.9
	Kober 5BB	70	-23.6	-24.1
	C 18-815	118	-23.7	-24.2

Table 3 (Cont.)	Mill. et Grasset 420	605	-26.2	-24.3
	SO4	119	-24.6	-25.1
	R. gloire	265	-24.8	-25.3
	SORI	95	-25.1	-25.6
	C 3309	87	-25.5	-25.9
	C 1616E	114	-26.2	-26.7
	C 3306	264	-27.1	-27.6
	Mill. et Grasset 101-14	63	-27.5	-28.0
	Azita	263	-25.1	-28.5
	Shakoka	73	-28.5	-29.0
	Sonona	152	-31.2	-34.7
	Mean		-24.9	-25.6
Species	V. cinerea (C66-6)	625	-22.9	-20.6
	V. berlandieri	261	-17.1	-20.6
	V. cordifolia (Rem 30-77)	1013	-24.0	-21.7
	V. rubra (Ru-66-10)	168	-24.5	-21.7
	V. argentifolia	1003	-22.3	-22.1
	V. riparia (Quebec)	612	-24.6	-22.3
	V. champini (Salt Creek)	622	-22.3	-22.8
	V. argentifolia(Rem 46-77)	970	-25.2	-22.9
	V. labrusca (Rem 26-75)	1023	-22.7	-23.0
	V. argentifolia	214	-21.4	-23.1
	V. riparia (Manitoba)	401	-25.1	-23.4
	V. labrusca (Rem 33-75)	967	-23.5	-23.8
	V. labrusca (Rem 43 -75)	1029	-23.6	-23.9
	V. cordifolia(B17)	171	-27.1	-24.3
	V. rupestris (Ganzin)	285	-26.7	-24.4
	V. riparia (Minnesota)	400	-26.2	-24.5
	V. argentifolia(Rem NE 19)	896	-26.9	-24.6
	V. cinerea (C66-14)	236	-27.0	-24.7
	V. riparia (Montreal)	193	-26.4	-24.7
	V. cordifolia(B18)	184	-27.8	-25.0
	V. labrusca (Rem 46-75)	1026	-24.8	-25.1
	V. longii	1026	-24.9	-25.2
	V. coignetiae (Pulliat)	18	-27.9	-25.6
	V. cinerea	170	-25.2	-25.7
	V. rubra	239	-25.9	-25.7
	V. argentifolia(Rem NE 4)	994	-28.1	-25.9
	V. riparia (Montana)	417	-27.8	-26.1
	V. rupestris (Pillans)	202	-24.2	-26.2
	V. champini	172	-24.6	-26.3
	V. riparia (Montana)	418	-29.2	-27.5
	V. rubra	174	-24.1	-27.5
	V. riparia (Colorado)	773	-29.2	-27.5
	V. andersonii	701	-27.8	-28.3
	V. riparia (Pulliat)	224	-31.9	-29.1

Table 3 (Cont.)	V. riparia (Montreal)	193	-25.6	-29.1
	V. solonis	158	-29.1	-29.6
	V. argentifolia	928	-27.2	-30.6
	V. rupestris(Tiefenback)	249	-29.2	-32.7
	V. longii	138	-29.3	-32.8
	Mean		-25.7	-25.4

The range in rootstock hardiness was greater than observed for cultivars grown for fruit. 9 rootstock cultivars had median LTE's more than 1 °C higher than Concord. They included Rupestris du Lot, Teleki 5C, Richter 110 and Kober 5BB. SO 4, Riparia Gloire, Sori and C. 3309 had LTE values similar to that of Concord. C. 1616E, C. 3306, M. GT 101-14 were hardier than Concord and 2 rarely used rootstocks which share northern *V. riparia* parents, Shakoka and Sonona, were more than 3 °C hardier than Concord.

The range in median LTE temperature was much greater among species selections (14.5 °C) than among the cultivars. Essentially all of the fruiting cultivars were of northern origin. Among the species, with a few exceptions, those which were much less hardy than Concord shared a southern origin. A *V. riparia* selection from Quebec, Canada was more than 3 °C less hardy than Concord, but these plants have symptoms suggesting a virus infection. There were also some other northern selections such as the *V. labrusca* selection Remaily 26-75 and the *V. argentifolia* selection Remaily 46-77 which were less hardy than the standard, Concord. In terms of very hardy material *V. riparia* dominated, but some southern representatives had cold hardy buds. They included *V. solonis* and the *V. rupestris* selection Tiefenback.

Discussion

The data on seasonal fluctuations in median LTE temperature of primary buds show that the changes in hardiness are reproducible among years and cultivars. When the field temperature fell below the predicted hardiness level, Cabernet Sauvignon buds died. This confirms that the data are meaningful. The fluctuation in temperature of the median LTE observed during the period of maximum hardiness in the 3 years is clearly related to prolonged freezing of non-vital bud tissues which lowers the LTE temperature (Pool *et al.* 1985). This variability associated with mid-winter conditions is the reason that the observed LTE temperatures need to be adjusted to reflect the status of the standard cultivar, Concord.

The data with standard wine and grape cultivars demonstrates both the validity and the limit of the technique in predicting field cold hardiness. LTE temperature accounted for only 43 % of the variance associated with our field ratings. The lack of agreement can be ascribed to several factors. First our ratings tend to be more conservative for cultivars with which we have had little experience. An example is the cultivar Morio Muscat which had hardy buds, but only a moderate hardiness rating. With more years of experience, we may well revise the field rating of Morio Muscat. A second factor is that before DTA can be used, the buds must be 'mature'. The physiological factors responsible for the 'mature' node condition are poorly understood, but it is clear that the buds of many cultivars poorly adapted to New York fail to develop the ability to supercool. Such buds die at a temperature higher than −8 °C. DTA is only suitable to measure hardiness of the 'mature' bud fraction and thus DTA may overestimate hardiness for varieties which do not reliably produce buds capable of supercooling. A third complication is that we measure maximum mid-winter bud hardiness with DTA. A cultivar like Cabernet Sauvignon, in which acclimation is delayed, may sustain early season cold injury before its buds become fully hardened. The final factor that causes bud LTE temperature to sometimes differ from field hardiness is the tissue evaluated. Some cultivars such as Perle, Century I and Price form cold hardy buds, but often fail to produce cold hardy trunks. That produces a situation in which the buds may survive, but the trunk injury is so severe that the above ground portions of the vine die.

While DTA cannot give a complete assessment of cold hardiness, it does give reproducible results concerning bud hardiness. The data produce good agreement between assessments made in different years except for three cases. Himrod, Alwood and Swenson Red produced lower median LTE temperatures in the table grape assessment than in that of the repository collection. This may have been due to the age and size of the vines in question. For the table grape assessment many mature vines were available from which to select canes. In the repository collection most of the vines were only 1 year old and only duplicate vines are planted. Thus, we may have inadvertently selected less hardy wood from the smaller population of canes.

The results of the DTA assessments of the repository collection are very interesting. Seyval is one of the most widely planted interspecific hybrid wine cultivars in New York, but its buds were not very hardy. It has been observed that primary buds of Seyval are frequently killed in the field, but that its fruitful secondary and base buds allow an adequate crop to be produced (Pool *et al.* 1978). Similarly the rootstock data related well to planting recommendations for New York (Lider and Shaulis 1974). None of the rootstock cultivars which had higher LTE temperatures than Concord are recommended for use in New York vineyards. The data for species was of course most variable. In general, southern species had higher LTE temperatures than did those from northern locations. However, several of the southern species produced very hardy buds. The 'southern' distribution of species like *V. rupestris* and *V. berlandieri* does not mean that these cultivars are not exposed to very low winter temperatures. Frequently their failure to tolerate northern winters seems to relate to their adaptation to regions with long summers rather than to regions with warm winter temperatures. Such vines will often fail to mature their wood or buds in the short growing season of northern New York state.

DTA appears to be a very useful tool for the grape breeder. While it will not measure overall vineyard hardiness, it will precisely measure the mid-winter freezing point of grape buds. Thus it produces the kind of information grape breeders require to plan their crossing strategies and to make objective assessments of their progenies. We plan to complete the evaluation of the collection of the National Apple and Grape Clonal Repository. The data will become part of the grape descriptors available on the Genetic Resources Inventory Network (GRIN), a plant information database operated by the United States Department of Agriculture.

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Grape breeding for cold resistance in North-east China for 30 years

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Jilin Province is located at north-east of China. The minimum temperature in winter is -34 °C. There was almost no grape production before the 1940s.

A breeding program based on *Vitis amurensis* (a native cold hardy species) x *V. vinifera* and *V. labrusca* hybridizations was initiated in 1951, including more than 200 combinations and 15,000 hybrid seedlings. Two winter-hardy and high-yield wine cultivars Gong-niang No. 1 *(V. vinifera x V. amurensis)* and Gong-niang No. 2 *(V. amurensis x V. vinifera)* were released and planted over a wide area. From progenies of *(V. amurensis x V. vinifera) x V. vinifera* some other winter-hardy genotypes with high sugar content and disease resistance were also obtained which are suitable for red and white wine.

The inheritance of winter hardiness of the hybrids between *V. amurensis* and *V. vinifera* was continuous variation. Most of the hybrid seedlings are adapted to the severe winter conditions which occur in Jilin Province.

The interspecific hybrids had high sugar content, and the wines were evaluated as having good quality and vinifera character. The F_1's berries were black in color and white color ones from which white wine could be produced were obtained only in progenies of *(V. amurensis x V. vinifera) x V. vinifera.*

The ratio between hermaphrodites (♂) and femals (♀) of the F_1 hybrid from *V. amurensis* (♀) x *V. vinifera* (⚥) was about 1 : 1, while more than 70 % hermaphrodite ones were obtained from F_1 (⚥) x *V. vinifera* (⚥).

The hybrids were high resistant to *Elsinoe ampelina*, but susceptible to *Plasmopara viticola* as is *V. amurensis*. Strains showing high resistance to *Plasmopara viticola* could be obtained from *(V. amurensis x V. vinifera) x V. vinifera.*