Southern Highbush Blueberry Breeding at the University of Arkansas

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Abstract
The blueberry breeding program at the University of Arkansas (UA) was initiated in 1976 by James N. Moore. This effort followed the cultivar and cultural evaluations that provided information in the early 1970s that blueberries could be grown successfully in Arkansas. From these evaluations, it was evident that breeding for the soils and climate of Arkansas would enhance cultivar adaptation for growers. From the outset, the UA breeding effort has had a strong cooperation with the U.S. Dept. of Agriculture (USDA). Major USDA cooperating scientists have been Arlen Draper, followed by Mark Ehlenfeldt. Since the program was begun, over 500 selections have been made from approximately 40,000 seedlings evaluated. Major goals have included adaptation to mineral (low organic matter content) soils, and all seedlings have been grown in sandy or silt loams. Additionally, an emphasis has been placed on high fruit quality and plant hardiness for the upper-South area of the U.S. ‘Ozarkblue’ was released in 1996, and is being produced to a limited extent in Arkansas but also in other areas of the world. ‘Summit’ was cooperatively released in 1998 by the University of Arkansas, North Carolina State University, and the USDA. A group of advanced selections with a range of ripening dates is under final evaluation for potential release. Seedling populations continue to combine a unique mix of species contributing to adaptation, including Vaccinium atrococcum, V. darrowi, and V. ashei combining with V. corymbosum. Recently the characterization of antioxidant content along with several individual nutraceutical compounds in various genotypes has been conducted. Additionally, postharvest evaluations are routinely done.

INTRODUCTION
The University of Arkansas (UA) blueberry (Vaccinium sp.) breeding program was begun in 1976 by James N. Moore, and he directed this program until his retirement at the end of 1996. Blueberry breeding was begun much later than the other breeding programs that Dr. Moore initiated in 1964. When Dr. Moore began his career at the UA in 1964, he initiated blueberry cultivar testing as there had been no investigations on the adaptation or culture of blueberries in the state or region. His initial effort focused on testing highbush (V. corymbosum L.) and rabbiteye (V. ashei Reade) cultivars in several locations in Arkansas. He found that highbush were adapted to northwest Arkansas, rabbiteye to central and southwest Arkansas, and in areas of intermediate climate in the transition due to elevation increases in the Ozark and Ouachita mountain regions, he recommended highbush in higher elevations and rabbiteyes in the valleys (Moore, 1979). At that time no southern highbush (Vaccinium sp.) cultivars, other than unadapted releases from Florida, had been released.

From this testing and cultural research, it was shown that blueberries could be grown in most areas of Arkansas, particularly if cultural practices were implemented that made the mineral soil environment more amenable to blueberries. Cultural practices recommended included application of sulfur to the soil prior to planting if pH was in excess of 5.5, the addition of peat moss to the planting hole, mulching with sawdust or
woodchip mulch to a depth of 15 cm, and trickle irrigation. Since the cultivar and cultural management trials had shown blueberries to be a potential commercial crop for Arkansas, commercial plantings were first established in the mid- to late-1970s. It was also determined that ultimately the optimum way to provide the best genotypes adapted to Arkansas soils and climate was to breed and select in the environmental conditions of this commercial production.

Therefore, the blueberry breeding program was begun in 1976, knowing that this would be a formidable task with the various limitations of climate (heat and cold) and mineral soils to be addressed in breeding. This program was a cooperative program from the beginning, with the primary cooperation with U.S. Dept. of Agriculture (USDA) and the blueberry breeder at that time, Arlen Draper. The major objectives of the program included: 1) upland soil adaptation, 2) drought, heat, and cold tolerance for various areas of Arkansas, 3) range of seasons of ripening with an emphasis on early ripening genotypes, 4) disease resistance with priority on Phytophthora root rot resistance, and 5) high quality fruit.

MATERIALS AND METHODS
The first seedlings grown in Arkansas were planted at UA Agricultural Research and Extension Center, Fayetteville. Dr. Draper sent 3,523 seedlings in February, 1976 and these were planted in the field that spring in a Captina silt loam. Culture of these and all seedlings subsequently planted in the Arkansas program included no soil amendments (no peat moss additions or mulching), to provide selection pressure for upland adaptation to low organic matter, mineral soils. This first group of seedlings had a wide range of parents, from highbush x highbush crosses, to many species hybrids including derivatives of *V. darrowi* Camp, *V. atrococcum* Heller, *V. constablaei* Gray, *V. myrtilloides* Michx., *V. tenellum* Ait., *V. angustifolium* Ait., and *V. ashei*. These seedlings yielded the first 158 selections in the program by 1980. The first crosses were made in Arkansas in 1979 and focused on standard highbush hybrids, Phytophthora root rot resistance, upland adaptation at the tetraploid and hexaploid levels, and interploidy crosses. Subsequent to those early years, additional seedlings were sent by Dr. Draper and in the 1990s by Mark Ehlenfeldt, also of the USDA. Crosses were also made in Arkansas in some years but not annually as was done with the other fruit breeding programs. Seedling evaluation continued in Fayetteville until the early 1990s.

Evaluation of seedlings, selections (mainly from other programs), and cultivars was begun in 1986 at the UA Fruit Substation, Clarksville. This location, 150 km southeast of Fayetteville, has a slightly different environment, with more moderate winter minima but higher summer maxima. The soil type at that location is a Linker fine sandy loam with native pH of 5.0 to 5.3, and is generally more desirable for blueberry seedling and selection growth. The first selections were made at Clarksville in 1988.

RESULTS AND DISCUSSION
Through 2003, a total of approximately 40,000 seedlings have been planted in Arkansas yielding 516 selections. As of 2004 approximately 3,000 seedlings are in the field for future evaluation. The current focus is almost exclusively on southern highbush types.

Early evaluations in Fayetteville revealed major differences in population adaptation to mineral soil, with the species hybrids, especially those derived from *V. darrowi*, *V. atrococcum*, and *V. ashei*, showing the best growth and vigor. Subsequent to these earlier evaluations, hybrids with US 676 (G-362 x JU 11; *V. corymbosum*, *V. atrococcum*, and *V. ashei*) and US 729 (US 75 x JU 11; *V. corymbosum*, *V. darrowi*, *V. atrococcum*, and *V. ashei*) have given some of the most unique plants for adaptation with improved fruit quality over the upland parents. Overall in the program, fruit quality was often much better than expected from some of the species hybrid derivatives with gains in fruit size, color, and scar, along with a mix of flavors derived largely from non-northern
Vaccinium atrroccum has provided very unique flavors, some peach-like. Hybrids that contained one-quarter or more Vaccinium darrowi in their parentages tended to have winter or injury to flower buds as did the few Vaccinium ashei-derived genotypes. It was determined early on that less than one-quarter Vaccinium darrowi background would be required to reliably crop southern highbush types in west-central to northern Arkansas and regions with similar climate.

Very good success was had at Clarksville with seedling evaluation and all seedling evaluation was shifted to there in the early 1990s due to a more favorable site and adequate resources to conduct the program. Also at this time there was a greater shift to southern highbush types in breeding since they would serve a larger portion of the state.

Primary selection evaluation has been conducted on the initially selected plants at the location of selection - i.e. if selected in Fayetteville then evaluated there, likewise at Clarksville. The first replicated trial of five advanced Arkansas selections was established at Clarksville in 1987, and since then replicated trials were planted at Hope (1999 and 2003, southwest Arkansas), Clarksville (1999), and Fayetteville (2000). The replicated trials in place now have a range of selections, including early selections such as A-4 and A-12, up to more recent genotypes such as A-439 (A-1 was the first selection made in the program). It is hoped that these trials will reveal the most outstanding genotypes for release in the next 2 to 3 years.

‘Ozarkblue’, tested as A-109, is the only cultivar released from the program thus far (Clark et al., 1996). This genotype was selected from the initial group of seedlings sent by Dr. Draper in 1976 and was a cross of G-144 x Fla. 4-76. ‘Ozarkblue’ was released due to adaptation to a range of environments in Arkansas (Hope, Clarksville, and Fayetteville), very high yields, large fruit size, and good fruit quality. It has demonstrated the ability to avoid late winter and early spring freezes, as it breaks buds much later than all other southern highbush cultivars tested. In Arkansas it ripens 7-10 days before rabbiteyes. This is an advantage for growers in central and southern areas of the state who traditionally grow only rabbiteye cultivars. Its background includes Vaccinium darrowi, Vaccinium ashei, along with a small amount of Vaccinium angustifolium, and the majority gene contribution from Vaccinium corymbosum. It has shown potential in other states including Oregon, where its late highbush-season ripening is of value, bridging a gap between mid-season cultivars and ‘Elliott’. It is patented and propagators have been licensed in several states in the U.S, Japan, Chile, Argentina, and Europe. It is one of the highest-chilling requirement, and likely hardier, of the current southern highbush cultivars.

‘Summit’ was cooperatively released by UA, N.C. State University, and USDA in 1988 (Clark and Moore, 1999). A sibling of ‘Ozarkblue’, ‘Summit’ has many good characteristics including exceptional flavor. The Arkansas contribution was in testing and data collection of ‘Summit’; it was selected in Hammonton, N.J. ‘Summit’ is not patented.

Since 1999, nutraceutical evaluations for oxygen radical-absorbing capacity, total anthocyanins, total phenolics, total hydroxycinnamic acids, and total flavanols have been conducted with Luke Howard and colleagues in the UA Dept. of Food Science. Major findings from this work indicate that genotypic influences on variables measured are greater than year (or growing season); however year effects can be substantial and it was recommended from this work that multiple years of sampling are required to fully screen germplasm (Howard et al., 2003). This research continues, and it is anticipated that the next releases from the program will have a nutraceutical characterization included in their release information.

Finally, the breeding program has had excellent cooperation with Dr. Penny Perkins-Veazie, USDA, Lane, Oklahoma (USA), in the postharvest evaluation of advanced selection material. This cooperative endeavor provides early evaluations of postharvest handling potential of germplasm that will be available at the time of release.
CONCLUSIONS

The blueberry breeding program, although smaller than the larger Arkansas breeding programs in blackberries, table grapes, and peaches/nectarines, continues to make progress. Advanced selection testing should identify several new cultivars in the next few years, with projected adaptation to the medium to higher-chill areas of the mid-to upper-South of the U.S. Likewise, adaptation is anticipated in other areas of the world with similar environments.

Literature Cited


