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Eastern United States Table Grape Breeding

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A discussion of table grape breeding in the eastern U.S. must include a definition of "eastern", along with some description of what a "table grape" is in this region. For the purposes of this discussion, the eastern U.S. includes all areas east of the Rocky Mountains (rather than a common delineation of the country using the Mississippi River). The primary reason for this basis is that in general all areas east of the Rocky Mountains, with some exceptions in Texas, Oklahoma, and other states that have relatively dry climates, all have rainfall most or all months of the year, and therefore have diseases, other pests, and fruit-cracking pressures exceeding that of more arid climates such as in the western U.S. states. The definition of a "table grape" is a more difficult task. In the East, even today, seeded, slip-skin grapes such as 'Concord' are sold in some markets as a fresh-eating grape. However, many would argue that 'Concord' is not a table grape, but rather a processing grape used for juice. Therefore, it seems that the definition of a table grape might vary based on a number of considerations. I believe that one might designate the following definitions with the first being a very basic and early U.S. designation and the last a more modern-day, purist definition:

- A grape that is improved in quality (over wild or poor quality fruits) and could be produced for fresh fruit consumption locally;
- A grape with improved fruit size over that of native or small-berry wine types;
- A grape bred specifically for improved eating quality (rather than for processing) but not necessarily seedless, non-slip skin, or crisp;
- A grape developed exclusively for the table market with the characteristics of seedless, crispness, and edible skin, that can be consumed easily with no discarding of skins or other inedible components.

The last definition would be what most modern-day consumers would consider a table grape, while the prior three types would be unfamiliar to most Americans today. This paper provides a condensed history of eastern U.S. table grape improvement along with current breeding program goals, progress, and advances through 2007.

New York and Early Progress in Public Breeding

The longest continuous table grape breeding program conducted by a public agency was initiated in 1919 by the New York State Agricultural Experiment Station (NYSAES) (9). The first breeder was A.B. Stout who was employed by the New York Botanical Garden located in the Bronx, New York City. This unique arrangement allowed evaluation and breeding to be done in Geneva while he worked in New York City the majority of his time. Stout directed the program until his retirement in 1948. The first eastern U.S. seedless grape released was 'Stout Seedless' which was introduced in 1930, followed by 'Bronx Seedless' released in 1937. These early introductions had significant limitations in performance including fungal disease susceptibility, tendency for fruit cracking, and winter hardiness limitations. The NYSAES program continued with noteworthy releases including the seeded 'Steuben' in 1947 and 'Alden' in 1952. Three additional seedless releases were 'Interlaken' (1947) along with 'Himrod' and 'Romulus' (1952). 'Sultanina' ('Thompson Seedless') was the primary

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source of seedlessness for these early seedless developments, and this *Vitis vinifera* L. cultivar also contributed genes for the shortcomings mentioned earlier. The NYAES program most recently released 'Einset Seedless' (1985) (1) and 'Marquis' (1996) (2). The program continues today, led by Bruce Reisch, although the major focus is now wine grape breeding. The objectives include improved postharvest handling, attractive clusters, cracking resistance, improved texture, large and seedless berries, and increased disease resistance (targeting "no spray" developments). The disease resistance sources include *V. aestavalis* Michx. and other species derivatives (B. Reisch, personal communication).

Midwestern and Canadian Breeding Public Efforts

The longest sustained grape breeding effort in the Midwest has been carried out by the Univ. of Minnesota. The program was begun in 1908, and the notable early release was 'Bluebell' in 1944. Although the modern emphasis has been on wine grape improvement, a small table grape effort continues under the leadership of P. R. Hemsted and J. J. Luby with objectives of cold hardiness, disease resistance, seedlessness, crisp texture, and enhanced flavors including muscat and other flavors (J. Luby, personal communication).

The grape breeding program based at the Horticulture Research Institute, Vineland Ontario, (now Univ. of Guelph) has largely focused on wine grape breeding, but the release of 'Vanessa Seedless' in 1985 provided an adapted, crisp/non-slip-skin genotype. This program continues today under the leadership of K. H. Fisher.

Other table grape improvement efforts that are no longer active include the Univ. of Illinois, the South Dakota Agricultural Experiment Station and the State Fruit Experiment Station at Mountain Grove Missouri (now a unit of Missouri State Univ.). Herb Barrett led the effort at Illinois, and a noteworthy release was 'Lady Patricia' in 1968. This genotype, although not a wide commercial success, has been used a parent for elongated fruit shape in other programs. The South Dakota effort was led by N.E. Hansen and later by R. M. Peterson, and included the release of 'Valiant' (1). P. H. Shepard and later K.W. Hanson led the Mountain Grove effort, with 'Bokay' the most well-known release (1).

Southern Public Programs

The Univ. of Florida conducted one of the most significant breeding efforts in the South, and this program continued until the early 1990s. L.H. Stover, followed by J.A. Mortensen, directed this program. Resistance to Pierce's Disease was a top priority of the Florida program, the most aggressive breeding program ever undertaken to address this major limitation to bunch grape production in the South. Important developments from this program included 'Lake Emerald' (1954), 'Blue Lake' (1960), 'Stover' (1968), and 'Conquistador' (1983) (1). These seeded introductions were considered multiuse, including fresh consumption. 'Orlando Seedless' (1986) was the first (and only confirmed) Pierce's Disease-resistant seedless table grape (1).

The Univ. of Arkansas program was begun in 1964 by J.N. Moore. This ambitious program focused primarily on table grapes, and included objectives such as fruit cracking resistance, improved texture including non-slip-skin, seedlessness, a range of flavors (American species and muscat), shape variation, attractive clusters, disease resistance, and winter hardiness (4). Releases included 'Venus' (1977), 'Reliance' (1983), 'Mars' (1985), 'Saturn' (1989) (1), 'Jupiter' (1999), and 'Neptune' (1999) (3). Upon Moore's retirement in 1996, I assumed leadership of this effort and the program continues today with the same major objectives.

Several other public programs were conducted in the South in the 1900s. Among these was the effort at Virginia Tech Univ. led by R.C. Moore and G. Oberle which in-

troduced 'Alwood' (1967) (1). Herman Hinrichs led the Oklahoma State Univ. program and developed 'Cimarron' (1958) and 'Bounty' (1975) (1). The Clemson Univ. program, directed by H.J. Sefick, released 'Oconee' (1970) (1). The grape breeding effort led by N.H. Loomis (U.S. Dept. of Agriculture, Meridian, Miss.), with subsequent collaboration and evaluation by J.P. Overcash at Mississippi State Univ., provided 'Mid South' (1981) (1). Finally, the program at the Tuskegee Institute in Alabama with leadership by B.T. Whatley introduced 'Foxxylottie' in 1982 (1). All of the cultivars mentioned from these various programs would likely be classified as multi-use as they were seeded and could be used for a range of processed products.

Private Programs

Numerous private grape breeding programs have been conducted in the East, and many of these focused solely on wine grapes. Table or multi-use grapes developed in private programs include 'Agawam' by E.S. Rogers (Massachusetts) and the expansive developments of multi-species hybrids in Texas by T.V. Munson (8). Robert Dunstan in North Carolina conducted innovative breeding in the development of 'Carolina Blackrose' and 'Aurelia' (1). J.L. Fennel in Florida introduced 'Biscayne', while George Remaily in New York provided 'Remaily Seedless' (1). Although wine grapes were a major focus for Elmer Swenson in Wisconsin, his introductions of 'Swenson Red', 'Edelweiss' (jointly with the Univ. of Minnesota) (1) and 'Petite Jewel' (5) provided hardy options for growers. An ongoing program with a small effort in bunch grapes continues in North Carolina led by Jeff Bloodworth.

Major Objectives in Eastern Table Grape Improvement

Texture. As with most fruit breeding efforts, table grape quality is increasingly taking the paramount role in cultivar improvement. In the U.S., most consumers are unfamiliar with non-crisp, slip-skin table grapes due to the dominance of the market by *V. vinifera* shipped from California. Therefore, a widely accepted genotype will likely have non-slip-skin texture. Two eastern developments that fit in this category are 'Vanessa Seedless' and 'Jupiter'. Although they lack the crispness of the California cultivars, they provide a different mouth sensation compared to slip-skin cultivars such as 'Mars' or 'Einset Seedless'. However, in breeding for firmer texture, an increase in the *V. vinifera* component is required, and this leads to many of the shortcomings mentioned earlier. An additional benefit of crisp texture is that seed traces are usually not as noticeable in crisp berries. However, the most discerning consumer will have concerns if grapes are not fully seedless if they are marketed as such.

Seedlessness. Complete seedlessness is desired in all table grape improvement programs. With the advent of seedless x seedless crossing, the development of fully seedless genotypes has been enhanced. However, currently the active eastern U.S. programs utilize seeded x seedless crosses, with a significant number of the resulting progeny being seeded along with variation in seed trace size. Complete seedlessness is found in most retail market table grapes, and eastern table grapes would be more desirable if absence of seeds was assured in market offerings. In the Arkansas program, I have observed that genotypes with no or very small seed traces grown in Arkansas can develop very large traces and even complete seeds when grown in the San Joaquin Valley of California. This appears to be related to high heat in California, and although not commonly documented in the literature, high heat appears to enhance seed trace development.

Fruit cracking resistance. One of the greatest challenges in developing table grape cultivars for climates where summer rains occur during ripening or harvest is resistance to the cracking or splitting of the skins. Substantial success has been made in this area over the years, and resistance to cracking is much more advanced than in the first eastern

cultivars. In general, the trend of increased quality with traits such as crisp texture, thin skins, and complete seedlessness results in a greater tendency to crack. The cultivar 'Reliance' is an example of a genotype with exceptional flavor and sweetness, but in many locations (including Arkansas where it was developed) it can exhibit extreme cracking if near mature when summer rainfall occurs (6). Imperative in developing cracking resistance is a thorough and routine screening for this trait which is provided for by normal rainfall. However, growing seasons vary in when and how much rain occurs each year so that selection pressure can vary from year to year. No weakness in a table grape cultivar is more devastating to a grower than fruit cracking and all genotypes must be evaluated carefully prior to release to have an accurate cracking tendency or resistance recommendation.

Improved postharvest handling. A table grape to be used in retail commerce must have some level of postharvest handling potential. Several components contribute to this success. First, freedom from shatter is needed, and the berries should remain attached to the pedicel during handling and storage. This can be achieved, but again the paradox of quality vs. a range of genetic limitations is a challenge to address. Also, the maintenance of firm fruit texture is needed; again this can be an issue of being firm on the vine and remaining firm to the final marketplace. Finally, the grapes need to retain an attractive appearance which is often related to bloom retention and lack of bruising or other physical damage. This issue can be much more substantial on green (white) genotypes as bruising and other damage is seen more readily with this skin color.

Flavors. I believe one of the most exciting areas of table grape improvement is the enhancement of flavors, with these coming from muscat and American species, particularly *V. labrusca* L. and hybrids of this species. Most commercial table grapes in retail markets have two main sensations upon eating: a crunch, crisp texture, and a taste of sweetness (assuming the grapes were mature when harvested). Those familiar with a wider array of flavors know that consumers are missing out on a much wider flavor profile than exists in current commercial table grape cultivars. In the Arkansas and New York programs, along with others in the eastern U.S., a range of flavors has been incorporated in table grape selections and cultivars, and these offer a much more exciting eating experience. If these flavors could be combined with crisp texture and seedless berries, the consumer would likely enjoy these new options.

Fruit shape. In the early years of eastern table grape breeding, cultivars most often had round berries with shape derived from their *V. labrusca* heritage. This has changed in the last 20-30 years with several more oval- to oblong-shaped cultivars released such as 'Vanessa Seedless', 'Saturn', 'Jupiter', and 'Neptune'. Moore in Arkansas began crossing with 'Lady Patricia' in the 1960s and selected for more elongated shape (4). Subsequent crossing among selections with this shape has resulted in unique very elongated-shape genotypes. None of these has been released, but at some point this shape will be found in retail markets. It will be interesting to see how this category of shape will be accepted by consumers.

Winter hardiness. A primary objective since the beginning of eastern table grape breeding has been to achieve a greater degree of winter hardiness than that found in *V. vinifera* which is unreliable in survival in the East. The more advanced achievements in hardiness in eastern cultivars have been in the Univ. of Minnesota program and the private program of Elmer Swenson. Excellent hardiness has also been achieved in many NY-SAES cultivars. The hardiest of the Arkansas cultivars is 'Reliance', which was found to be hardy in Wisconsin in its early evaluation prior to release. As with many other traits, increased *V. vinifera* genetic component in new varieties usually leads to hardiness limita-

tions. Combining hardiness with high quality continues to be challenging.

Disease resistance. All programs have some degree of screening for common diseases such as black rot (*Guignardia bidwellii* Viala & Ravaz), powdery mildew (*Uncinula necator* Burr.) and downy mildew (*Plasmopara viticola* Berl. & de Toni), anthracnose (*Elsinoë ampelina* Shear), and other fungal concerns. Field screening of seedlings and selections is the primary method of identifying disease resistance. The NYSAES program is a leader in current disease resistance breeding, and probably has the most intense screening for resistance in its routine breeding procedures. In the Arkansas program, fungicides are applied to some degree in the seedling and selection vineyards, due to the extreme disease pressure in this environment of high temperatures and humidity plus rainfall. It is not likely that cultivars with exceptionally high quality will be developed that do not require some fungicide applications for reliable production.

Future Prospects for Eastern Table Grape Production

Table grape production in the eastern U.S. appears to have declined in the last 10 years. Commercial table grapevine sales have not expanded during this time. This is disappointing as genetic progress continues and the limited number of new cultivars released in the last 15 years offer new options for growers. However, the increased marketing of fruits "on-farm" and at farmers markets combined with increased interest in local production by consumers and retailers could contribute to an increase in eastern table grape production.

An area of promise in table grape improvement is the combination of eastern hybrids and *V. vinifera* cultivars produced in more arid climate of California. The release of 'Thomcord' (7), a hybrid of 'Thompson Seedless' x 'Concord' by David Ramming (U.S. Dept. of Agriculture, Agricultural Research Service, Parlier, Calif.), is evidence of interest in the "eastern" x "western" combination. The current work in combining more advanced eastern selections x pure *V. vinifera* genotypes in private programs in California is very exciting. One example of this is the cooperative endeavor of the University of Arkansas and International Fruit Genetics of Bakersfield, Calif. In this effort, the most advanced selections with improved quality developed in the last 40-plus years in Arkansas are being hybridized with some of the newest high-quality *V. vinifera* genotypes from California. The resulting progeny have excellent fruit quality (crisp, seedless, excellent skin attributes) plus some enhancement in fruit cracking and disease resistance (personal observation). Also, the resulting offspring provide a range of new flavors never combined in this level of fruit quality. The potential promise of these unique hybrids is very exciting and could offer an entirely new flavors and quality profiles for future cultivars.

As seen many years ago with the first eastern table grapes developed by Stout, issues of fungal disease susceptibility, tendency for fruit cracking, and winter hardiness limitations continue to be very important. Combining all the desired traits in one or several cultivars of table grapes has been the biggest challenge of my career. I hope that continued breeding efforts along with diversified use of eastern genetic improvements in broader geographic breeding will lead to further progress.

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TOWARDS UNDERSTANDING GENETIC CONTROL OF THE TIME OF BUDBREAK

In the Western Cape region of South Africa, winter chilling can be insufficient, so the application of dormancy-releasing chemicals is part of standard orchard management. Demand exists for new apple cultivars better adapted to local climatic conditions. Van Dyk et al. report the construction of framework genetic maps in two apple families using the low chilling cultivar 'Anna' as common male parent and the higher chill requiring cultivars 'Golden Delicious' and 'Sharpe's Early' as female parents. Time of IVB (IVB) was assessed over multiple years, both in the nursery and in replicated adult trees in the field. These data and the genetic maps were used to identify a region of DNA that affected time of initial vegetative budbreak on linkage group 9. The results contribute towards a better understanding regarding the genetic control of IVB in apple and may help elucidate the genetic basis of other dormancy related traits. Paraphrased from M. M. Van Dyk et al. 2010. Tree Genetics & Genomes 6(3):489-502.

CONCORD GRAPE JUICE SUPPLEMENTS FOR "BRAIN POWER"

Concord grape juice contains polyphenol compounds, which have antioxidant and anti-inflammatory properties. Previous studies showed that Concord grape juice supplementation reduced inflammation, blood pressure and vascular pathology in people with cardiovascular disease. In addition, preliminary animal data have indicated improvement in memory with grape juice supplementation. Krikorian et al. enrolled 12 older adults with memory decline but not dementia in a randomized, placebo-controlled, double-blind trial with Concord grape juice supplementation for 12 weeks. The subjects showed significant improvement in a measure of verbal learning and non-significant enhancement of verbal and spatial recall. There was no effect on weight or waist circumference. The authors suggest that more comprehensive investigations are warranted to evaluate potential benefit and assess mechanisms of action for the observed enhancement of cognitive function. Paraphrased from R. Krikorian et al. 2010. British J. Nutrition 103(5):730-734.