Breeding Better *Aronia* Plants©

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INTRODUCTION

The genus *Aronia*, commonly known as chokeberry, is a genus of deciduous, multi-stemmed shrubs native to eastern North America. Three species of chokeberry are commonly accepted: *A. arbutifolia*, red chokeberry; *A. melanocarpa*, black chokeberry; and *A.* × *prunifolia*, or purple chokeberry. The third species, *A.*× *prunifolia*, is generally considered to be a naturally occurring, interspecific hybrid between *A. arbutifolia* and *A. melanocarpa* (Brand, 2010; Dirr, 2009; Rehder, 1920). Most sources distinguish the species by either red or black fruit color (Hardin, 1973), plus the degree of pubescence on leaves, stems and inflorescences (Krussmann, 1986). *Aronia arbutifolia* possesses dense tomentum on the undersides of leaf blades, stems, and inflorescences compared to nearly glabrous *A. melanocarpa*. Brand (2010) demonstrates both extremes of fruit color and pubescence can be observed in *A.* × *prunifolia*, indicating additional characteristics such as fruit ripening times, ploidy, geography, and DNA marker information are required for accurate identification. The genus *Aronia* belongs to the *Rosaceae* subtribe *Pyrinae* (formerly subfamily *Maloideae*) which includes *Sorbus* (mountain ash), *Malus* (apple), *Pyrus* (pear), *Amelanchier* (serviceberry), *Crataegus* (hawthorn), and several other woody plants with pomes or apple-like fruits (Campbell et al., 2007; Gleason and Cronquist, 1991; Robertson et al., 1991).

ARONIA AS AN ORNAMENTAL CROP

Aronia is widely adaptable and performs well under a range of cultural conditions. It is a multi-season ornamental which produces showy white flowers in spring, red or black fruits in the summer or fall, and showy orange and red fall foliage color. The chokeberries have been recommended as native replacements for exotic invasive shrubs including *Euonymus alatus* and *Berberis thunbergii* (Abbey, 2004). There are two main ornamental black chokeberry cultivars, both are semi-compact forms: 'Autumn Magic' and 'Morton' (Iroquois Beauty™) (Dirr, 2009). 'Brilliantissima', the dominant red chokeberry cultivar, is supposed to possess larger fruit, glossier foliage, better plant habit, more intense fall color, and prolonged leaf retention than the species. Preliminary observation suggests that some wild types in our current germplasm collection may be superior to 'Brilliantissima' for fall color, habit, and leaf retention.

ARONIA AS A FRUIT CROP

In the 19th century, black chokeberry was introduced to Russia where it was originally intended for berry production in home gardens. Since the 1940s, it has been cultivated as a commercial fruit crop in Russia (Kask, 1987), where the berries are processed and the juice is used for a range of products. In 1984 there were 17,800 ha of chokeberry cultivated in the Soviet Union. *Aronia* berries, while edible as a fresh fruit, are much tastier when the fruits have been processed. *Aronia* berries are very suitable for industrial processing since they are not prone to mechanical damage during transport and have low pectin content (Jeppsson, 1997). Moreover, *Aronia* berries can be harvested by machine (Gatke and Wilke, 1991) and there is a long harvest window. *Aronia* juice is blended with other more flavorful juices such as apple, cranberry, grape, and black currant juice to make popular juice beverages. Other common uses include jellies and jams, syrup, soft spreads, teas, wine, and to flavor ice cream and yogurt. *Aronia* juice is also an excellent colorant.

The University of Wisconsin-Madison Center for Integrated Systems (Secher, 2008) evaluated 13 potential uncommon fruits with sustainability potential. *Aronia* was chosen as the crop with the greatest potential, beating out currants, gooseberries, and elderberries. Low input requirements, high adaptability, high pest resistance, high nutraceutical content, short time to first yield, ease of culture, and high machine harvest potential were given as reasons why *Aronia* is tops for commercial production potential.

There is growing evidence that chokeberry consumption can have numerous and varied health benefits (Kokotkiewicz et al., 2010). Aronia berries are valued for antioxidant capacity and gastroprotective effects, anti-inflammatory, and antidiabetic properties, for immunomodulatory activities, and suppression of colon cancer (Bermúdez-Soto, 2007; Sueiro et al., 2006). Aronia is among the richest food sources of polyphenols due to its anthocyanin and proanthocyanidin content, and is among the best sources of quercetin in edible berries (Häkkinen et al., 1999; Perez-Jimenez, 2010).

ARONIA GERMPLASM

Various researchers have recognized that wild germplasm represents one of the best ways to expand the genetic diversity in commercial *Aronia* cultivars (Persson Hovmalm et al., 2004). We hold the world's largest *Aronia* germplasm collection that contains 106 wild accessions collected from the following states: AL, CT, DE, FL, IN, MA, MD, ME, MI, NY, NC, NH, OH, PA, TN, TX, VA, VT, WI, and WV. Additional wild accessions are from Ontario, Canada. The wild *Aronia* germplasm is comprised of 19 *A. arbutifolia* accessions, 57 *A. melanocarpa* accessions, and 41 *A.* × *prunifolia* accessions. Forty four new *Aronia* accessions have been contributed to the National Plant Germplasm System which has tripled the U.S.D.A. holdings of this genus.

Aronia accessions are established at the University of Connecticut in a common planting containing three replicates of each accession. Plants are maintained in clean cultivated rows with mowed grass alleys between rows. All plants receive full sunlight and are lightly fertilized once each spring. Accessions are well-established and reproductive so they can be evaluated for growth, performance, and fruit production characteristics and serve as a genetic resource for an *Aronia* breeding program. Study of the germplasm collection has been conducted from 2008 to present and plants have been evaluated for plant growth rate, plant size, plant habit, flowering date, fruits per infructescense, infructescences per stem, fruit ripening date, fruit color and transition, fruit weight, and fruit diameter.

We have found that there is considerably more variation within the genus *Aronia* than has been reported in the literature or has been understood by the scientific community. Of particular interest for breeding new commercial black chokeberry cultivars is the variation we have found in plant habit, fruit ripening date, fruit size, and phytochemical composition. Plant habit can vary from distinctly upright and tall to very low growing and prostrate. Previous to our germplasm collecting, prostrate forms were not reported. Prostrate forms are able to confer a compact habit to their progeny, regardless of the other parental genotype. We have also found significant variation within red chokeberry for fruit ripening date, fruit size, and ripe fruit color. Some more compact forms of *A. arbutifolia* do exist, but none are prostrate growers as were found for *A. melanocarpa*.

PLOIDY AND APOMIXES

Based on our analysis of wild collected *Aronia*, all *A. arbutifolia* exists as tetraploids, although literature references suggest that both diploids and tetraploids exist. *Aronia* × *prunifolia* also exists as tetraploids, with the rare occurrence of triploids. We did not find any diploid *A.* × *prunifolia*. Within *A. melanocarpa*, that is where things get interesting as far as ploidy is concerned. Wild *A. melanocarpa* from New England are diploid, while *A. melanocarpa* from all other parts of its natural range are tetraploids.

Ploidy is an important breeding consideration for *Aronia*, since we believe that polyploids produce almost exclusively apomictic (asexual) seed. Seedlings we have grown from tetraploid maternal plants have produced morphologically uniform

populations that appear to be identical to the seed parent. Populations grown from diploid maternal parents clearly segregate to produce morphologically diverse populations. We are currently conducting studies to thoroughly document the extent and completeness of apomixis in various segments of the *Aronia* genus. While polyploid *Aronia* may serve well as paternal parents, they have limited use as maternal parents. Recent European and Russian *Aronia* breeding efforts have made little progress due to their extensive use of polyploidy breeding stock and lack of awareness of apomixis.

ARONIA MITSCHURINII — THE LARGE FRUITED COMMERCIAL CHOKEBERRY

Aronia mitschurinii includes the commercial cultivars 'Viking', 'Nero', 'Aron', and likely all other large-fruited cultivars originating from Europe or Russia. Despite the phenotypic variation amongst wild North American *Aronia* species, none possess morphology closely resembling the plant material used in Eurasian commercial orchards. This has lead to the proposal by Skvortsov and Maitulina (1982) that this phenotype be designated as a fourth species, *A. mitschurinii*. The *A. mitschurinii* phenotype is most similar to *A. melanocarpa* in appearance because both species have black fruits, relatively glossy, glabrous leaves, stems and flowers, but *A. mitschurinii* does possess some unique distinctions from *A. melanocarpa*. Skvortsov and Maitulina (1982) found that *A. mitschurinii* fruits are 1.5-2 times larger than *A. melanocarpa* and possess distinct morphology. Fruits are dull, globular, somewhat depressed at the apex in comparison to wild *A. melanocarpa* fruits which are shiny and oval or pyriform in shape. *Aronia mitschurinii* was also shown to have larger inflorescences, rounder leaf morphology and a faster growth rate than *A. melanocarpa*.

Skvortsov et al. (1983) traced *A. mitschurinii*'s origins back to early 20th century Russia and the research facility of pomologist Ivan Michurin. Michurin focused his research on developing fruit crops suitable for cultivation in Russia. Michurin's notes describe successful hybridizations between North American *Aronia*, originally received from Germany, native European *Sorbus aucuparia* L., and other members of the subtribe Pyrinae, Rosaceae (Michurin, 1948, 1949).

INTERGENERIC HYBRIDIZATION IN THE *PYRINAE*

The *Pyrinae* base chromosome number is 17 and hybridization between species within genera is common, along with polyploidy, and apogamy (Persson Hovmalm et al., 2004; Campbell et al., 2007). Wide hybridizations and allopolyploidy have been important factors in speciation in the Pyrinae (Campbell et al., 2007; Roberston et al., 2010; Robertson et al., 1991). Robertson et al. (1991) noted reports of 16 genera of Pyrinae involved in intergeneric hybridizations, some of which are highly fertile and occur repeatedly in the wild. *Sorbus* demonstrates a particularly strong ability to partner successfully with many other genera including *Amelanchier* (×*Amelosorbus*), *Aronia* (×*Sorbaronia*), *Cotoneaster* (×*Sorbocotoneaster*), *Crataegus* (×*Crataegosorbus*), and *Pyrus* (×*Sorbopyrus*) (Postman, 2011). Of particular importance to chokeberry breeding are the diploid ×*Sorbaronia dippelii* (*S. aria* × *A. melanocarpa*), ×*Sorbaronia fallax* (*S. aucuparia* × *A. melanocarpa*), and ×*Sorbaronia sorbifolia* (*S. americana* × *A. melanocarpa*).

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