Aronia: Native Shrubs With Untapped Potential

Mark Brand

The genus *Aronia* is a group of largely overlooked shrubs native to the eastern United States. *Aronia* species have tremendous potential for use as ornamental landscape plants and as an edible fruit crop. One thing that has held back consumer acceptance of *Aronia* is the unfortunate common name chokeberry—a name unlikely to endear a plant to consumers. The name chokeberry may have been given to *Aronia* because people have observed that the berries are initially overlooked by birds and are only taken later in the winter when they are the last fruits remaining. The strong tannin flavor of chokeberry fruits may seem to be the reason why birds avoid the fruits, but ornithologists point out that it may actually be the relatively low protein content of the fruits compared to other fruits that are more readily taken by birds.

I am always working to enlighten people about *Aronia* and in doing so I have found that confusion abounds when it comes to chokeberry and chokecherry. I regularly have people tell me they are familiar with chokeberry, only to find out that they meant chokecherry (*Prunus virginiana*). *Aronia* is one of the best kept plant secrets around—surprising since this genus is as complex and interesting as it is useful.

Aronia Species and Their Characteristics

Chokeberries are in the Rosaceae and are multi-stemmed, deciduous shrubs. They readily form rhizomes and can sucker to form small colonies in a non-aggressive manner. Two species

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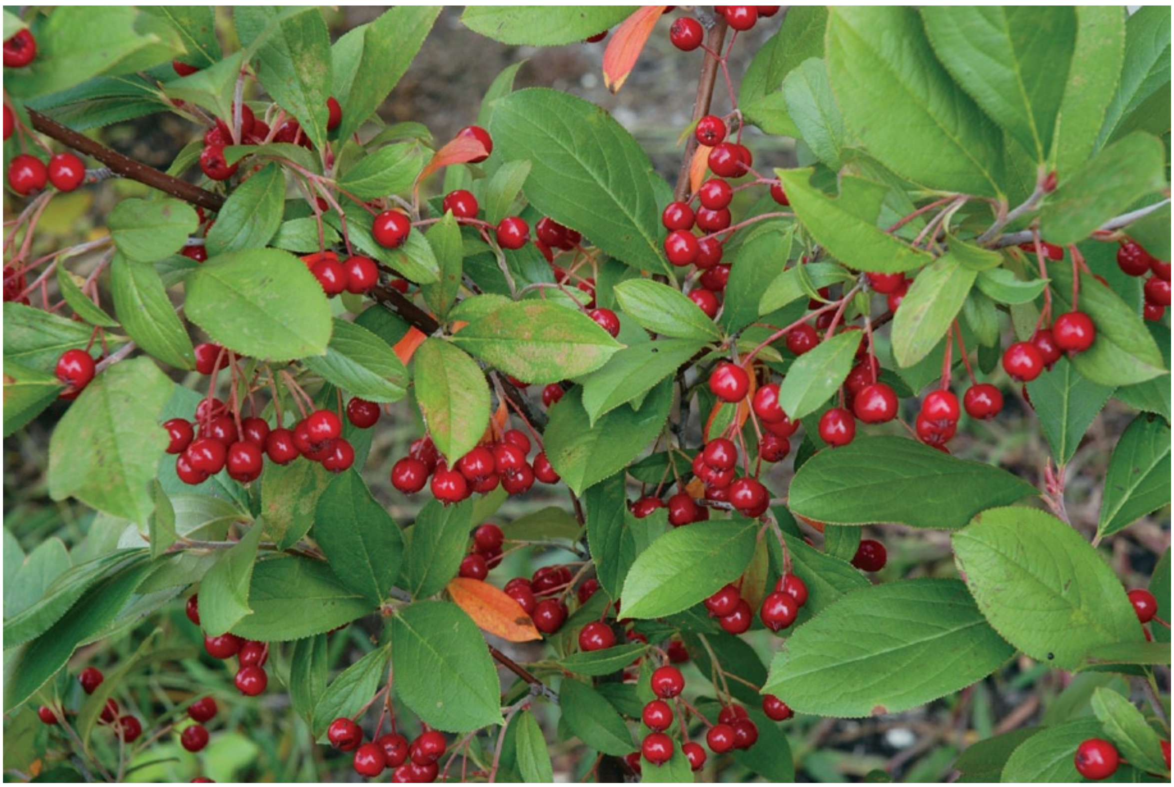


Red chokeberry's striking fruit display lasts several months.

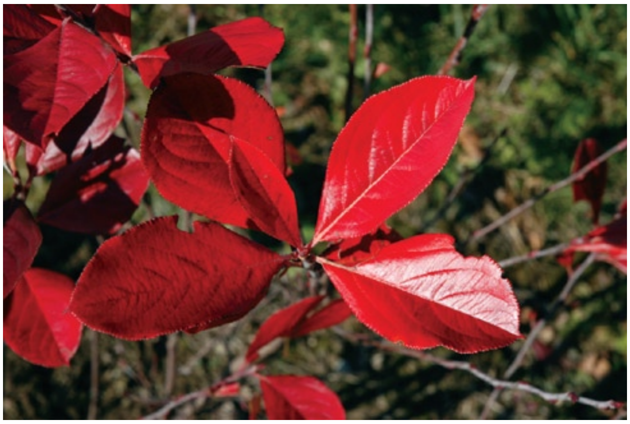
The leaves of red chokeberry (seen here) are pubescent on the lower surface while black chokeberry leaves lack pubescence.

Red chokeberry has an upright growth habit.

of *Aronia* are generally recognized: *A. arbutifolia* (red chokeberry) and *A. melanocarpa* (black chokeberry). Hardin (1973) suggests that fruit color—red versus black—should be used to differentiate between species. In addition to fruit color, Krussmann (1986) used degree of pubescence on stems, leaves, and inflorescences to distinguish red from black chokeberry. A third species, *A. prunifolia* (purple chokeberry), is generally recognized as having purple-black fruits and amounts of pubescence intermediate between the red and black species. In my observation, the amount of pubescence on plants that could be considered *A. prunifolia* can range from moderate to heavy. Table 1 summarizes some of the characteristics that can be used to try to differentiate red from black chokeberry. Speciation within the *Aronia* genus is far from clear cut and more research needs to be conducted to determine if *A. prunifolia* is a hybrid between *A. arbutifolia* and *A. melanocarpa* or should be considered as part of the *A. melanocarpa* species. (See the taxonomy sidebar for more information on *Aronia* speciation).

The **red chokeberry** grows 6 to 10 feet (1.8 to 3 meters) tall and 3 to 5 feet (.9 to 1.5 meters)

Though not long lasting, red chokeberry's flowers are attractive in the spring.



Red chokeberry has outstanding red fall foliage color.

wide. It is a multi-stemmed shrub with a distinctly upright growth habit. Even though the plant suckers and spreads, it can become somewhat leggy and open at the base. Most of the foliage on a mature red chokeberry will be found in the upper half of the plant. Summer foliage of red chokeberry is shiny or flat green above and grayish tomentose below. New growth on stems is also quite pubescent. Leaves are obovate or elliptical with a short acuminate tip and marginal serrations. Red chokeberry fall foliage turns a vibrant red crimson or purple red and can be spectacular in sunny locations. Even in partly shaded locations the leaves muster a very nice blend of orange and red. In addition to being attractive in the summer and fall, the red chokeberry also flowers in spring, usually in early May in New England. Small white flowers are produced in clusters that are about 1.5 inches (3.8 centimeters) wide and can be so numerous that they cover the canopy surface. The flowers do not last a particularly long time (about the same amount of time as *Amelanchier* flowers), but they do add early season interest to the plant.

Perhaps the best part about the flowers is that they give rise to abundant red fruits in late September and early October. The clusters of small (0.25 inch [.64 centimeter] diameter) fruits are quite showy and typically remain firm, glossy, and attractive through December. As stated before, birds rarely strip the fruits from the plants until after they have lost ornamental appeal.

The **black chokeberry** can generally be distinguished from the red chokeberry (when fruit are absent) by the lack of pubescence on stems and leaf undersides. Black chokeberries are also shorter than their red-fruited counterparts, attaining a mature height of 4 to 8 feet (1.2 to 2.4 meters). Like the red chokeberry, it suckers profusely, but forms dense plants and colonies, rarely appearing very leggy.

Black chokeberry has outstanding, lustrous, dark green summer foliage that turns a pleasing blend of yellow, orange and red in the fall. While

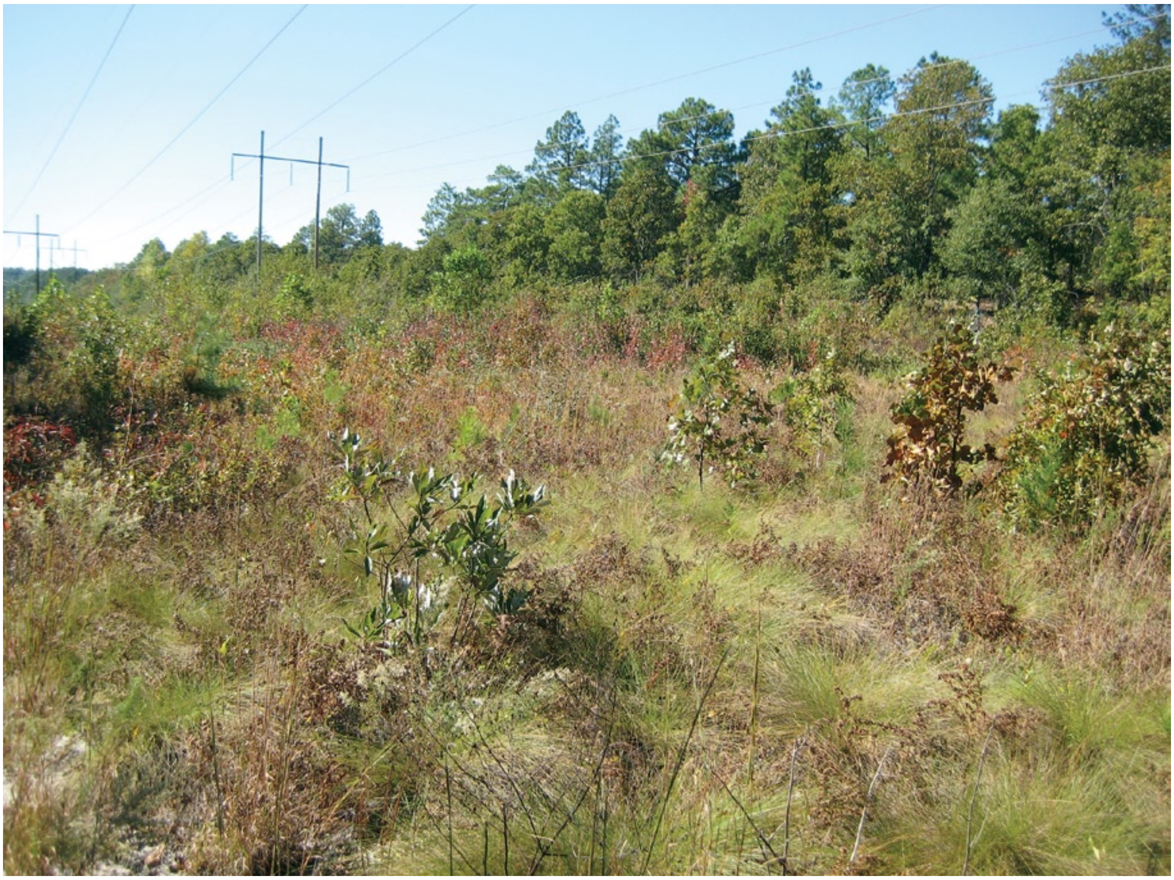
Black chokeberry bears glossy black fruit.

the black chokeberry's autumn foliage display may fall a bit shy of that of its red-fruited relative, it is still superior to many shrubs. Flowers are white, borne in May, and are similar in landscape effectiveness to the red chokeberry. The black fruits, from which *A. melanocarpa* gets its common name, are shiny and larger (0.3 to 0.5 inch [0.8 to 1.3 centimeters] diameter) than the fruits of *A. arbutifolia.* Fruits can ripen as early as mid-July, but they primarily ripen dur-

Table 1: Comparison of red (*Aronia arbutifolia*) and black (*A. melanocarpa*) chokeberry characteristics

RED	BLACK
fruit color cherry red	fruit color black
fruit relatively small (≤ 0.3 inch)	fruit relatively large (≥ 0.3 inch)
fruit ripens Sept.–Oct.	fruit ripens late July–Aug.
fruit persistent into winter	fruit shrivels and drops
leaves, stems, inflorescences pubescent	leaves, stems, inflorescences glabrous
habit upright, leggy at base	habit rounded, full to base
found primarily on damp/wet sites	found on both damp/wet sites and dry sites
inhabits coastal southeastern U.S.	inhabits northeastern and midwestern U.S.

The glabrous foliage of black chokeberry is green in summer and can develop good red to orange and yellow fall color.



A powerline cut with sand overlaying moist seeps is home to red chokeberries in North Carolina.

ing the month of August. Black chokeberries wither soon after ripening and either drop off or persist for a while as "raisins" on the plant. *A. melanocarpa* populations in the upper Midwest typically have more persistent fruit than populations in the Northeast.

Distribution and Habitat

The geographical range for *Aronia arbutifolia* is centered in the southeastern Coastal Plain, but it can be found extending out into suitable habitats westward into the Appalachian Mountains. It ranges from eastern Texas to northern Florida and continues up the eastern seaboard. It is common in much of the Carolinas, Virginia, Maryland, and New Jersey. Although it can be found in New England, red chokeberry occurs much less frequently there and is generally found close to the coast. The center of distribution for *Aronia melanocarpa* is in the northeastern states and the Great Lakes region, with range extension into the higher elevations of the Appalachian Mountains. In the Appalachian Mountains and the Northeast there is considerable overlap of the red and black chokeberry range. Although the information is somewhat incomplete, *A. prunifolia* seems to be found throughout much of the black chokeberry range and extends somewhat into the red chokeberry range.

Aronia arbutifolia occurs in bogs, swamps, savannahs, lowland woods, the edges of water bodies, moist rocky seeps, and moist pine barrens. *A. melanocarpa* occurs in similar wet locations, but can also be found growing on sand dunes, dry rocky slopes, dry bluffs and balds, and grassy areas. You will rarely find *A. arbutifolia* on the same dry rocky bluffs and

One type of black/purple chokeberry environment in Maine.

dunes where *A. melanocarpa* occurs, but I have found it growing in thin layers of organic duff on the exposed spines of rock balds. *A. prunifolia* is found in areas similar to *A. arbutifolia,* but also in somewhat drier clearings.

Cultural Conditions

Chokeberries are considered to be hardy to USDA hardiness zone 4 and, with proper genotype selection, the red species can exhibit good heat tolerance as well. Plants can be grown successfully in partial shade or full sun, but better flowering, fruiting, and fall color occur in full sun situations. Both red and black chokeberries seem to tolerate dry or wet soil conditions, even though the red species naturally occurs most often in wet areas. Best growth can be expected in moist soils, but soil type is not critical. Transplanting and establishment are easy with chokeberries even when they are given only modest aftercare. Like most members of the Rosaceae, *Aronia* has a seemingly endless list of insects and diseases that could attack it, but the plants rarely seem to be affected by much and are considered relatively carefree. I have found that powdery mildew can hit *A. melanocarpa,* but it doesn't seem to show up to any degree on *A. arbutifolia.* Lacebug is one insect that I have observed occasionally afflicting black chokeberry growing on hot, dry sites.

Aronia Genetics: Ploidy and Apomixis

Published literature states that *A. arbutifolia* has a 2n number (number of chromosomes in somatic cells) of either 34 or 68 and *A. melanocarpa* has a 2n number of 34 (Darlington and Janaki 1945). At the University of Connecticut I have an *Aronia* germplasm collection of over

This rocky outcropping in the Appalachian Mountains in Tennessee is a typical habitat for *Aronia.*

Taxonomic Teasers in *Aronia*

Over the years, *Aronia* has been placed in numerous genera, including *Mespilus, Pyrus, Adenorachis, Sorbus,* and *Photinia* by different taxonomic authorities (Robertson et al. 1991). Rehder (1949) and Hardin (1973) chose to use the genus *Aronia* for the chokeberries. In 1991, Robertson et al., placed the chokeberries in the genus *Photinia,* citing no differences in floral and fruit morphology between plants formally in the genus *Aronia* and those in *Photinia.* According to Robertson et al., red chokeberry becomes *Photinia pyrifolia,* black chokeberry becomes *Photinia melanocarpa,* and purple chokeberry becomes *Photinia floribunda.* The USDA Plants Database (plants.usda.gov) has adopted *Photinia* as the genus for the chokeberries, but USDA GRIN (www.ars-grin.gov/) is still allowing *Aronia.* Likewise, in the new 6th edition of Michael Dirr's *Manual of Woody Landscape Plants, Aronia* is still being used for the chokeberries. Until more conclusive genetic studies are undertaken, there will likely be continued uncertainty about the correct genus for the chokeberries.

Another point of nomenclatural uncertainty is with *Aronia prunifolia.* Should it be considered a separate species or be folded into *A. melanocarpa* or *A. arbutifolia* as a variety? If it is a separate species, does it have its origins as an interspecific hybrid of *A. arbutifolia* and *A. melanocarpa* and should it be designated as *Aronia* x *prunifolia?* Most of the evidence seems to suggest that the purple chokeberry is the result of interspecific hybridization between red and black chokeberry. We know from our own hybridization work that it is relatively easy to cross red and black chokeberries and get offspring that are not the result of apomixis. We have pollinated diploid black to tetraploid red and have many purple plants which are triploid. Hardin (1973) points out that garden hybrids between red and black have arisen at times and have been referred to as *Aronia floribunda.*

Some have argued that the naturally occurring *A. prunifolia* is something different from *A. floribunda* because it can occur outside areas where the red and black chokeberries are sympatric, but this argument is flawed. It does not take into consideration the likely scenario that interspecific red-black hybrids produce viable seeds apomictically. The purple species could arise at the margins of overlap of the red and black species and then spread by seed to regions far beyond each parent species' range. Purple chokeberry could also spread vegetatively by rhizomes. Furthermore, purple chokeberries seem to occur in the greatest abundance and have the most within-population variability in areas where both the red and black chokeberries overlap. Paper chromatography done in the 1960s on red, black, and purple chokeberry found that purple chokeberry contained the greatest number of unique compounds in comparison to red and black, adding more weight to the theory of hybrid origin (Alston et al. 1965). These arguments, along with the fact that *A. prunifolia* generally has morphological characteristics (degree of leaf/stem pubescence, fruit color, fruit ripening date, plant habit) that are intermediate between *A. arbutifolia* and *A. melanocarpa,* seem to tip the balance in favor of hybrid origin. One bit of work conducted in the 1970s, at the now closed Long Ashton Research Station at the University of Bristol, found that the flavone C-glucoside vitexin is restricted to *arbutifolia* and *prunifolia* x *arbutifolia* material and absent from *melanocarpa* and *prunifolia* x *melanocarpa* material. These findings do not support the involvement of *A. arbutifolia* in the parentage of *A. prunifolia* (Anon. 1974).

100 accessions of black, purple, and red species. So far, based on flow cytometry results, we have not found any diploid (2n=34) red chokeberries. With additional collecting, we hope to find the elusive diploid *A. arbutifolia.* Black chokeberries collected from outside of New England have all been tetraploids (2n=68), while New England black chokeberries have been diploid (2n=34). There are numerous accessions that we believe to be *A. prunifolia* and these plants are either tetraploid or triploid.

There is mounting evidence that suggests that *Aronia* is capable of producing apomictic seeds (Persson Hovmalm et al. 2004). These are seeds that develop without fertilization of the egg and are, therefore, clones of the mother plant. This is particularly true of tetraploid and triploid forms of *Aronia.* Apomictic seed set has been suspected from observations of the homogeneity in cultivated Russian plant material (Poplavskaya 1995). In our own breeding work with *Aronia* at the University of Connecticut, we have found that seedling populations from tetraploid plants are visually identical to the female parent regardless of the ploidy of the pollen used. When we use a diploid female parent, we get segregation within the population. We have also found that triploid *Aronia* produce fertile seed, even though triploidy typically results in sterility. It is likely that polyploid forms of *Aronia* have evolved to produce seed through apomixis as a functional manner in which to reproduce.

Why the Interest in *Aronia*?

The future is particularly bright for *Aronia* and it will undoubtedly emerge from its relative obscurity to serve as both an important ornamental landscape shrub and as a nutraceutical fruit crop. There is growing interest among gardeners, landscapers, landscape architects, and the general public in making better use of our

NANCY ROSE

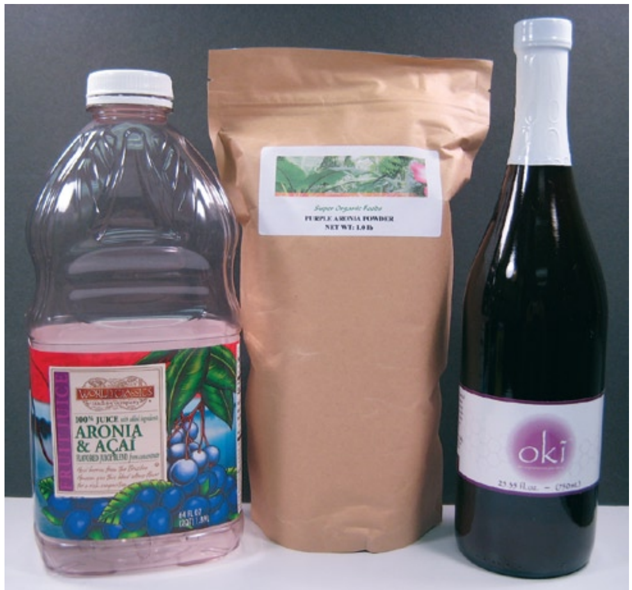
Chokeberries are versatile ornamental landscape shrubs. A planting of black chokeberry is seen here in fall color.

own native plants, especially when they can serve as alternatives to problematic aggressive and invasive exotic species.

In the Northeast, the popular winged euonymus or burning bush (*Euonymus alatus*) has become invasive and has even been banned in Massachusetts and New Hampshire. Its main landscape attributes are stunning red fall color, dense habit, and easy culture. Since native highbush blueberry (*Vaccinium corymbosum*) also has excellent red fall color it is often recommended as a replacement for burning bush, but it is not adapted to many of the landscape sites where burning bush has typically been employed. *Aronia* can serve as a much better alternative to *E. alatus* because it is site adaptable in addition to having multi-season interest, including red fall color. To become popular ornamental shrubs, chokeberries simply need a little marketing and perhaps a more appealing common name.

In addition to uses as an ornamental, black chokeberry is rapidly gaining momentum as a new small fruit crop for many parts of the United States. The blueberry-sized black fruits produced by *Aronia melanocarpa* have the highest known levels of antioxidants (anthocyanins and flavonoids) of any temperate fruit, five times higher than cranberry and blueberry, and also contain strong anticancer compounds. *Aronia* has been widely grown in Eastern Europe and Russia where the fruits are processed and used in beverages, wine, jelly, and baked goods (Kask 1987). In the United States, *Aronia* is largely unknown as a fruit crop, but there are no obvious limitations to prevent it from becoming popular here as well, especially given the public's growing interest in functional foods. Preliminary work in Iowa, Oregon, Wisconsin, and Nebraska has demonstrated the viability of *Aronia* as a fruit crop in many regions, including New England.

Aronia berries, while edible as a fresh fruit, are much tastier when the fruits have been processed. They are high in sugar (12 to 20% soluble solids), anthocyanins (560 to 1050 mg/100 g fresh weight), have a pH of 3.3 to 3.7, and 0.7 to 1.2% titratable acidity (Jeppsson and Johansson 2000; Oszmianski and Sapis 1988). Chokeberries are very suitable for industrial processing since they are not prone to mechanical damage during transport and have low pectin content (Jeppsson 1999). Moreover, chokeberries can be harvested by machine (Gatke and Wilke 1991) and there is a long harvest window.



Aronia juice products (left to right): aronia blended with acai juice to make a fruit juice drink similar to cranberry cocktail, powdered juice to mix into food or drink as a nutraceutical, and a nutraceutical beverage containing aronia juice.

Since "chokeberry juice" is unlikely to sell, it is usually labeled as "aronia juice." Wine red to dark purple in color, it is often blended with other more flavorful juices such as apple, cranberry, grape, and black currant to make popular beverages. Other common uses include jellies and jams, syrup, soft spreads, teas, wine, and flavorings for 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.

The fruit of 'Viking'(left) and typical wild-type *Aronia melanocarpa* (right). 'Viking' and 'Nero' are the primary cultivars available for fruit production in the United States (McKay 2001). Both are tetraploid forms (Brand, unpublished data) with large, relatively sweet berries and are the highest producing cultivars currently available (Strik et al. 2003).

Breeding and Selection

Breeding efforts to improve ornamental chokeberries at the University of Connecticut are focused primarily on red chokeberry. There is a need to reduce the plant's stature by half and eliminate its tendency toward legginess. Another goal would be increased fruit size to provide a more impressive display in the fall and early winter. Fall foliage impact can be enhanced by improving leaf retention as the leaves turn red; currently available forms of red chokeberry tend to drop leaves too quickly after coloring. Selections can also be made for resistance to powdery mildew in black chokeberry. So far, improving red chokeberry has been challenging because all of the accessions we have are tetraploids that probably produce apomictic seed. Finding a wild diploid *A. arbutifolia* could prove to be very useful in breeding this species. Polyploidy can also make it more difficult to use mutation breeding on red chokeberry due to the extra sets of chromosomes that can mask incomplete mutations. Nonetheless, we have made some progress in developing more compact forms of red chokeberry using chemical mutagens and irradiation.

European and Russian breeding efforts to enhance black chokeberry for fruit production have been largely constrained by the highly homogenous gene pool in domesticated Russian plant material. To make progress in this area it is, therefore, necessary to broaden the genetic basis through the introduction of germplasm from native stands (Persson Hovmalm et al. 2004). There is evidence suggesting that flavonoid content of chokeberries can be increased by incorporating native germplasm that contains higher levels of flavonoids into a breeding program (Sueiro et al. 2006). Due to apomixis, diploid forms of black chokeberry are at the core of plant improvement efforts at the University of Connecticut. It is unclear whether tetraploid forms are autotetraploids or allotetraploids. It is possible that commercial

Aronia cultivars like 'Viking' could be allotetraploids, since *Aronia* is known to hybridize with plants in the Rosaceae genus *Sorbus.*

Our primary goal at the University of Connecticut is to improve black chokeberry as a fruit crop by increasing levels of antioxidants and anticancer compounds in the fruits while maintaining or increasing fruit size above that found in current commercial cultivars such as 'Viking'. Of course, improving fruit flavor is also important. We are currently trying to unravel the genetics that have given us cultivars like 'Viking' and 'Nero'. Some authorities designate the large fruited black chokeberries as *Aronia mitschurini* (Strik et al. 2003). In the late 1800s and early 1900s, Russian and eastern European breeders had significant *Aronia* breeding programs. Ivan Michurin, a Russian plant breeder, produced a plant called 'Likernaya' that is an intergeneric hybrid between *Sorbus aucuparia* and *Aronia melanocarpa* (Kask 1987). It is possible that this intergeneric hybrid, or others like it, were eventually back crossed to *A. melanocarpa* to give rise to cultivars such as 'Viking'. By understanding how 'Viking' was created, we hope to re-create superior large-fruited forms for the fledgling domestic chokeberry fruit industry.

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