HIGHBUSH BLUEBERRY BREEDING
AUGSTKRŪMU MELLEŅU SELEKCIJA

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Abstract
Most of the blueberry cultivars now grown in the world came from the breeding programs of Frederick Coville (1908 – 1937), George Darrow (1938-1958) and Arlen Draper (1965 - present) of the United States Department of Agriculture, and Paul Lyrene (1978 - present) of the University of Florida. Until about 30 years ago, highbush blueberry cultivation was restricted to cold climates, as the original cultivated species, *Vaccinium corymbosum,* required about 800 – 1000 chilling hours below 7 ^{0}C for normal floral development. To expand the range of highbush blueberry cultivation into the southern USA, Ralph Sharp of the University of Florida and Darrow hybridized the original northern highbush types with native southern species. There are now three types of highbush blueberry varieties grown worldwide - Northern, Southern and Intermediate. These vary in the number of chilling hours they require for normal floral development and their level of tolerance to winter cold. The primary goals of today's southern and Intermediate highbush breeders are to obtain early ripening types with high plant vigor, disease resistance and a later bloom (particularly in Florida). Northern highbush breeders are concentrating on flavor, longer storing fruit, expanded harvest dates, disease and pest resistance and machine harvestability. Current trends in highbush blueberry breeding include speeding the cultivar release process, expanding the germplasm base of varieties and licensing.

Kopsavilkums
Lielākā daļa no krūmmelleņu šķirnēm, kas pašreiz tiek audzētas pasaulē ir izveidojuši Frederick Coville (1908 – 1937), George Darrow (1938 – 1958), Arlen Draper (1965 – pašlaik) un Paul Lyrene (1978 – pašlaik). Apmēram pirms 30 gadiem augstkrūmu melleņu audzēšanu ierobežoja aukstais klimats, jo kultivētām *Vaccinium corymbosum* sugām, lai ziedkopa normāli attīstītos, nepieciešamas 800 – 1000 aukstuma stundas zem + 7 ^{0}C. Lai paplašinātu diapazonu augstkrūmu melleņu audzēšanā ASV dienvidu daļā, R. Šarps no Floridas universitātes un G.Darovs krustoja vietējās ziemeļu augstkrūmu mellenes ar vietējām dienvidu sugām.
Šobrīd ir trīs veidu augstkrūmu melleņu šķirnes, ko audzē visā pasaulē – ziemeļu, dienvidu un starpformu. Tās atšķiras ar nepieciešamo aukstuma stundu skaitu, lai attīstītos normālas ziedkopas un krūmi būtu aukstumizturīgi. Galvenais selekcijas mērķis dienvidu un starpformu krūmmellenēm ir iegūt agrīnas, ar lielu augšanas spēku, pret slimībām izturīgas un vēlu ziedošas (īpaši Floridā) krūmmellenes. Ziemeļu augstkrūmu melleņu selekcionāri koncentrē uzmanību uz aromātisku ogu ieguvi, ilgāku augļu uzglabāšanos, ienākšanās laika pagarināšanu, slimību un kaitēkļu izturību un izturību pret mehanizētu vākšanu. Nozīmīgi augstkrūmu melleņu selekcijā ir virzība uz ātrāku šķirnes atzīšanas procesu, šķirņu gēnu banku paplašināšanu un licences izsniegšanu.

Key words: *Vaccinium corymbosum,* varieties, cultivars

Introduction
There are now three types of highbush blueberry varieties grown - Northern, Southern and Intermediate. These vary in the number of chilling hours they require for normal floral development and their level of tolerance to winter cold. Northern highbush varieties are adapted to quite cold mid-winter temperatures below -20 ^{0}C, but grow well anywhere there are 800 – 1000 hours of chilling. These are grown primarily in Australia, France, Germany, Michigan, New Jersey, New Zealand, the Pacific Northwest, Poland and Chile. Southern highbush varieties do not tolerate winter temperatures much below freezing and require chilling hours under about 350 hours. They are grown primarily in Australia, Argentina, California, Florida, Chile and southern Spain. Intermediate highbush varieties have a wide range in chilling requirements from 400 – 800 hours. They generally fail in the colder climates because they bloom too early and are too slow to harden

in the fall, resulting in freeze damage to the flower buds. The Intermediate highbush types are grown primarily in Arkansas, Chile, North Carolina and the Pacific Northwest.

History of blueberry breeding.

Blueberry breeding is a very recent development (Hancock, 2006a; Lyrene, 1998). Highbush breeding began in the early 1900s in New Jersey, with the first hybrid being released in 1908 by Frederick Coville of the United States Department of Agriculture (USDA). He conducted the fundamental life history studies of the blueberry that served as the basis of cultivation such as soil pH requirements, cold and day-length control of development, pruning strategies and modes of propagation. Working with Elizabeth White and others, he collected several outstanding wild clones of *V. corymbosum* and *V. angustifolium*, which he subsequently used in breeding improved types. Over 75 % of the current blueberry acreage is still composed of his hybrids, most notably 'Bluecrop', 'Jersey', 'Weymouth', 'Croatan', 'Blueray', 'Rubel' and 'Berkeley' (Mainland, 1998).

George Darrow took over the USDA program after Coville died in 1937 and made important contributions on the crossibility and phylogeny of the native *Vaccinium* species working with the taxonomist W. H. Camp (Hancock, 2006b). He formed a large collaborative testing network that encompassed both private growers and Agricultural Experiment Station Scientists (AES) scientists in Connecticut, Florida, Georgia, Maine, Massachusetts, Michigan, New Jersey and North Carolina. From 1945 to 1961, he sent out almost 200,000 hybrids to his cooperators for evaluation. Arlen Draper followed Darrow and focused on mixing the genes of most wild *Vaccinium* species into the cultivated highbush background. He maintained and strengthened Darrow's collaborative network and released a prodigious number of southern, intermediate and northern highbush cultivars, with improved fruit color and firmness, smaller pedicle scars and higher productivity (Hancock and Galletta, 1995). His Northern highbush 'Duke' and 'Elliott' have been major successes, along with his newer Intermediate release 'Legacy'. Mark Ehlenfedlt took over the USDA program in 1998.

Ralph Sharp began working in the 1950s in Florida on the development of Southern highbush types in collaboration with Darrow (Sharp and Darrow, 1959; Lyrene, 1998). To expand the range of highbush blueberry cultivation into the southern USA, they hybridized the original northern highbush types with native southern species. Sharp was the first collector of *V. darrowii* for breeding, and until very recently, all southern highbush cultivars contained genes from his wild clones. Sharp developed a number of successful cultivars, including 'Sharpblue', which was grown commercially until very recently. Paul Lyrene took over the breeding work in Florida in the late 1970s.

Stanley Johnson at Michigan State University spent a considerable amount of time in the 1950s and 1960s improving the cold tolerance of highbush by crossing it with *V. angustifolium*. Out of this work came the "half-high" cultivar Northland and the mostly pure Northern highbush type 'Bluejay', which was released by his successor Jim Moulton. The program was abandoned in 1978, but was renewed in 1990 by Jim Hancock.

Joseph Eberhart, in Washington released three Northern highbush cultivars, Pacific, Olympia, and Washington in the 1920s and 1930s. 'Olympia' is still grown today in the Pacific Northwest, but not planted.

Outside of the USA, blueberry breeding work was conducted in Australia, Germany and New Zealand. Johnston sent open pollinated seed to D. Jones and Ridley Bell in Australia in the 1960s that generated the important Northern highbush cultivar 'Brigitta Blue' along with several others. Narandra Patel at HortResearch in New Zealand released the Northern highbush cultivars Nui, Puru and Reka from breeding material initially provided by the University of Arkansas and the USDA at Beltsville in the 1960 and 1970s. Walter Heermann in Germany, working with seed provided by Frederick Coville, released several Northern highbush varieties in the 1940s and 1950s including 'Blauweiss-Goldtraube', 'Blauweiss-Zukertraube', 'Heerma', 'Rekord', 'Ama' and 'Gretha'.

Current Breeding Goals. The current goals of Southern and Intermediate highbush breeders are to obtain early ripening types with high plant vigor, disease resistance and a later bloom (particularly in Florida). Established breeding lines are being used for this purpose, along with hybrids derived from native *V. ashei*, *V. elliottii* and *V. darrowii*. There is also growing interest in developing very low chill, evergreen types that fruit in both the summer and fall (Lyrene, 2007; Darnell and Williamson, 1997).

Southern and Intermediate highbush cultivars are being developed at several locations, including Arkansas, Australia, California, Florida, Georgia, Mississippi, Chile and Spain. Paul Lyrene at the University of Florida has the most active program dealing with very low chill genotypes and has released many high impact cultivars including 'Emerald', 'Jewel', 'Misty' and 'Star'. Jim Ballington in North Carolina has the most significant program operating at the interface between Northern and Southern highbush types, and has generated a number of important cultivars including 'Lenore', 'New Hanover', 'O'Neal', 'Reveille' and 'Sampson'. O'Neal is a very low chill type, while the rest are intermediate. Jim Moore and now John Clark at the University of Arkansas have focused on mixing southern wild species with northern types and released 'Ozarkblue,' a late Intermediate type. Scott NeSmith at the University of Georgia has generated several new early Intermediate varieties including 'Rebel', 'Camelia' and 'Palmetto'. Steve Stringer, Arlen Draper and Jim Spears at the USDA in Mississippi have developed a number of Intermediate highbush types including 'Biloxi', 'Gupton' and 'Magnolia'. Several private breeding programs have also emerged that are developing Southern and Intermediate highbush types including Atlantic Blue in Spain, Berry Blue in Michigan and Chile, Driscoll Associates in California**,** Mountain Blue Orchard in Australia and Vital Berry in Chile.

Northern highbush breeders are concentrating on flavor, longer storing fruit, expanded harvest dates, disease and pest resistance and machine harvestability. Established breeding lines are being used in these efforts, along with complex hybrids made up of *V. darrowi*, *V. angustifolium*, *V. constablei* and most of the other wild species. Even though it has limited winter hardiness, *V. darrowii* has proven to be an interesting parent in colder climates, because it passes on a powderblue color, firmness, high flavor, heat tolerance and potential upland adaptations.

Northern highbush blueberries are currently being bred in New Jersey, Michigan, Oregon and Chile. Jim Hancock at Michigan State University is focusing on late maturing, long storing genotypes and has released three new Northern highbush cultivars that show high promise, 'Aurora', 'Draper' and 'Liberty'. Mark Ehlenfeldt of the USDA program in New Jersey is focusing on identifying genotypes with high disease resistance and tolerance to winter cold, and has released several cultivars including 'Chanticleer' and 'Hannah's Choice'. Nicholi Vorza at the Cranberry and Blueberry Research Station of Rutgers University has begun a program in New Jersey to develop locally adapted highbush cultivars with machine harvestability and high fruit quality. Chad Finn of the USDA in Oregon is active in identifying genotypes that are well suited to the Pacific Northwest. The HortResearch program has recently changed hands to Dave Brazelton and Fall Creek Nursery in Oregon. Other worldwide northern highbush breeding projects include 'Berry Blue' in Michigan and Chile, Driscoll Associates in California, the University of Talca and Vital Berry in Chile.

Recent trends in highbush breeding. There has been a recent trend to speed up the cultivar release process. While it used to take up to 25 years from the original cross to the farm, there is now a push to go from seed to release in 10 – 12 years, with 8 years being thought possible. In the early days, a plant was often evaluated for 6 – 12 years before selection and then the elites were evaluated for another 6 – 12 years in replicated trials before release. A good example is 'Elliott,' which was released 25 years after the cross. Today, the primary selection and replicated trial stages have each been reduced to 3 to 4 years in some programs. 'Draper' was released 12 years after the original cross, and 'Aurora' and 'Liberty' were evaluated only 10 years.

The rapid expansion of the industry and the need for new improved types has stimulated this acceleration, along with a need to keep evaluation costs low. The key to the success of this approach is to make sure that the replicated trials are conducted across a wide range of environments, so that the full potential of the selections is recognized as soon as possible. Still, today's growers must be more prepared to abandon a cultivar if it fails to live up to expectations or a better one appears.

Another trend which is to produce varieties with a blend of species genes. In the early days, virtually all the cultivars were pure derivatives of *V. corymbosum*, with at little bit of *V. angustifolium*. The southern breeders changed all of this when they used *V. darrowii* and to some extend *V. ashei* to reduce the chilling requirement of southern highbush. With increasing frequency, native species genes are finding their way into the blood of northern types. For example, Legacy is 25 % *V. darrowii* and 2 % *V. angustifolium*; 'Sierra' is 20 % *V. darrowii*, 15 %

V. ashei, 13 % *V. constablei* and 2 % *V. angustifolium*. Breeders are finding that the use of *V. darrowii* has dramatic impacts on fruit quality, and it only takes two or three generations to restore winter hardiness (Hancock et al, 1995). The complex genetic background of modern breeding populations also makes testing of superior genotypes across broad climatic zones imperative to finding their optimal adaptive zone, particularly for selections of southern and intermediate highbush families. For example, a few years ago we split our breeding families between Oregon and Michigan, and evaluated them independently at each location (Finn *et al.*, 2003). We used a diverse array of families with varying amounts of southern species blood in their heritage. The elite families that emerged in Michigan where also elite in Oregon, but there were a number of elite families in Oregon that proved poorly adapted to the heat and cold in Michigan. Had we relied on Michigan screens, we would have disregarded some important families.

One other important change in highbush breeding is the move towards patenting and licensing blueberry varieties. Today, only the USDA breeding program does not license their varieties, and they are headed in this direction. This move has come primarily as a means to support further breeding work, as State resources dwindle. Licensing may save some public programs from extinction due to diminishing state support, but it will also restrict the availability of new varieties.

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FRUIT DEVELOPMENT IN *VACCINIUM* SPECIES
VACCINIUM SUGU AUGĻU ATTĪSTĪBA

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Abstract

Fruit development and ripening represent one of the most complex developmental processes in plants. Functionally, the role of fruits is to cover the developing seeds and promote the dispersal of mature seeds through the production of attractive colour, flavour and aroma compounds. After fertilisation, the first phases of fruit development include the division and the expansion of the cells. The ripening phase is initiated after the completed seed maturation. Tissue softening and accumulation of flavour compounds, aromatic volatiles and pigments occurs during the ripening phase. The quality of fruits is determined by the different developmental steps via the signalling cascade that is responsible for the metabolic and structural changes during the ripening phenomenon. Genus *Vaccinium* is widespread over the world and it includes many economically important cultivated and wild berry species. Fruits of the *Vaccinium* species are non-climacteric