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Blueberry Breeding: Improving the Unwild Blueberry

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Abstract

The history, present status, and future challenges of blueberry (*Vaccinium* spp.) breeding are summarized, including breeding of highbush, rabbiteye and southern highbush blueberries.

The blueberry has become an important small fruit noted for its many health benefits and its flavor. The predominant types of blueberries grown commercially in the U. S. are highbush (*Vaccinium corymbosum* L.), lowbush (*V. angustifolium* Aiton), rabbiteye (*V. ashei* Reade), and finally the southern highbush (interspecific *Vaccinium* hybrids), which originated quite recently by crossing the highbush blueberry with several low chilling species native to the southeastern U.S. Another recent addition to the commercial blueberry family is the half-high highbush blueberry. It originated from intercrossing lowbush and highbush blueberry and selecting relatively short plants that would survive cold temperatures when covered with snow. Highbush blueberry has the longest history of breeding, followed in order by rabbiteye, lowbush, southern highbush, and half-high highbush blueberries. Originally grown in the acid soils of eastern and southeastern U.S., the blueberry is now grown in other parts of the U.S. and internationally in both hemispheres. The acreage of southern highbush blueberries is growing rapidly, especially in Argentina, Uruguay, Spain, and Mexico. Chile, New Zealand and Australia have grown blueberries for a number of years. Several countries are now engaged in blueberry breeding.

Blueberry breeding of all species is a large topic to cover in a short talk and no slight is intended if some topics are mentioned briefly or totally missed. The author makes no claims as historian or writer, as age has conferred neither wisdom nor writing skills. I invoke an additional disclaimer that much of the content of this paper is opinion and you are free to disagree. Two informative papers on blueberry breeding give useful breeding techniques (5) and merits of Vaccinium species that might prove useful in breeding commercial cultivars (2).

Past

Highbush blueberry. It is impossible to speak of blueberry breeding and not begin with the many contributions to highbush blueberry breeding of Dr. Frederick Vernon Coville of the U. S. Department of Agriculture, who started modern blueberry breeding. One hundred years ago (1906) Dr. Coville initiated a series of experiments to learn fundamental requirements of growing and breeding blueberries (1). It took two years to learn that blueberries require an acid soil and in the ensuing 100 years of breeding that has not changed. After two more years of study he learned how to propagate blueberries by seed and rooted cuttings, and how to make crosses.

In 1908, he selected a native highbush blueberry plant (*V. corymbosum* L.) in New Hampshire and called it ‘Brooks’. In 1909, he selected the second blueberry plant (*V. angustifolium* Aiton) in New Hampshire for breeding and named it ‘Russell’. In the spring of 1911, Dr. Coville crossed these two native selections and began an activity that has continued based on that foundation. Dr. Coville cast a long shadow in which all blueberry workers stand.

In 1911 occurred another important event

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in blueberry breeding history. Miss Elizabeth C. White became a cooperator with Dr. Coville in the blueberry breeding (6). She provided land (with acid soil) in the pine barrens of southeastern New Jersey where many wild blueberries grow. It provided a good place to grow seedlings from controlled crosses (6). An important contribution Miss White made to the breeding that should be emphasized was the obtaining of superior plants from the wild to use in blueberry breeding. One hundred selections were obtained with the help of local woodsmen who gathered wild berries. Selections 'Adams', 'Harding', 'Dunfee', 'Sam', and 'Rubel' proved to be the superior New Jersey clones. Of the 102 native selections, ('Brooks' and 'Russell' from New Hampshire and 100 from New Jersey), all of the best progenies came from intercrosses of the above-named seven selections (6). Thus, a rather narrow genetic base was created for future breeders. One selection, 'Rubel', was an excellent parent and became a widely grown cultivar still propagated and grown today. It is the only one of the original wild selections that is self-fertile (6). In advanced selection trials, the lack of self-fertility is not easily discerned, but it becomes apparent when a selection is grown in solid blocks.

The cooperative work of Dr. Coville and Miss White ended in 1928 (6); Dr. Coville retired in 1936. From this work under his direction came highbush blueberry cultivars that established a commercial industry including the "Big Six" ('Earliblue', 'Blueray', 'Bluecrop', 'Berkeley', 'Herbert', and 'Coville') (2). The cooperative nature of the work by Dr. Coville and Miss White set a model that was continued by Drs. Darrow, Scott, and others for many years (5). In looking back at this work some important principles stand out to breeders of today: (1) careful selection of parents to be used in crosses, (2) adequate number of seedlings per progeny grown for selecting purposes, (3) rigorous selection applied in seedling progenies for fruit and plant characteristics. Now new gene combinations are needed from native plants of *V. corymbosum, V. angustifolium* and *V. ovatum*, a cluster-fruited western U. S. species.

Rabbiteye blueberry. Rabbiteye blueberry breeding began as a cooperative effort between the U. S. Department of Agriculture, the University of Georgia, and North Carolina State University in 1940. The first cultivars were released in 1950 (3). The breeding history of this marvelous southern blueberry followed the pattern used in highbush blueberry breeding (3). Superior plants gathered from the wild were intercrossed and rigorous selection practiced in seedling progenies. Approximately 6 native selections were used as parents and this established the rabbiteye blueberry breeding on a narrow genetic base. Several generations of breeding have improved fruit color and quality; plant vigor and productivity are inherent in this species. 'Woodard' and 'Tifblue' provided the foundation for the commercial rabbiteye blueberry industry. Sufficient genetic diversity is present in this species to obtain advances in season of ripening, fruit quality, and reduced plant stature. Additional selections from the wild are needed to broaden the genetic base. Experience indicates that *V. amoenum, V. virgatum* and feral plants of *V. ashei* have valuable genes to contribute to rabbiteye blueberry improvement.

Southern highbush blueberry. The southern highbush blueberry is relatively new on the scene of commercial blueberries; it is a highbush blueberry gone south. Internationally speaking, it is a highbush blueberry that derived a low-chilling requirement from native species adapted to areas with mild winter climates.

The University of Florida began breeding southern highbush blueberries in 1950 by crossing *V. darrowi* Camp with *V. ashei* Reade and the hybrids with highbush blueberry cultivars (5). These hybrids proved to be pentaploid (5x) but were useful in breeding. The first low-chilling cultivars originated were 'Flordablue' and 'Sharpblue' in 1976.
In 1967, the U. S. Department of Agriculture started making crosses to originate tetra-

ploid low-chilling cultivars using the native *Vaccinium* species *V. darrowi, V. elliottii, V. atrococcum, V. tenellum, V. myrsinites*, and *V. ashei* and some tetraploid hybrids from Professor Sharpe of the University of Florida. V. darrowi, especially Florida 4B, proved to be a very valuable parent and appears in the parentage of a number of cultivars (4). It is fortunate that this diploid (2x) plant through unreduced gametes produced tetraploid seedlings when crossed with cultivars ‘Bluecrop’ and ‘Berkeley’. It was also good fortune that Florida 4B transmitted the tendency of producing unreduced gametes to some seedlings. For example, US388 is a diploid hybrid of Fla 4B and *V. elliottii* that produces unreduced gametes. This work was cooperative with North Carolina State University and the Southern Horticultural Laboratory, USDA-ARS at Poplarville, Mississippi. Later, State Experiment Stations of Arkansas, Georgia, and Texas joined the cooperative breeding of southern highbush blueberry.

Southern highbush blueberry cultivars originating from the above-named breeding programs are being grown in the U.S. and in several countries in the southern and northern hemispheres. They are remarkable in adaptation, productivity, and fruit quality, but new sources of low-chilling germplasm need to be incorporated into the breeding of southern highbush blueberries. Regardless of the species used in breeding southern highbush blueberries, it is important for the final entity to be tetraploid (4x). Plants of *V. elliottii* and *V. fuscatum* offer plant adaptation to low-chill areas and good plant structure.

Present

Blueberries were traditionally grown in areas with naturally occurring acid soils. As interest in growing blueberries arose in areas without acidic soils, breeders tried to develop cultivars tolerant of soils with higher pH. Partial success was achieved generally with southern highbush cultivars due to genes obtained from *V. darrowi* and *V. ashei*. Some areas with high soil pH (California, for example) must use soil amendments such as mulch, acids, sulfur, and acidic fertilizers to successfully grow blueberries.

A fairly recent innovation in plant propagation from hard- and softwood stem cuttings to tissue culture methods has significantly shortened the period from advanced selection to released cultivar. Other essential steps in blueberry breeding remain almost unchanged since practiced by Dr. Coville: crosses made in the greenhouse, seed germinated in the greenhouse, seedlings transplanted to containers and grown to size for field or container fruiting, selection among fruiting seedlings, selections propagated and tested, selections propagated for release as cultivar. About 10 years is still required to go from seedling selection to cultivars. However, there appears to be a decrease in recent years in the number of seedlings grown per progeny. Previously progenies of 300-500 seedlings were not uncommon. It may indeed be advantageous to grow more progenies with fewer plants, 80-100 appears adequate. There has been a move toward using less space per plant in seedling nurseries. Some breeders are growing and fruiting seedlings in 1-gallon (3.8 L) containers, then transplanting the selections to field plantings for further evaluation. Merits of this practice remain to be proven.

Future

Blueberry breeding has become an international endeavor worldwide in scope. In order to meet the demands of varied climates and soils, breeders must use a wide array of breeding germplasm. Some fruit characters in present day cultivars such as color, size, scar, firmness, and flavor (to a lesser extent) are adequate. But consistent high annual yields have not reached maximum. Blueberry breeders have long wished to reciprocally exchange desired traits in tetraploid highbush and hexaploid rabbiteye blueberries (5). That goal has largely remained unmet. We are fortunate to have in the U.S. numerous native *Vaccinium* species as a source of genes for genetic improvement. Interspecific hybridization followed by rigorous selection in succeeding backcross and intercross generations, plus a dash of serendipity, appear key to cultivar improvement.

In addition to species *V. darrowi* and *V. ashei*, plants of *V. elliottii*, and *V. atrococcum* have contributed useful traits in southern highbush blueberry breeding. New sources of genes for improving highbush blueberries will be required, perhaps from native plants of *V. corymbosum* and *V. angustifolium*. Early-ripening, late-flowering genotypes with high quality fruit and productivity are a challenge that remains since the inception of highbush, rabbiteye and southern highbush blueberry breeding. The challenge for rabbiteye blueberry breeders is to maintain the productivity and robustness of the plant but reduce the size and suckering habit. Its fruit is very tart when it first turns blue. It is usually picked at this stage which gives a very negative image in the marketplace. All of these traits can be improved by breeding. The name rabbiteye needs to be replaced with a more descriptive one related to the plant. A name that appears to be more appropriate is southern bigbush blueberry. Improvement by breeding of this remarkable blueberry is on the threshold of helping it to take its place among the elite commercial blueberries. Perhaps, some of the diploid *Vaccinium* species will someday be grown commercially. The future of blueberry breeding is bright because of gene confirmations already originated by breeders and the genes of native species awaiting the ingenuity of man to give the world an even more remarkable fruit.

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Safety Assessment of Transgenic Plums Resistant to Plum Pox Virus

The potential impact of transgenic plums expressing viral coat protein (CP) gene constructs on the diversity and dynamics of virus populations was assessed under open and confined conditions in a research program sponsored by the European Commission. Across all field trials conducted in different locations (France, Romania, and Spain) and environments (continental and Mediterranean), transgenic plums expressing the CP gene of Plum Pox virus (PPV) had no detectable effect on the emergence of recombinant PPV species over eight to ten years. Also, no statistically significant difference was found in the number and type of aphids, including viruliferous individuals, and other arthropods that visited transgenic and nontransgenic plum trees. In addition, apple chlorotic leaf spot virus, prune dwarf virus, and Prunus necrotic ringspot virus did not influence the stability of the engineered resistance to PPV in co-infected transgenic plums over three dormancy periods. Altogether, the transgenic plums had a neutral impact on virus populations and non-target organisms over an extended time. See Fuchs, M. et al. 2007. Safety assessment of transgenic plums and grapevines expressing viral coat protein genes: new insights into real environmental impact of perennial plants engineered for virus resistance. J. Plant Pathol. 89:5-12.