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Trends in Lowbush Blueberry Cultivar Development

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Abstract

Although lowbush blueberries (*Vaccinium angustifolium* Ait.) have been commercially produced for over one hundred and forty years, the development of superior lowbush blueberry cultivars has lagged behind the development of northern and southern highbush and rabbiteye cultivars. With traits including good winter hardiness, low maintenance, low agrochemical input requirements, resistance to pests, ease of mechanical harvest, moderate to high yields and berry compositional attributes including high soluble solid and low acid levels, and more recently, high antioxidant and phytochemical contents, there has been renewed interest and efforts in breeding lowbush and interspecific hybrid cultivars. The objectives of this review are to briefly review the blueberry industry and breeding activities and examine the contributions and roles of the lowbush blueberry (*Vaccinium angustifolium* Ait.) in blueberry cultivar development.

Introduction

For centuries, blueberries (*Vaccinnium* spp.) have been touted in folklore and medicine as a valuable functional food. Due to the abundance and palatability of wild blueberries, indigenous people were harvesting and using blueberries in fresh and preserved forms as a critical component of their diet long before North America European colonization (20). In 1615, the French explorer Samuel de Champlain found indigenous peoples near Lake Huron gathering lowbush blueberries (*Vaccinium angustifolium* Ait.) for their winter stores. The berries were dried in the sun, beat into a powder, and used in foods including a dish called "Sautauthig", and also used to contend with medical ailments including inflammation and diabetes (2, 20). Blueberries were probably the first familiar foodstuff found by many North America colonists, since these berries were almost identical to the hurtleberries (*V. myrtillus*) which grew in large quantities over England and Scotland (20). The natural sweetness of the wild berries made this fruit one of the most popular of native fruits to the colonists, especially with the scarcity and expense of sugar (20).

Blueberries are calcifuge plants and belong to the genus *Vaccinium* in the heath family Ericaceae. Several taxa of *Cyanococcus* (true blueberries) are cultivated in North America which include *V. corymbosum* L. (highbush), *V. ashei* Reade (rabbiteye), *V. angustifolium* Ait. (sweet lowbush) and *V. myrtilloides* Michx. (sour-top lowbush) (8, 11, 13, 20, 30, 34, 35). North America is the world's leading blueberry producer, accounting for nearly 90% of the world production at the present time, with the largest production cultivated areas consisting of Michigan (29.4 million kg), New Jersey (16.3 million kg), British Columbia (14.7 million kg), Oregon (9.95 million kg), and North Carolina (5.88 million kg) (26, 33). In addition, the lowbush or 'wild' industry provides an additional 85.9 million kg of blueberries with the largest production areas consisting of Maine (50.0 million kg), the Canadian Atlantic provinces (27.2 million kg), and Quebec (8.60 million kg) (26, 33). Crop usage varies between the cultivated and wild blueberry industries with the fresh and processed markets accounting for 43.3 and 56.6%, and 1.98 and 98.2% of the harvested cultivated and wild blueberries, respectively (26, 33).

The major categories of blueberries being produced in North America include northern highbush, southern highbush,

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rabbiteye, and lowbush (i.e., wild) blueberries (11, 30, 34, 35). Northern highbush blueberries are vigorous, productive, drought sensitive, grow best on well drained acidic soils, and are comprised of a multitude of cultivars with examples including 'Berkeley', 'Bluetta', 'Bluecrop', 'Blueray', 'Collins', 'Coville', 'Duke', 'Elliot', 'Jersey', 'Lateblue', 'Patriot', 'Rubel', and 'Spartan' (5, 6, 7, 11, 31, 35, 36). The southern highbush blueberry is a relatively new introduction that has low chill requirements, is self fruitful and is an interspecific hybrid of the northern highbush (*V. corymbosum*) and one or more native southern blueberry species (e.g., *V. darrowi* and *V. ashei*) (3, 36). Examples of southern highbush blueberries presently include the cultivars 'Avonblue', 'Blueridge', 'Cape Fear', 'Cooper', 'Flordablue', 'Georgiagem', 'Gulf Coast', 'Jubilee', 'Misty', 'O' Neal', 'Ozarkblue', 'Reveille' and 'Sharpblue' (34, 36). The rabbiteye blueberry contributes approximately 5% to the total cultivated blueberry industry, is grown in the south-eastern United States, generally blooms earlier and has a longer period from flowering to maturity than southern highbush and is the most productive and tolerant cultivated blueberry to pests and disease (3, 5, 6, 11, 34, 35, 36). Examples of commercially used rabbiteye cultivars include 'Baldwin', 'Beckyblue', 'Bluebelle', 'Briteblue', 'Brightwell', 'Centurion', 'Chaucer', 'Choice', 'Climax', 'Delite', 'Powderblue', 'Premier', and 'Tifblue' (3, 11, 34, 35, 36). The wild blueberry (*V. angustifolium*), or commonly known as Britton's blueberry, huckleberry, low sugar blueberry, and the lowbush blueberry, is a perennial shrub which grows in acidic soils with high organic matter (1, 4, 10, 11, 20, 22, 32). Although lowbush blueberry cultivars have been developed, the crop in Maine, the Canadian Maritimes, and Quebec is almost entirely produced by genetically diverse wild clones (1, 4, 20).

Domestication Efforts

Blueberry domestication began in New Hampshire in 1908 by the United States Department of Agriculture. Dr. Frederick Coville and Ms. Elizabeth White coordinated this initiative, were active in seeking selections of superior wild highbush blueberries (*Vaccinium corymbosum*), and released the first fifteen commercial cultivars of highbush blueberries (5, 11). Following Dr. Coville, Dr. George Darrow coordinated the USDA blueberry breeding program, and provided over 200,000 seedling plants between 1946 and 1962 to cooperators in 13 states (5, 11, 30). This has resulted in the continued expansion of cultivated blueberry production in North America from 56,715 metric tons in 1986 to 83,260 metric tons in 1995 (26, 33).

Domestication of the lowbush blueberry was begun in Maine in the 1930's by Dr. L. Whitten at the Maine Experimental Station with the selection of 'Augusta' from a wild commercial blueberry field (Table 1) (32). Following on the success of highbush blueberry development, extensive efforts were made by Agriculture Canada researchers at Kentville, Nova Scotia to develop superior cultivars for commercial scale planting (1, 10). Recognizing the genetic potential of *V. angustifolium*, an initial screening of 200,000 wild phenotypes occurred in Ontario and in commercial fields throughout the Atlantic region from which 1,000 were selected based on growth, development and yield characteristics (10). From the selected wild phenotypes, breeding trials focused on enhancing plant vigour, fruit appearance, and yield characteristics, and resulted in the release of cultivars including 'Brunswick', 'Chignecto', 'Blomidon', 'Cumberland', 'Fundy' and 'Kenlate' (Table 1) (10). Despite initial results indicating that large yields (i.e., 14,000 kg/ha) could be obtained with *V. angustifolium* cultivars such as 'Augusta'(13), initial efforts at introducing these cultivars into commercial production were met with limited success as a result of excessive input costs associated with high planting densities (i.e., 1 x 1 m planting densities), slow growth and vegetative expansion and subsequently long establishment intervals (i.e., 7 to 10 years).

Table 1. Lowbush and half-high blueberry cultivars introduced in the past 70 years.

Cultivar	Year Introduced	Location	Breeder/Selector	Parentage	Season
Kentville and Ottawa, Canada (lowbush)					
Blomidon	1970	Kentville, N.S., Canada	L. Aalders, Kentville Res Sta, Agriculture Canada	451 (selected from Kirkhill, N.S.) x Augusta	mid
Brunswick	1965	Fairfield, N.B., Canada	L. Aalders, Kentville Res. Sta, Agriculture Canada	Selection from native lowbush type	mid
Chignecto	1964	Westbrook, N.S. Canada	L. Aalders, Kentville Res. Sta., Agriculture Canada	Selection from native lowbush type	mid
Cumberland	1964	Westbrook, N.S., Canada	L. Aalders, Kentville Res. Sta. Agriculture Canada	Selection from native lowbush type	mid, 4 days after Brunswick and 4 d before Blomidon
Fundy	1969	Sheffield farm of Kentville Res. Sta.	L. Aalders, Kentville Res. Sta., Agriculture Canada	OP seedling of Augusta	mid, same as Cumberland
KBF-7	1990	Kentville, N.S., Canada	Kentville Res. Sta., Agriculture and Agri-Food Canada	Selections from superior lowbush clonal material	early
KBF-10	1990	Kentville, N.S., Canada	Kentville Res. Sta., Agriculture and Agri-Food Canada	Selections from superior lowbush clonal material	early
Kenlate	1940	Ottawa, Canada	Kentville Res. Sta., Agriculture and Agri-Food Canada	Unknown	mid to late
Maine, United States (lowbush)					
Augusta	1933	Frankfort, Maine	Dr. L. Whitten, Maine Exp. Sta.	Selection from OP seed of clone 3302	early to mid
Burgundy	~1985	Maine, USA Blueberry Hill Farm	Univ. of Maine, Western Maine Nurseries	Wild selection of *V. angustifolium*	early
Claret	~1985	Maine, USA Blueberry Hill Farm	Univ. of Maine	Wild selection of *V. angustifolium*	early
Jonesboro	~1985	Maine, USA Blueberry Hill Farm	Univ. of Maine	Wild selection of *V. angustifolium*	early
Pretty Yellow	~1985	Maine, USA Blueberry Hill Farm	Univ. of Maine	Wild selection of *V. angustifolium*	early
Spring	~1985	Maine, USA Blueberry Hill Farm	Univ. of Maine	Wild selection of *V. angustifolium*	early
Verde	~1985	Maine, USA Blueberry Hill Farm	Univ. of Maine	Wild selection of *V. angustifolium*	early

Table 1. Continued

Cultivar	Year Introduced	Location	Breeder/Selector	Parentage	Season
Europe (lowbush)					
Hele	1996	Piikkiö, Finland	AgriFood Research Finland	*V. angustifolium*	early
Putte (half-high)	1988	Balsgård, Sweden	Swedish Univ. of Agr. Sci.	*V. corymbosum* x *V angustifolium*	early
Tumma	1996	Piikkiö, Finland	AgriFood Research Finland	*V. angustifolium* (*V. Brittonii*)	early
Minnesota, United States (half-high cultivars)					
Chippewa	1996	Minnesota, USA	J. Luby and D. Wildung Univ. of Minnesota	B18A (G65 x Ashworth) x U53 (Dixi x Michigan lowbush No. 1)	mid
Northblue	1982	Minnesota, USA	J. Luby and D. Wildung Univ. of Minnesota	(G65 x Ashworth) x R2P4	mid
Northcountry	1986	Minnesota, USA	J. Luby and D. Wildung Univ. of Minnesota	B6 (G65 x Ashworth) x R2P4	early mid
Northsky	1982	Minnesota, USA	J. Luby and D. Wildung Univ. of Minnesota	(G65 x Ashworth) xR2P4	mid
Polaris	1996	Minnesota, USA	J. Luby and D. Wildung Univ. of Minnesota	Bluetta x B15 (G65 x Ashworth)	early
St. Cloud	1990	Minnesota, USA	J. Luby and D. Wildung Univ. of Minnesota	(G65 x Ashworth) x U53	early
Michigan, United States (half-high cultivars)					
Northland	1967	Michigan State University	R. Anderson	Berkely x 19-H (lowbush x Pioneer seedling)	early
Tophat (half-high)	1977	Michigan State University	R. Anderson, S. Johnston, J. Moulton	*V. corymbosum* x *V. angustifolium* (Mich. 19-H x Berkeley)	early

Realizing the cost and plant establishment challenges associated of using selected cultivars in a commercial lowbush blueberry operation, Agriculture and Agri-Food Canada researchers have recently focussed on the development of seedling plants (14). This has resulted in 42 seedling families being developed from which KBF-7 and KBF-10 have been introduced (Table 1). KBF-7 is preferred when yield and fruit quality are considered (14). KBF-10 is of interest due to these seedlings being more typical of those found in commercial fields (14). KBF-10 is shorter than KBF-7 and produces rhizomes more readily making KBF-10 potentially suitable for planting into bare spots in commercial fields (14). Yields of 4,600 to 8,400 kg/ha have generated interest in the use of these seedling plants (13, 14). However, despite having access to plant material that has vigorous rhizome growth and is late blooming, self-fruitful, disease resistant and produces large, uniformly ripening berries (6, 20, 32), the lowbush blueberry industry in North

America has been reluctant to use superior lowbush blueberry plant material. Although superior plant material could be used in existing wild blueberry fields to fill in bare areas and replace poorer yielding phenotypes (32), the lowbush industry is actively engaged in promoting the crop as a wild species that is harvested from natural stands (20). This reluctance to use lowbush blueberry plant material in North America is in sharp contrast to the increasing interest and research on *V. angustifolium* plant material in Northern Europe, especially in areas where northern highbush and half-high blueberries are susceptible to winter injury and/or cannot be grown (27). The inability of the native bilberry (*V. myrtillus*) to tolerate full sunlight, stringent forest management regulations restricting input use, labour shortages for harvesting, and an inherent low yield potential and soft fruit, have resulted in the breeding and recent release of the Finnish *V. angustifolium* cultivars 'Hele' and 'Tumma' (Table 1), as well as facilitating breeding efforts now underway at the Estonia Agricultural University (27). In conjunction with the lowbush cultivars developed in North America, these new cultivars are seeing increasing use throughout northern Europe, especially in spent peat bogs situated in Estonia, Latvia, Finland, and Norway.

In addition to the development of superior lowbush blueberry phenotypes, the lowbush blueberry has also been used in the development of winter hardy, self-fruitful blueberry cultivars that are generally 60 to 120 cm in height (i.e., half-high) and consist of *V. angustifolium* and *V. corymbosum* parentage (31). Breeding efforts for half-high blueberries at the University of Minnesota, Michigan State University, and the Swedish University of Agricultural Sciences have resulted in the release of cultivars including 'Chippewa', 'Northblue', 'Northcountry', 'Northsky', 'Polaris', 'St. Cloud', 'Northland' and 'Putte' (Table 1) (31, 34). These cultivars branch close to the ground and produce fruit that have highbush blueberry size (31). Their short-stature provides the advantage of snow cover for winter protection allowing half-high blueberries to withstand winter temperatures of -40°C (8). Due to the winter hardiness of the half-high blueberries, these cultivars have gained increasing popularity for fresh produce markets in areas where northern highbush blueberries would be prone to winter injury including Manitoba, Minnesota, northern Michigan and Wisconsin (8, 31).

Additional breeding efforts with lowbush and half-high blueberries have been made in the landscaping industry, with uses including shrubbery, hedges and a naturalized groundcover. This also allows for the provision of naturalized plants that have edible fruit, attract wildlife, and a multitude of fall colours. The phenotypic diversity of lowbush plant material has resulted in the selections from native stands of several selections in Maine for landscaping purposes including 'Spring', 'Verde', 'Burgundy', 'Claret', 'Jonesboro', and 'Pretty Yellow' (Table 1). In addition, the half-high cultivar 'Tophat' is only used for ornamental purposes due to its low stature (Table 1). 'Tophat' was developed at the Michigan State University, is a self-compatible selection that grows to a height of less than 60 cm, and is being used for border plantings, small gardens, and containers.

Potential Health Benefits of Blueberries

Lowbush blueberries contain many essential nutritional components including water (85%), vitamins A, C, and E, carbohydrates (15%), protein (0.70%), fibre (1.5%), and fat (0.50%) (11, 16, 28). In addition to these essential components, lowbush blueberries also contain many organic acids and polyphenolic substances including chlorogenic, citric, malic, quinic, acetic, caffeic, p-coumaric, and shikimic acids (16, 28). These phytochemicals give blueberries the highest oxygen radical absorbance capacity (ORAC) of over forty commercially available fruits and vegetables (17, 28) and, within blueberries, lowbush blueberries

have a higher anti-oxidant (AO) capacity than highbush blueberries (18). The presence of these phtyochemicals and associated AO capacity reduce blood sugar, serum cholesterol and triglyceride levels (2, 23), and have antiallergenic, anti-inflammatory, anti-viral, and antiproliferative activities (12, 23). In addition, these phytochemicals provide protective measures against diabetes (2, 23), stroke (19, 23), cardiovascular disease (25), lung (21, 24) and stomach (9, 21) cancers, reduce the loss of age-related motor skills and memory (15), and improve urinary tract and visual health (15, 23, 28, 29).

Future Directions

Given the excellent winter injury tolerance, pest resistance, ease of mechanical harvest, low maintenance, multiple landscaping uses and relatively high sugar, low acid and high phytochemical levels within the berries, the future for the continued development of new lowbush blueberry cultivars is bright. With the abundance and variability of protective phytochemicals in lowbush blueberries, the next phase of lowbush blueberry cultivar development may be to examine methods to optimize these compositional traits by conventional or biotechnological breeding techniques. These favourable traits will also continue to be used in the development of interspecific half-high and highbush hybrids resulting in the continued evolution of superior blueberry cultivars.

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Resistance of Geneva and Other Apple Rootstocks to Fireblight

Vigorously growing shoots of 49 different apple rootstocks were inoculated with fireblight (*Erwinia amylovora*) in a greenhouse. B.9, O.3, M.9, and M.26 were the most fireblight susceptible. Geneva 11, Geneva 65, Geneva 16, Geneva 30, and Pillnitza Au 51-11, M.7 and several selections showed the greatest resistance. There were significant strain x rootstock interactions. In general the evaluation under orchard conditions agreed with results from controlled blossom inoculation or to natural blossom infection. From: Norell, J.L., H. T. Holleran, W.C. Johnson, T. L. Robinson, and H. S. Aldwinckle 2003. Plant Disease 87: 26-32.