Muscadine—A Classic Southeastern Fruit

The muscadine, or muscadine grape (*Vitis rotundifolia* Michx., or, alternatively, *Muscadinia rotundifolia* Small), is native to the Southeastern United States and has been cultivated for >400 years. Indigenous muscadine populations range throughout the southeastern U. S., except in mountainous areas, but are most abundant in the coastal plains along the Atlantic Ocean and the Gulf of Mexico. There is no other fruit with such strong personal associations for many native Southerners. The fruit has a distinct fruity, or "musky" aroma, while the juice by itself is sweet with a light taste and aroma, and lacks the "sticky" after-taste of some fruit juices. If the southeastern U.S. were to establish an official regional fruit, it would quite likely be the muscadine (Gohdes, 1982). The fruit has been eaten fresh and made into juice, wine, pies, jelly, etc., for as long as people have inhabited the natural range of muscadines. Native Americans preserved muscadines as dried fruit long before Europeans inhabited this continent (Bartram, 1791).

There are currently >1600 ha of muscadines in commercial production (Olien, 1990). More than 95% of this production is in coastal states from North Carolina to Louisiana. The commercial history of this crop has been based primarily on wine production. As early as 1565, Captain John Hawkins reported that the Spanish settlements in Florida made large quantities of muscadine wine (Hedrick, 1908). The current industry includes production for wine, fresh fruit, and "U-pick" operations. A recent motivating force has been the production of unfermented juice and other processed products on an industrial scale for national markets.

Native muscadines are functionally dioecious (Hedrick, 1908; Reimer and Detjen, 1910), with male vines making up three quarters of the population (Reimer and Detjen, 1910). Nearly all native female vines produce dark purple to black fruit, but a small percentage of the population bear light yellow (bronze) fruit at maturity. These rare bronze-fruited vines have been especially valued from early times because of greater stability when made into wine (Gohdes, 1982; Hedrick, 1908). In marked contrast to *Euvitis* grapes, the anthocyanin constituents of dark-fruited muscadines are readily oxidized, resulting in off-colors and -flavors after aging (Ballinger et al., 1974). Recently discovered muscadine germplasm may allow

improvements in the anthocyanin balance in future breeding of dark-colored muscadine cultivars (Goldy et al., 1989).

For much of the history of this crop, cultivars were simply wild selections preserved through vegetative propagation. The first recognized muscadine cultivar was a bronze selection, found before 1760 by Isaac Alexander in Tyrrell County, N.C. (Reimer, 1909). This selection is important historically, as well as viticulturally, as the first American grape cultivar. It was at first known as 'The Big White Grape' or 'Hickmans Grape', and was later named 'Scuppernong' after the area in which it was found (Reimer, 1909). With time, the name scuppernong became generic for all bronze muscadines, regardless of actual cultivar name. In common usage, scuppernongs are sometimes even thought of as a separate species from muscadines or "bullises", traditional generic names for the dark-fruited types.

Bullis and its variants (bullace, bullet grape, bull grape) are very old names for dark-fruited muscadines. The origin of this name is not so generally known as that of scuppernong, but it is an intimate part of muscadine heritage and lore. Not surprisingly, there is no consensus on the etymology. Bartram wrote in 1802 (as cited in Hedrick, 1908) that "Bull grape" was an abbreviation of "Bullet grape", so called because the fruit were the size of a musket ball. Others state that "Bull" reflects comparison of the berries with cow or pig eyes, or, alternatively, that muscadines were called "Bullace" because of their resemblance to a European plum of the same name, and that Bullis, Bull, and Bullet are corruptions of Bullace (Gohdes, 1982).

Muscadines are usually considered to be a grape, both in common terminology and in taxonomic classification. However, there is a long and controversial history regarding how closely "bunch grapes" (i.e., "true grapes", or *Euvitis*, such as the European *Vitis vinifera* L., American *V. labrusca* L., etc.) and muscadines are related. These groups differ on every level, including chromosome number, vine and berry anatomy and morphology, and physical and chemical characteristics of the fruit and juice (Olien, 1990).

The most commonly used nomenclature for muscadines and true grapes is that accepted by Bailey (1937), Hedrick (1908), Liberty Hyde Bailey Hortorium (1976), Radford et al. (1968), and Terrell et al. (1986). These authors follow the classification of Planchon, published in 1803 (as cited in Hedrick, 1908), which divides the genus *Vitis* L. into two subgenera: *Euvitis* Planch. and *Muscadinia* Planch. *Euvitis* contains ~60 species (Winkler et al., 1974), with >20 species of American origin (Munson, 1909; Bailey, 1937). There have been only three

species identified in the *Muscadinia* group, all native to North America (Fennell, 1940; Weaver, 1976; Winkler et al., 1974). Of these, the common name "muscadine" refers exclusively to *V. rotundifolia* Michx., initially described by Michaux in 1803 (Hedrick, 1908).

An alternative classification was provided by Small (1913). He did not recognize the subgenera classification of Planchon, but instead placed the "true grapes" under *Vitis*, and the *Muscadinia* as a separate genus. Thus, the scientific name for muscadines becomes *Muscadinia rotundifolia* Small. In light of the cytogenetic, anatomic, and morphologic differences referred to previously, some recent authors have adopted Small's nomenclature (Bouquet, 1980; Chaparro and Goldy, 1989; Olmo, 1986; Weaver, 1976). In fact, there is reason to believe that the *Muscadinia* are the remnants of a much older group once widely distributed around the world, and that "true grapes" descended from the *Muscadinia* after the last ice age (Bouquet, 1980). Regardless of taxonomic classification, muscadines and *Euvitis* are different in necessary horticultural practices and in fruit and processing characteristics (Olien, 1990).

Nearly 100 years of breeding work has resulted in the release of many improved cultivars. An early goal was to develop perfect-flowered, self-fertile cultivars. The first of these were released in 1948 (Dearing, 1948). Since that time, many cultivars have been released with improved yield and fruit quality for both fresh fruit and processing uses. At present, about 25 cultivars account for most of the commercial production (Olien, 1990). There are scores of additional cultivars in limited production and grown in backyards. 'Scuppernong', long the major cultivar, has been replaced by 'Carlos', 'Doreen', 'Nobel', 'Magnolia', and others for juice and wine; and by 'Fry', 'Jumbo', 'Sugargate', etc. for fresh fruit. The first seedless muscadine cultivar, Fry Seedless, is now available commercially. Further development of seedless types is expected (Goldy et al., 1988).

A second long-standing goal among both *V. vinifera* and *V. rotundifolia* breeders has been to produce hybrids between these species (Einset and Pratt, 1975). Hybridization is difficult due to a difference in chromosome number ($2x = 2n = 38$ in *Euvitis* and $2x = 2n = 40$ in *Muscadinia*), and has only been successful when *Euvitis* is used as the female parent (Einset and Pratt, 1975). Hybrids could overcome weaknesses in both species. *Vitis vinifera* is highly susceptible to pests and diseases, requiring the use of pesticides, especially in humid regions, and must be grown on resistant rootstock to avoid devastation from grape phylloxera (*Phylloxera vitifoliae* Fitch), a root-infesting insect, and other pests and diseases (Bouquet, 1980; Einset and Pratt, 1975; Winkler et al., 1974). In contrast, muscadines are relatively tolerant to pests and diseases common in North America. This degree of tolerance would make muscadines extremely valuable as

(continued on inside back cover)

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rootstock for *Euvitis* grapes, except that *Euvitis* and muscadines are graft-incompatible (Winkler et al., 1974). Thus, there has been a desire to genetically incorporate pest- and disease-tolerance from muscadines into bunch grape cultivars and rootstock. At the same time, breeders would like to incorporate *Euvitis* traits into muscadine to increase juice yield per tonne of fruit, to modify juice chemistry (especially anthocyanins) for improved juice and wine stability, and to incorporate heedlessness from *Euvitis* into muscadine-like hybrids (Carroll, 1985; Goldy et al., 1988; Lane, 1978).

The hybrids that have been produced are completely or nearly sterile (Einset and Pratt, 1975), and no hybrid cultivars have been released for fruit production. However, there is evidence that *V. vinifera* is graft-compatible with *Euvitis* × *rotundifolia* hybrids, and two such hybrid rootstock have recently been released as disease- and pest-tolerant rootstock (Walker et al., 1989). In vitro techniques, including embryo culture (Goldy et al., 1988), and protoplasm isolation (Lee and Wetzstein, 1988), are being developed to facilitate hybridization of these species.

In addition to cultivar improvement, enological and processing research have improved juice extraction methods and the quality of wine, juice, and products such as jelly, syrup, etc. These subjects recently were reviewed by Carroll (1985). Current efforts include developing means to increase muscadine juice yield per tonne of fruit (Carroll, 1985). Content of ellagitannin and ellagic acid in muscadine products is also becoming an important topic (Lin and Vine, 1989). Ellagitannins are easily hydrolyzed to release ellagic acid (Robinson, 1983). Under in vitro laboratory conditions, ellagic acid inhibits the activity of chemical carcinogens such as polycyclic aromatic hydrocarbons, aflatoxin, and nitrosamines (Stoner, 1989; Windholz, 1983). It is yet to be determined whether consumption of muscadine, strawberry, raspberry, blackberry, and other fruit high in ellagitannins are effective in reducing cancer (Stoner, 1989).

Viticultural problems of muscadines have been dealt with to a much lesser extent than breeding and processing. Detailed muscadine production manuals have been published for >100 years, but many of the recommendations have come from observation, and not from controlled, replicated studies. There has often been an assumption that cultural methods developed for *Euvitis* grapes should directly transfer to muscadines, but differences in growth and fruiting habit make this impractical in many cases (Olien, 1990). The concept of canopy design for op-

timum light climate and a pruning system to balance vegetative and reproductive growth have never been adequately addressed in muscadines. Additional topics that need further research include optimum planting and establishment methods, nutrient fertility needs, optimum soil moisture control through the season, vineyard floor management, and integrated control strategies for pests and diseases, especially the grape root borer (*Vitacea polistiformis* Harris). Lack of physiological and cultural research in these areas are major limitations to continued growth and stability of the muscadine industry. Research is needed in these areas before the grower and processor can be assured of consistent yields, high fruit quality, maximum economic efficiency, and reasonable profit.

Complete installation costs for a new vineyard (including an irrigation system, labor, equipment, etc.) are estimated at (in U.S. dollars) \$8650/ha (\$3500Pdc) and costs of harvest, recommended cultural practices, equipment depreciation, etc., in mature vineyards are about \$3700/ha (\$1500/acre) (Bateman et al., 1987). Some states have instituted programs to help offset interest payments on loans for new vineyards until production begins in the 3rd or 4th year. Fresh fruit and U-pick sales are more limited than sales to processors, but prices paid to the grower are four to seven times that for processing muscadines. Current prices paid to growers by processors are around \$220/t (\$200/ton), with net profit from mature vineyards estimated at \$940/ha (\$380/acre) for yields of 20 t-ha⁻¹ (9 tons/acre) (L. Bateman, unpublished data). Average yields are below these values in many states, but yields of > 20 t-ha⁻¹ are readily attainable with improved cultivars and cultural practices.

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