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Evaluation of Dormant Primary Bud Hardiness of Muscadine Grape Cultivars

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Abstract

Primary bud hardiness of 11 muscadine grape (*Vitis rotundifolia* Michx) cultivars and 'Mars' bunch grape (*V. labrusca* L.) was evaluated using differential thermal analysis on samples taken in November and December, 1994, and January and February, 1995 from vines growing at the University of Arkansas Fruit Substation, Clarksville. Bud hardiness increased during the sampling period with the lowest mean low temperature exotherms (MLTE) measured in January and February samples. 'Sterling' muscadine was the hardiest cultivar in the first two sample dates. 'Sugargate' muscadine had the lowest MLTE for any cultivar at any date in February, –23.8 °C. Overall, no cultivar exhibited consistently greater hardiness than others over all sample dates, although 'Fry,' 'Loomis and 'Tara' were consistently the least hardy cultivars in December, January and February. MLTE for 'Mars' were not lower than those for the muscadines at any date, a surprising finding since 'Mars' is considered much hardier than muscadines. Bud hardiness levels for muscadines exceeded what is generally considered the overall minimum temperature for survival of muscadine vines, suggesting that vine components other than buds may limit their hardiness.

Muscadine grapes (*Vitis rotundifolia* Michx) are native to the southern United States, and their production is limited to this region of the country. Hardiness is a major factor in the area of adaptation of muscadines, and it is not recommended that this species be planted in areas where temperatures drop below –12 °C, and death of the vines may occur at –18 °C (1). Information on the hardiness of muscadine cultivars is limited mostly to field evaluations in cultivar trials. Hardy cultivars reported by Poling (6) included 'Carlos,' 'Sterling,' 'Nesbitt,' 'Magnolia' and 'Doreen,' 'Sterling' was released largely due to its hardiness, because its trunk and spur hardiness were as great as those of the most hardy muscadine cultivars tested in the piedmont and coastal plains of North Carolina (5). Clark and Moore (3), reporting on vine damage, rated vine response the following growing season after exposure to –21 °C in December, 1989. Their results indicated that the hardiest cultivars, based on a rating of whole-vine damage, were 'Carlos,' 'Sterling,' 'Dixiered' and 'Magnolia.'

Differential thermal analysis (DTA) was used successfully to determine primary bud hardiness of muscadine grapes by Clark, et al. (4). In their study, which included 'Carlos' and 'Summit' muscadine cultivars and 'Mars' (*V. labrusca* L.) bunch grape, buds of all cultivars produced low-temperature exotherms consistent with the number of buds tested. Bud hardiness increased during the sampling period from November to January. Mean low-temperature exotherms (MLTE) for 7 Jan. samples were –21.5 °C for 'Carlos,' –23.4 °C for 'Summit' and –22.4 °C for 'Mars.'

Our study was conducted to utilize DTA in evaluating muscadine dormant primary bud hardiness among a range of cultivars, with the goal that this technique would expand the capability of testing cultivars for hardiness beyond that of relying solely on field observations following damaging temperatures. The vines sampled in this study were grown in Arkansas near the northern limit of successful production, with the intention that near-maximum hardiness would be measured.

Materials and Methods

Cultivars included in the evaluation were: 'Carlos,' 'Fry,' 'Loomis,' NC 67A015-17, NC 67A015-26, 'Nesbitt,'

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'Sterling,' 'Sugargate,' 'Summit,' 'Tara' and 'Triumph' muscadines and 'Mars' bunch grape. The vines were grown at the University of Arkansas Fruit Substation, Clarksville. All vines sampled had fruited the previous season, and ranged in age from four to 12 years old. There were three single-vine replications of each cultivar. All muscadine cultivars were trained to a bilateral cordon training system, and had been pruned to 3- to 4-node spurs each dormant season before the study but had not been pruned before bud collection in this study. The 'Mars' vines were trained to a four-arm Kniffin training system and cane pruned in all years prior to this study. All vines were trickle-irrigated, and weeds were controlled with pre- and post-emergent herbicides. Fungal diseases were controlled on 'Mars,' but no fungicides were applied to the muscadine cultivars since they were resistant to the more common grape fungal pathogens; no foliar diseases which contributed to loss of leaves were present at any time on the muscadines.

Cane samples were collected from the upper, sunlight-exposed portion of the vine canopy to include buds at nodes 1 through 6. Three cane samples from each replication were collected, with each cane supplying one bud for the freezing session. Samples were collected in the field from all replications at one time for each date. Due to freeze-chamber capabilities, a total of six freezing sessions were required to evaluate all entries which took three consecutive days of freeze-chamber operation. Cane samples were stored in plastic bags and the bags stored in ice while waiting to be subjected to the freezing session. Samples were collected on the following dates: 11 Nov. and 14 Dec. 1994, and 18 Jan. and 8 Feb. 1995.

Buds from node positions 2 to 4 were used for DTA. The buds were excised from the canes with 0.5 to 1.0 mm of subtending nodal tissue attached to the bud. One bud from each of three cane samples from each cultivar/replication combination was placed on 3 x 3 cm thermopiles (Melcor Electronics, Trenton, N.J.) on which a piece of moistened tissue paper had been placed to serve as a heterogeneous nucleator. A 0.5105-mm diameter copper-constantan thermocouple was placed on the opposite side of the thermopile, and parafilm was used to keep the buds and thermocouple in constant contact with the thermopile plate. Aluminum foil was wrapped around the parafilm to maintain good heat exchange between the two sides of the plate. The prepared thermopiles were then placed inside small glass jars and the jars placed in a programmable freeze chamber (Tenney Jr., Tenney, Inc., Union, N.J.). The system contained six thermopiles, allowing six, single-vine replications to be run each session. Chamber setpoint was controlled with a data acquisition system (Interactive Microware, State College, Pa.) interfaced with a microcomputer. All sessions were begun with the chamber at 20 °C at loading; the temperature was then lowered to 0 °C in 1h, and cooling then proceeded at the temperature reduction rate of 4 °C/hour to a minimum of –25 °C. Thermopile voltage and separate thermocouple temperature data were recorded every 10 s.

MLTE values were calculated from the three primary bud exotherms from each cultivar/replication combination of each freezer session. The MLTE data were then analyzed by analysis of variance as a split-plot in time, with the whole-plot factor cultivar and the split-plot factor date. Means were separated by LSD.

Results and Discussion

The analysis of variance indicated that significant sources of variation were cultivar, sampling date and the interaction of cultivar and date. Hardiness of the buds increased during the sampling period, with an overall average MLTE among all cultivars of –12.9 °C for November, –19.3 °C for December, –21.7 °C for January and –22.0 °C for February. The MLTE values for each month corresponded to the average high and low temperatures at the vineyard location, in that average temperatures were much lower in

December, January and February compared to those in November. For the 14 days prior to each sampling date, the average daytime maxima and minima at the vineyard were 20.3 and 8.0,12.2 and 0.0, 9.9 and –0.4, and 12.0 and –0.3 °C for November, December, January and February, respectively.

MLTE values for each cultivar for each month revealed the bud hardiness among cultivars (Table 1). For November, the muscadine cultivar Sterling was hardiest with a MLTE of –14.7 °C, and the range in MLTE values among the muscadines was –2.2 °C. Surprisingly, 'Mars' had the highest MLTE (–10.6 °C), which was an unexpected finding since *V. labrusca* cultivars are considered much hardier than muscadines (1). December MLTE values reflected a great increase in hardiness of all cultivars, with 'Mars' increasing hardiness the most and having a MLTE of –20.6 °C. 'Sterling' again had the lowest MLTE of the muscadines, although not statistically different from that of 'Summit' or 'Triumph.' The range among MLTE for the muscadines was –2.6 °C, similar to the range of the previous sample date. The lowest MLTE values were found for January and February sample dates. MLTE ranges among cultivars increased slightly for these months compared to November and December: –3.3 °C for January and –3.2 °C for February. The lowest MLTE for any cultivar for any date (–23.8 °C) was achieved by 'Sugargate' for February. Generally, there were no cultivars exhibiting consistently (among sample dates) lower MLTEs compared to other cultivars tested. 'Sterling,' which had the lowest MLTE of the muscadines the first two sample dates, was not the hardiest cultivar at the two later sample dates. 'Fry,' 'Loomis' and 'Tara' consistently had the highest MLTE values for December, January and February, indicating less hardiness than most other cultivars. This may be because all three of these cultivars were developed and tested in Georgia, an area with less selection pressure for winter hardiness compared to our test site. However, 'Summit' and 'Sugargate,' also both developed in Georgia, had equal or higher hardiness at some dates compared with other cultivars. 'Mars' was similar or nearly similar in MLTE of the hardiest muscadines, although at no sample date did 'Mars' primary bud hardiness exceed that of all muscadines.

Our data agree to some extent with previous findings of hardiness from field observations. Clark and Moore (3) found 'Fry' to be among the least hardy cultivars, and 'Fry' exhibited lower bud hardiness than most other cultivars in our study. Also, their report and that of Poling (6) indicated 'Carlos' was among the hardier cultivars, and our data indicated it had among the higher bud hardiness levels for January and February sample dates. However, the differences among MLTE values for the muscadine cultivars were not consistent throughout the sampling period, and these differences in values may not be great enough to determine comparative hardiness among cultivars from this data or by using DTA. Reasons for the lack of consistent differences during sampling include possible variation in hardening and de-hardening among cultivars during the sampling period, or the lack of much genetic variation in muscadine cultivars in primary bud hardiness, thereby limiting the extent of hardiness expression.

The comparable bud hardiness of several of the muscadine cultivars and 'Mars' was noteworthy. Bourne et al. (2) reported 'Mars' had MLTE values in mid-January of 1988 and 1989 of approximately –23 and –21 °C, respectively, and Clark et al. (4) reported MLTE on 7 Jan. 1994 of –22.4 °C, which coincide with our MLTE of –22.8 °C for 18 Jan. Therefore, the MLTE reported in our study are comparable to those of the three previous reports on 'Mars,' all of which were from measurements on vines growing at the same location in Arkansas. Comparable bud hardiness between 'Mars' and the muscadines was an unexpected finding and indicates that the limited hardiness of mus-

Table 1. Mean low temperature exotherms for eleven muscadine cuttivars and 'Mars' bunch grape from samples collected at four dates in the winter of 1994-95 at Clarksville, Ark.

Cultivar	Date of sample			
	11 Nov.	14 Dec.	18 Jan.	8 Feb.
Carlos	−12.5 c[z]	−18.5 de	−22.4 ab	−22.7 ab
Fry	−12.5 c	−18.0 e	−20.5 d	−21.0 de
Loomis	−12.5 c	−18.5 de	−20.9 cd	−21.1 de
NC67A015–17	−13.4 bc	−19.3 bcd	−21.8 bc	−21.7 bcde
NC67A015–26	−12.4 c	−18.9 cde	−21.1 cd	−22.5 bc
Nesbitt	−12.9 bc	−19.3 bcd	−23.4 a	−21.9 bc
Sterling	−14.7 a	−20.6 a	−22.0 bc	−21.5 cde
Sugargate	−13.1 bc	−19.4 bcd	−22.0 bc	−23.8 a
Summit	−13.9 ab	−20.1 ab	−22.5 ab	−22.5 bc
Tara	−12.9 bc	−19.0 bcde	−20.1 d	−20.6 e
Triumph	−13.1 bc	−20.0 abc	−21.2cd	−21.8 bcd
Mars	−10.6 d	−20.6 a	−22.8 ab	−22.5 bc

[z]Mean separation within column by LSD (5%).

cadines may not be due to the lack of primary bud hardiness.

Since muscadines are generally not recommended for growing in areas where winter minima commonly drop below −12 °C, and vine damage and death may occur near −18 °C, it is interesting that the MLTE values reported here are lower than the accepted minima for adaptation. Trunk, cordon and spur damage, in addition to aerial root development, are common results of winter injury of muscadines. Based on the findings in our study, primary buds may well be hardier than other vine components, and their hardiness may not be the limiting factor in adaptation. Therefore, further research on the determination of hardiness of other vine components would shed light on hardiness limitations of muscadines, and it is obvious that testing of hardiness would need to be done on more than primary buds to ultimately evaluate variation in cultivar hardiness.

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S19 New Rootstock from Japan

S19 was selected from open pollinated seedlings of Wu Xiang Hai Tang *(Malus honanensis)*. Trees are 2.5m in height and 75% of M.7 interstem trees. They were free standing and formed good graft unions. The trees are drought tolerant and precocious with high fruit quality and firmness.

From Zhang and Dong. 1994. ISHS Hort Congress Abstracts P-22-26. p.246.