A Century of Muscadine Grape (*Vitis rotundifolia* Michx.) Breeding at the University of Georgia

Patrick J. Conner[1]

Abstract

Muscadine grapes have been cultivated commercially in the southeastern United States since the middle of the 18th century. Production trends have waxed and waned, but there is a renewed interest in this grape because of recent studies indicating their high nutraceutical content. Early cultivars were simply selections from the wild, but current cultivars were all developed from breeding programs. The University of Georgia (UGA) operates the oldest and largest breeding program dedicated to the improvement of the muscadine grape. The UGA program began in 1909 and over the years has released over 30 cultivars. One of those cultivars, the bronze skinned 'Fry', is the leading cultivar for fresh market use and is widely grown. More recent releases such as 'Summit' and 'Tara' are gaining in popularity. Current goals of the breeding program include the development of new cultivars which combine large berry size with perfect flowers, earlier and later maturing cultivars, berries with dry stem scars and edible skins, and increased cold hardiness. Recently work has begun in using several *Euvitis* Planch. × *Muscadinia* Planch. hybrids in order to introduce disease resistance and quality traits into *V. rotundifolia* Michx.

Introduction

Muscadines are considered to be grapes in common terminology, but there is debate in their taxonomic distribution (13). Many authors, including this one, accept the nomenclature of Planchon (1803) which divides the genus *Vitis* into the subgenera of *Euvitis*, or bunch grapes, and *Muscadinia* or muscadine grapes. The *Muscadinia* subgenera consists of just three species: *V. rotundifolia* the common muscadine grape known throughout the southeastern U.S., *V. munsoniana* (Simpson ex Munson) a semitropical variant of *V. rotundifolia* native to southern Florida, and *V. popenoeii* Fennell (1940) a tropical native to southern Mexico. More recently, Small (16) placed true grapes into the genus *Vitis*, and muscadine grapes into the genus *Muscadinia*. Regardless of their classification, the muscadine grape differs from the familiar bunch grape (*Vitis labrusca* L., *V. vinifera* L., and their various hybrids) in several morphological characteristics including that they have smaller clusters, the berries abscise from the cluster (shatter) at maturity, the tendrils are unbranched, and the berries have thick skins and a unique fruity aroma. In addition, the *Muscadinia* have 40 chromosomes as compared to the 38 chromosomes of *Euvitis*.

Muscadines are native to the southern United States and have been cultivated for over 400 years (7). They are one of the few fruit crops that are well suited for this region. They grow best on fertile sandy loams and alluvial soils where temperatures seldom go lower than -12 □C and rarely -18 □C, and grow poorly on wet and heavy soils (12). Muscadines need a long growing season, requiring approximately 100 days on the vine to mature fruit.

Alternative crops are being explored by many growers in the state of Georgia as a means of increasing profits or diversifying farm operations. While fresh market muscadines have always been popular in this region, there has been a recent increase in consumption of juice and wine products. Muscadine wines are gaining in regional appeal as consumers begin to appreciate their unique fruity bouquet and the positive health effects derived from moderate consumption (15). Prices paid for processed muscadine grapes for wine were $500 per ton in 2002, up sharply from the 1990's (15). Increasingly, there has also been an interest in nutraceutical products containing a wide range of phenolic phytochemicals, including ellagic acid from waste products containing skin, seeds, and pulp (5, 14). This is important as it gives producers an additional revenue stream from what was once a waste product.

Numerous muscadine cultivars are of commercial importance. Olien (12) listed 25 important cultivars, with various states growing from one to 14 cultivars of them. Newer cultivars are increasing in importance since that report, and there is continuing interest in developing improved cultivars better suited to growers' needs. The current muscadine production guide for Georgia (6) lists 34 fresh market cultivars (nine most recommended) and six processing cultivars. Even with this large number of cultivars, many are lacking essential characteristics and growers are very interested in new cultivars with a higher combination of specific traits found in the various cultivars now in use.

Materials and Methods

The muscadine breeding program was housed for most of its life at the experiment station located in Griffin, Georgia (33□ 14'N, 84□ 17'W). In 1998, however, it was relocated to a different experiment station in Tifton, Georgia (31□ 30'N, 83□ 31'W) which is closer to the major muscadine production regions. Winter lows in Tifton are typically -5 to -10 □C and summer highs are 38 to 40 □C.

All crossing is conducted on field-grown material. Seedlings are given optimum nutrition and irrigated by laying a drip tube along the row. No fungicides are applied to the seedling vines so that susceptibility to disease can be monitored. Seedlings grow quite vigorously and generally some begin to flower in the second season with most flowering in the third year. Emphasis in the initial selection is based on harvest date, berry size (at least 9 g), presence of hermaphroditic flowers, and vine productivity. Other factors of importance include flavor, skin thickness and palatability, non-leaking stem scars, berry color, disease resistance, and vine vigor. Selections which are to be advanced to the mid-stage evaluations are propagated by softwood cuttings and are replicated into 2-vine plots. Selections are evaluated for berry quality, vine phenology, vine productivity, and disease resistance. Superior selections are advanced to replicated plantings with standard cultivars for comparisons at both Tifton and Athens Ga. to evaluate for yield, vine performance, and fruit characteristics. Plants are also planted at other sites in Georgia as well as with cooperators in other states. Selections which perform better than the standard cultivars, or which fill a niche within the market, are considered for release.

Results and Discussion

Historical Releases 1909-1938. The muscadine breeding program was initiated in 1909 and was continued for many years under the direction of H.P. Stuckey and J.G. Woodroof. Germplasm used in the initial crosses were commonly grown cultivars that had been selected from the wild. Female vines used included 'Scuppernong', 'Thomas', and 'Flowers', and male vines were 'White Male #1' and 'Black Male' (17). 'Scuppernong' was by far the most commonly grown cultivar of the time, and was popular because of its large size, bronze berry color, good fruit quality. 'White Male #1' was found to have very good general combining ability and was especially useful in transferring large fruit size to its progenies (2). During this period 13 cultivars were released, the most important of which were 'Hunt', 'Dulcet', 'Yuga', and 'Creek' (10, 11). Early selections were strongly selected for non-shattering berries and a sweet tender pulp. All of these selections have a small fruit size ranging from 2.5 to 5 g per berry. The breeding program was temporarily halted by a labor shortage during the WWII.

Releases 1951-1968. The breeding program was renewed under the direction of B.O. Fry during this period, and his cultivars provided the genetic foundation for most fresh market cultivars today. Fry selected for large berry size, bronze berry color, and high soluble solids. All of Fry's crosses involved 'White Male #1' or a seedling thereof (2). In 1955 'Higgins', from the cross 'Yuga' x 'White Male #1' was released. This cultivar was much larger than previous releases, averaging nearly 9 g per berry. 'Higgins' was found to transfer large fruit size to its progeny and was used in parentage of Fry's other cultivars: 'Jumbo', 'Fry', and 'Cowart'. 'Fry' set the standard for fresh market muscadine cultivars for decades, and is still one of the most important cultivars in use (8). Among 'Fry's' most important traits are large berry size (9.3 g), bronze color, good flavor in berries before they are fully ripe, and high soluble solids content (18%). Limitations of 'Fry' include mediocre productivity and vigor, and susceptibility to fruit rots. 'Cowart' was a notable release in that it was the first UGA release with perfect flowers, this enabled growers to stop planting male vines in the vineyard for pollination, and 'Fry' and 'Cowart' were a popular vineyard pairing.

Releases 1969-1996. The third era of the breeding program was under the direction of R.P. Lane. Emphasis during this period was to combine the large fruit size and quality of the Fry cultivar with perfect flowers. Notable releases in this period include 'Summit', 'Triumph', 'Golden Isles', 'Tara', and 'Scarlett' (8). 'Summit' is a female cultivar that is more productive than 'Fry' and has better disease resistance. 'Summit' is currently a chief cultivar for the fresh market. 'Triumph' and 'Tara' are bronze self-fertile cultivars that are recommended as pollinizers for 'Summit' and 'Fry'. 'Golden Isles' is a wine grape that was released because its juice has a less "foxy" taste and aroma and is more like a *Vinifera* juice. 'Scarlett' has a light reddish color and thin skin with a very high consumer appeal.

A notable feature of all these cultivars is that ‘Higgins’ is prominent in their background. ‘Summitt’ and ‘Triumph’ are full sibs originating from the cross ‘Fry’ x Ga. 29-49. ‘Summitt’ and ‘Triumph’ were then crossed in order to produce ‘Tara’ and ‘Scarlett’ (Fig. 1). Despite the relative high degree of inbreeding in these cultivars, these cultivars remain vigorous, suggesting that muscadine is relatively tolerant to inbreeding.

Current Breeding Program. The breeding program has recently expanded under the author to have the potential to produce and evaluate 2,000 seedlings a year. Our primary emphasis is on developing new cultivars for the fresh-market, although a number of crosses of wine types are also being made. Several improvements in berry quality will be instrumental in increasing the acceptance of the muscadine in the marketplace (4). Currently most muscadine cultivars have a thick, unpalatable skin which is usually not eaten. Skin thickness, however, varies widely and several selections in our germplasm have a thinner, crisper skin. Crossing among these should yield cultivars with an edible skin. Other important quality traits include dry stem scars and a meaty, plum-like pulp. Cultivars with self-fertile flowers have the advantage of not needing a pollinator, and often produce higher yields than female cultivars. In the past, self-fertile cultivars have had smaller berry size. However, recent introductions such as ‘Tara’ have a berry size comparable to the large fruited females, indicating there is not a barrier to producing these types. The market now needs more large fruited self-fertile cultivars of bronze, red, and purple coloration. We anticipate most future releases to possess self-fertile flowers.

In contrast to *Euvitis* grapes, muscadine grapes are picked and marketed as single berries. In nature, the mature berries freely abscise (shatter) from the vine. Selections from early breeding programs were often made for persistent fruit (3). Unfortunately, when these types are picked, the vasculature remains attached to the pedicel, leading to an open wound which can leak juice onto the fruit. Current cultivars vary widely on the force required to remove berries, and on the size and closing of the remaining stem scar. Cultivars such as ‘Supreme’ which are prone to tearing of the skin around the pedicel scar may lead to as much as 30% of the fruit being unsuitable for the fresh market. In order to develop berries more suitable for mechanical harvest and with longer storage life we are selecting cultivars with a concentrated harvest and small dry pedicel scars.

Muscadines have resistance to most of the diseases which make bunch grapes difficult to grow in the humid southeast. However, there are diseases which cause significant damage to the muscadine crop, especially in large plantings. The most important berry rots affecting Georgia muscadines are ripe rot, caused by the fungus *Glomerella cingulata* (Stonem.) Spauld. & Schrenk, and macrophoma rot caused by the fungus *Botryosphaeria dothidea* (Moug. Ex Fr.) Ces. & de Not (6). Both of these diseases can appear suddenly and spread rapidly causing a soft rot of ripening berries. Other berry rots of importance in Georgia are bitter rot, caused by the fungus *Greeneria uvicola* (Berk. & Curt.) Punithalingam, syn. *Melanconium fuligineum* (Scribner &Viala) Cav., and black rot caused by the fungus *Guignardia bidwellii* f. *muscadinii* (Ellis) Viala &Rvaz. Angular leaf spot, caused by the fungus *Mycosphaerella angulata* Jenkins, only

attacks the leaves, but can cause severe premature defoliation in the right conditions.

Usable genetic variation for relative disease resistance has been demonstrated in the improved muscadine germplasm (1). Another potential source of resistance is interspecific hybrids between the muscadine and bunch type grapes. 'Southern Home' is the only released hybrid between bunch grapes (*Euvitis*) and muscadine grapes (*Muscadinia*) (9). This cultivar was released primarily as a dooryard cultivar because of its excellent disease resistance and attractive leaf shape. Small berry size and mediocre flavor make this variety unsuitable for commercial use. 'Southern Home' has a complex background with ancestry from several species including *V. rotundifolia*, *V. munsoniana*, *V. vinifera*, and *V. popenoei*. 'Southern Home' is six generations removed from *V. vinifera*, and is heavily muscadine in traits, although the leaf shape has a distinctive maple leaf pattern making it highly ornamental. 'Southern Home' is reported to be highly resistant to ripe rot, bitter rot, and black rot, and has shown no symptoms of Pierce's disease (*Xylella fastidiosa* Wells et al.). The development of hybrids such as 'Southern Home' with improved fruit quality may be a method of improving resistance to several diseases simultaneously. We are currently using 'Southern Home' and several other interspecific hybrids in our breeding program to improve disease resistance of our muscadine germplasm. Other potential traits of interest in this material includes ornamental leaf shapes and possibly more stable juice pigments.

Literature Cited

1. Chen, J. and O. Lamikanra. 1997. Resistance of muscadine grapes to angular leaf spot (*Mycosphaerella angulata* Jenkins) in North Florida. HortScience 32:94-95.
2. Fry, B. 1967. Value of certain varieties and selections in the breeding of high quality, large-fruited muscadine grapes. Proc. Amer. Soc. Hort. Sci. 91:213-216.
3. Goldy, R. and O. Onokpise. 2001. Genetics and Breeding p. 51-90.In: F. Basiouny and D. Himelrick (eds.). Muscadine Grapes. ASHS Press, Alexandria, Vir.
4. Gupton, C. 2000. Muscadine traits potentially useful in breeding. J. Amer. Pom. Soc. 54:114-117.
5. Hartle, D., P. Greenspan, and J. Hargrove. 2005. Muscadine Medicine. Blue Heron Nutraceuticals, St. George Island, FL.
6. Krewer. G., M. Hall, D. NeSmith, D. Horton, H. Sherm, P. Sumner, T. Tyson, G. Westberry. 2000. Georgia Muscadine Production Guide. Georgia Coop. Ext. Serv. Bul. 739. Athens, Ga.
7. Lane, R. 1997. Breeding muscadine and southern bunch grapes. Fruit Var. J. 51:144-148.
8. Mortensen, J. Cultivars p. 91-105.In: F. Basiouny and D. Himelrick (eds.). Muscadine Grapes. ASHS Press, Alexandria, Vir.
9. Mortensen, J., J. Harris, D. Hopkins, and P. Anderson. 1994. 'Southern Home': An interspecific hybrid grape with ornamental value. HortScience 29:1371-1372.

10. Murphy, M., T. Pickett, and F. Cowart. 1934. Muscadine grapes, culture, varieties, and some properties of juices. Georgia Exp. Sta. Bul. 185. Griffin, Ga.
11. Murphy, M., T. Pickett, and F. Cowart. 1938. Muscadine grapes, culture, varieties, and some properties of juices. Georgia Exp. Sta. Bul. 199. Griffin, Ga.
12. Olien, W. 1990. The muscadine grape: botany, viticulture, history, and current industry. HortScience 25:732-739.
13. Olien, W. 2001. Introduction to the muscadines, p. 1-13.In: F. Basiouny and D. Himelrick (eds.). Muscadine Grapes. ASHS Press, Alexandria, Vir.
14. Pashrana-Bonilla, E., C. Akoh, S. Sellappan, and G. Krewer. 2003. Phenolic content and antioxidant capacity of muscadine grapes. J. Agric. Food Chem. 51:5497-5503.
15. Poling, B., C. Mainland, W. Bland, B. Cline, and K. Sorenson. 2003. Muscadine Grape Production Guide. N.C. State Ext. Serv. Bul. AG-94. Raleigh, N.C.
16. Small, J. 1913. Flora of the southeastern United States. 2nd ed. The author, New York.
17. Stuckey, H. 1919. Work with Vitis rotundifolia, A species of muscadine grape. Georgia Exp. Sta. Bul. 133. Griffin, Ga.

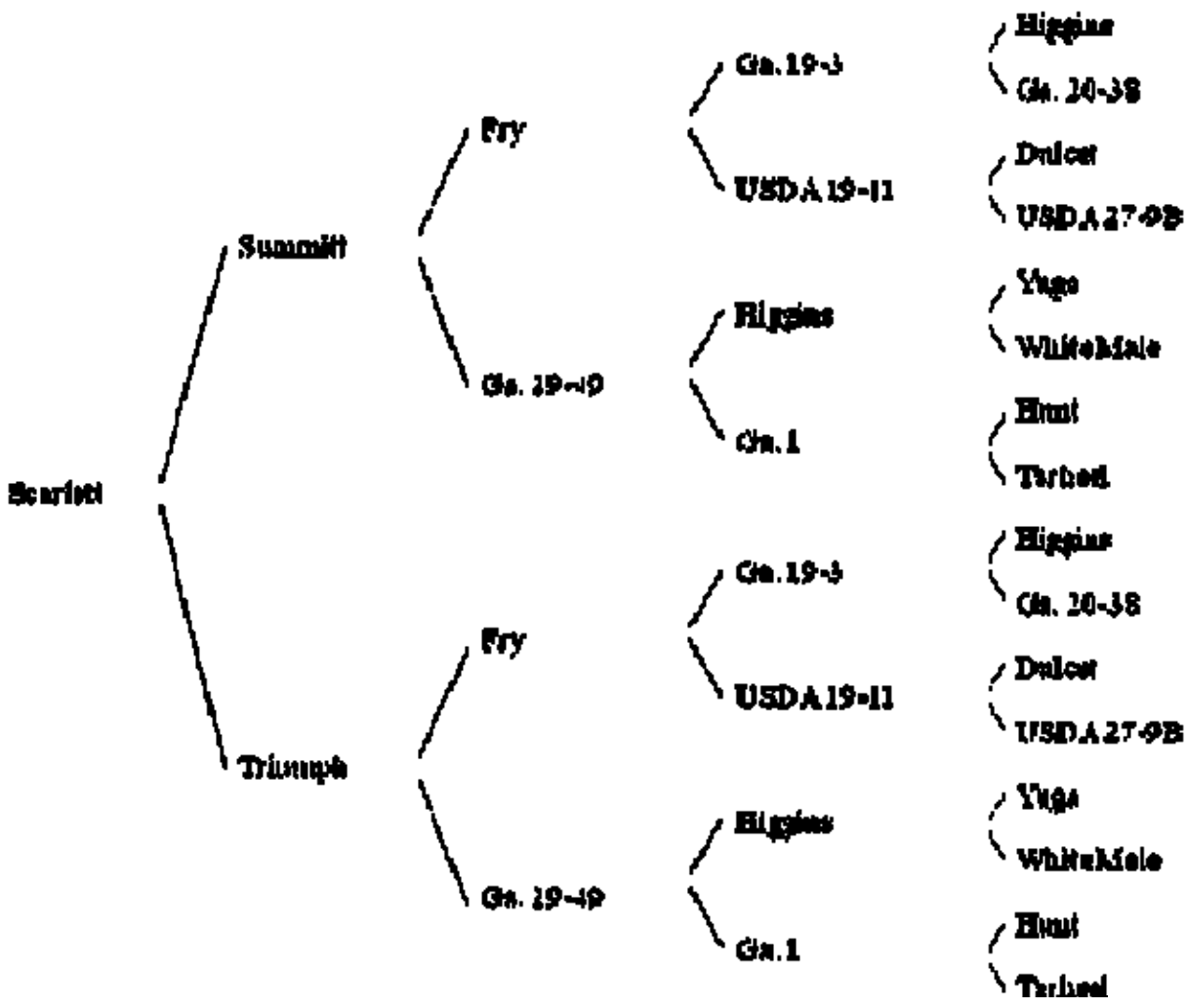

Fig. 1. Pedigree for ‘Scarlett’ muscadine grape.