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Evaluation of Seed and Fruit Characteristics of Muscadine Grape

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Abstract

Muscadine grape (*Vitis rotundilofia* Michx.), is a unique fruit grown in the southern United States, used mostly for the production of juice, jams and jellies. There is potential for breeding programs to focus on advancing muscadine characteristics as a fresh-market fruit. Seventeen genotypes of muscadine grapes were evaluated in 2013, and measurements of critical fresh-market attributes (seed characteristics, berry attributes and percent wet stem scar) were evaluated. Breeding selection AM 28 and 'Supreme' had the highest berry weight (15.0 g) and volume (37.3 and 36.3 cm^3, respectively), while AM 03 had the lowest berry weight (6.7 g) and AM 15 had the lowest berry volume (22.8 cm^3). Both berry weight and berry volume were positively correlated with percent wet stem scar ($r = 0.53$), which has not been previously reported in muscadine. The genotype AM 28 also had the highest individual seed weight (0.10 g), while AM 02 and AM 03 had the lowest individual seed weight (0.05 g), and berry weight and seed weight were positively correlated ($r = 0.61$). Individual seed number ranged from 2.9 to 4.5, and seed volume ranged from 0.88 to 1.54 cm^3. Percent wet stem scar ranged from 20.1 to 69.5%. For several traits evaluated, muscadine breeding selections performed better than the cultivars studied, potentially showing that improvements in muscadine are being made through crossing and selection. This information can be further used by muscadine breeders in evaluating traits for improvement along with parent selection resulting in new cultivar development.

Native to the southeastern United States, the muscadine grape (*Vitis rotundifolia* Michx.) is commonly grown because of its high level of insect and disease resistance and the production of fruit with a unique flavor (Silvia et al., 1994; Striegler et al., 2005; Walker et al., 2001). Muscadine berries vary in color, shape, and size, but are typically large, sweet, and very fruity in flavor. The berries have a thick skin and usually contain 3-4 seeds per berry. The recent recognition that muscadine berries are important sources of antioxidants for nutraceutical benefit has increased their demand by consumers (Perkins-Veazie et al., 2012; Striegler et al., 2005). Additionally, the potential for growing muscadines is being explored by many growers in the South as a means of increasing profits or diversifying farm operations (Conner, 2009).

In the past, breeding efforts in fresh-market muscadines were a mix of both private and public programs, most with a focus on releasing self-fertile cultivars with large berries. Breeding efforts for muscadine berry improvement began in the late 1800s (Goldy, 1992), but have been limited since the 1980s. There is potential for modern breeding programs to focus on advancing muscadine characteristics as a fresh-market fruit. Muscadine cultivars currently available lack some important characteristics that growers and consumers value such as, seedlessness, longer post-harvest storability, and crisper fruit (Conner, 2009). Percent wet stem scar (the point of berry attachment that remains open in the center, or the skin tears around the scar) can strongly influence the post-harvest storage potential of fresh-market mus-

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cadines (Savoy and Hatton, 1980; Starnes Saunders et al., 1981; Takeda et al., 1983). Gupton (2000) found that variation in seed number among cultivars was generally small, although 'Fry' and 'Summit' had fewer seeds than other cultivars. He also found that the relationship between seed number and seed weight was not significant, while seed weight and berry weight were highly correlated. Gupton concluded that evaluation of newer genotypes might result in the identification of those that produce superior fresh-market fruit to supply the current trends of production.

Research on the consumer acceptance of muscadines is limited (Degner and Mathis, 1980), but it is hypothesized that consumers favor large muscadine berries with smaller, fewer, or even no seeds. Improvements in berry and seed size as well as reduction in wet or torn stem scars are important characteristics to evaluate in modern muscadine breeding programs (Conner, 2009; Gupton, 2000). The objective of this study was to evaluate cultivars and breeding selections (genotypes) in the University of Arkansas Fruit Breeding program for berry size, seed characteristics, and percent wet stem scar to identify potential genotypes for use as parents in breeding or potential release as cultivars.

Materials and Methods

Muscadine berries were once-over hand harvested from one vine per selection/cultivar growing at the University of Arkansas Fruit Research Station, Clarksville, AR in 2013. The 2013 season was considered optimum due to a full crop of fruit produced with no unusual environmental stresses. Nine breeding selections and eight cultivars were harvested from mid-August until late September. Berries were transported to the University of Arkansas Institute of Food Science and Engineering, Fayetteville, AR for evaluation.

Percent wet stem scar (number of berries with torn or wet stem scars) was calculated from a 50-berry sample in triplicate. Then, three representative berries per genotype were used to provide three replications for further analysis resulting in a total of nine berries evaluated per genotype. The samples were placed in plastic bags and stored frozen at -20°C until analysis. Total berry weight and volume, total fresh seed weight, individual fresh seed weight, percent fresh seed weight, seed number, percent seed volume per berry, and average seed volume per berry were determined.

The experiment utilized a randomized complete block with 17 muscadine genotypes. Analysis of data was done with JMP® (version 11.0; SAS Institute Inc., Cary, NC). Tukey's HSD (Honest Significant Difference) was used for means separation ($P = 0.05$). Associations among all dependent variables were determined using multivariate pairwise correlation coefficients of the mean values using JMP® (version 11.0; SAS Institute Inc., Cary, NC).

Results and Discussion

Significant variation was found for most of the traits evaluated among the 17 genotypes. The female-flowered genotypes AM 28 and 'Supreme' had the highest berry weight (15.0 g), and berry volume (36.3 and 37.2 cm^3, respectively) while the perfect-flowered AM 03 had the lowest weight (6.7 g) and AM 15 had the lowest volume (22.8 cm^3) (Table 1). Overall, berry weights were higher than those reported for the same genotypes by Striegler et al. (2005), but similar to those reported by Mortensen and Harris (1989). Seed weight ranged from 0.10 (AM 28) to 0.05 g (AM 02 and AM 03) (Table 1), with the reduced seed weight potentially important for parent selection due to reduced perception of seediness. The perfect-flowered selection AM 02 was also identified as having the lowest total seed weight (0.15 g) and percent seed weight of the total berry weight (1.7%), while 'Ison' had the greatest total seed weight (0.32 g) and percent seed weight of the total berry weight (3.3%) (Table 1). The perfect-flowered selection AM 27 had the lowest seed volume (0.89

Table 1. Mean separation of muscadine berry and seed attributes.

Genotype	Flower type	Berry weight (g)	Berry volume (cm^3)	Total seed weight (g)	Individual seed weight (g)	Seed weight (%)	Seed number	Seed volume (cm^3)	Seed volume (%)	Wet stem scar (%)
AM 01	P[z]	7.9 efg[y]	26.6 cdef	0.20 bcd	0.06 ab	2.5 abc	3.5 cde	0.98 fg	3.7 cde	20.9 gh
AM 02	P	8.3 cdefg	26.8 cdef	0.15 d	0.05 b	1.7 c	3.0 de	1.14 cdef	4.3 bcde	61.2 ab
AM 03	P	6.7 g	23.8 ef	0.21 abcd	0.05 b	3.0 ab	3.8 bcd	0.88 g	3.7 cde	51.4 bc
AM 04	P	9.2 cdef	28.7 bcd	0.22 abcd	0.07 ab	2.4 abc	2.9 e	1.23 bcde	4.3 bcde	44.6 cd
AM 15	P	7.0 fg	22.8 f	0.22 abcd	0.07 ab	3.0 ab	3.6 cde	1.06 defg	4.6 abc	31.5 efgh
AM 18	P	8.1 defg	26.1 def	0.20 bcd	0.06 ab	2.4 abc	3.3 cde	1.03 efg	3.9 cde	36.1 de
AM 26	P	10.3 bcde	31.4 b	0.26 abcd	0.08 ab	2.5 abc	3.1 cde	1.31 bc	4.2 bcde	23.4 fgh
AM 27	P	8.8 cdefg	25.8 def	0.25 abcd	0.06 ab	2.8 abc	4.4 ab	0.89 g	3.4 e	29.8 efgh
AM 28	F	15.0 a	37.2 a	0.28 abc	0.10 a	1.9 bc	3.6 cde	1.33 abc	3.6 de	69.5 a
Delicious	P	8.4 cdefg	25.1 def	0.26 abcd	0.07 ab	3.0 ab	3.7 bcde	1.26 bcd	5.0 ab	33.3 defg
Fry	F	12.5 b	30.9 bc	0.31 ab	0.07 ab	2.6 abc	4.5 a	1.23 bcde	4.0 cde	55.4 bc
Ison	P	9.6 cde	27.4 bcde	0.32 a	0.08 ab	3.3 a	3.9 abc	1.38 ab	5.0 ab	31.4 efgh
Nesbitt	P	10.8 bc	28.9 bcd	0.30 abc	0.09 ab	2.8 abc	3.3 cde	1.54 a	5.3 a	20.1 h
Southern Jewel	P	10.4 bcd	28.9 bcd	0.30 abc	0.08 ab	2.9 abc	3.8 bcd	1.27 bcd	4.4 abcd	54.3 bc
Summit	F	9.3 cdef	26.3 def	0.26 abcd	0.08 ab	2.8 abc	3.4 cde	1.17 bcdef	4.5 abcd	26.8 efgh
Supreme	F	15.0 a	36.3 a	0.28 abc	0.08 ab	1.9 bc	3.6 cde	1.37 ab	3.8 cde	60.9 ab
Tara	P	8.8 cdefg	24.7 def	0.18 cd	0.06 ab	2.1 bc	2.9 e	1.03 efg	4.2 bcde	34.9 def
P value		<0.0001	<0.0001	<0.0001	0.0407	0.0006	<0.0001	<0.0001	<0.0001	<0.0001

[z] P = perfect flowered; F = female flowered

[y] Means followed by the same letter are not significantly different at = 0.05, separated by Tukey's HSD.

cm^3) and percent seed volume (3.4%), while 'Nesbitt' had the highest seed volume (1.54 cm^3) and percent seed volume (5.3%) (Table 1 and Fig. 1). Total seed number ranged from 2.9 seeds/berry (the perfect flowered AM 04 and 'Tara') to 4.5 seeds/berry (the female flowered 'Fry'), which is contrary to the findings of Gupton (2000), who found that 'Fry' had the fewest seeds (< 3 seeds/berry) of the genotypes evaluated. Differing from the findings of Gupton (2000), but similar to the findings of Mortensen and Harris (1989),

Fig. 1. Observable differences in seed size for muscadine berries with the largest ('Nesbitt' and smallest (AM 27) seed size.

percent wet stem scar ranged from 20.1% ('Nesbitt') to 69.5% (AM 28) in our study. Gupton (2000) found wet stem scar ranges of 6.0 to 44.0%, while Mortensen and Harris (1989) found 12.6 to 91.6%. Percent wet stem scar has been shown to play a key role in post-harvest storage of muscadines, and there is also evidence that percent wet stem scar is strongly influenced by environment at harvest (temperature and humidity) as well as berry maturity (Starnes Saunders et al., 1981). Multiple years of data collection are needed to fully evaluate stem scar characteristics, and it may be impacted by harvest maturity of each genotype.

Significant multivariate pairwise correlations were identified for many of the traits evaluated. Seed weight was positively correlated with total berry weight (r = 0.61), berry volume (r = 0.50), total seed number (r = 0.57), seed volume (r = 0.69), and individual seed weight (r = 0.73) (Table 2). Similar to seed weight, percent seed weight was negatively correlated to berry volume (r = -0.55). Individual seed weight ranged from 0.05 g (AM 02 and AM 03) to 0.1 g (AM 28), and was positively correlated with berry weight (r = 0.69), seed weight (r = 0.73), and berry volume (r = 0.66) (Table 2). As expected, berry volume was strongly correlated with berry weight (r = 0.95) (Table 2). Interestingly, percent wet stem scar was positively correlated to berry weight (r = 0.53) and berry volume (r = 0.53) (Table 2), potentially showing that as berries increased in size, they also increased in percent wet stem scar.

Conclusions

Seed characteristics, berry size, and percent wet stem scar of muscadine berries are important traits to commercialize muscadine grapes as a fresh market fruit.The findings of this study support the overall findings of previous work (Gupton, 2000; Striegler et al.,2005), although differences among an expanded number of genotypes were found. Gupton (2000) identified 'Supreme' as having high potential for important traits, which was also found in this study. Interestingly, we found the genotypes with the largest berries and most seeds were female-flowered, while the genotypes with the smallest berries and fewest seeds were perfect-flowered. The positive correlations between percent wet stem scar and berry size was interesting and not previously reported in muscadine. For several traits evaluated, muscadine breeding selections performed better than the cultivars studied, potentially showing that improvements in muscadine are being made through crossing and selection. This information can be further used by muscadine breeders in evaluating traits for improvement along with parent selection resulting in new cultivar development.

Table 2. Multivariate pairwise correlations of muscadine berry and seed attributes.

	Berry weight (g)	Seed weight (g)	Seed weight (%)	Seed number	Berry volume (cm^3)	Seed volume (cm^3)	Seed volume (%)	Wet stem scar (%)
Berry weight (g)	1.00							
Seed weight (g)	0.61*	1.00						
Seed weight (%)	NS	NS	1.00					
Seed number	NS	0.57*	NS	1.00				
Berry volume (cm^3)	0.95*	0.50*	-0.55*	NS	1.00			
Seed volume (cm^3)	0.65*	0.69*	NS	NS	0.62*	1.00		
Seed volume (%)	NS	NS	NS	NS	NS	0.59*	1.00	
Wet stem scar (%)	0.53*	NS	-0.54*	NS	0.53*	NS	NS	1.00
Individual seed weight	0.69*	0.73*	NS	NS	0.66*	NS	NS	NS

* Significant correlations ($p < 0.05$).
NS = non-significant at ($p < 0.05$).

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