

perennial fruit

new, unusual, and unique crops for northern climates

acknowledgements

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This publication is dedicated in memory of Paul Otten, 1938-2018. Paul was from the tropics, but spent much of his life promoting the cultivation of currants and other emerging crops suitable for the north. He was a mentor and teacher to many. He promoted the health benefits of berries long before the topic became popular, and demonstrated that our farms could be self sufficient.

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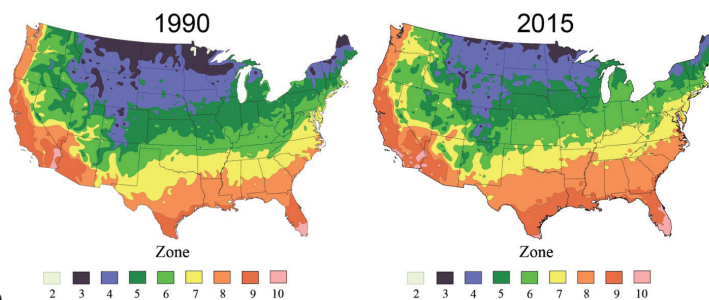
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introduction

Most of Minnesota lies within the USDA hardiness zones 3 and 4, and gardeners often wish they could grow a larger cultivar of fruit. Cold winters kill or harm trees and branches, while short growing seasons

prevent certain crops from properly maturing. In spite of these shortcomings, a surprising diversity of new and unusual crops can grow here. Some crops grow better here than in surrounding states, and the number of Zone 3 and 4 crops available to plant is increasing. In some cases, crops that were forgotten by older generations are being rediscovered; while in other cases, cold hardy varieties and species are being introduced from Eastern Europe and Asia. Meanwhile, some native plants with commercial potential are still being domesticated. A major driving force behind the growth in new crops is the recently discovered and rediscovered health benefits of berries and other fruits.



Map courtesy of the Arbor Day Foundation

Our current base of knowledge for these emerging crops is extremely small compared to crops like apples or strawberries. Most of what we know about emerging crops comes from people who experiment in their own yards or farms.

Innovative growers are constantly discovering new varieties or developing new ways of growing emerging crops. Most of the emerging crops covered in this publication currently have a small market. Many crops would benefit from breeding work to improve fruit quality or disease resistance. All these crops require labor-intensive management. Few of these crops are suitable for the fresh market, so they must be processed into value-added products like juices, jam, or jelly. The economic potential for these crops will increase as innovative farmers, food entrepreneurs, and researchers discover or re-learn better ways to plant, manage, harvest, process, and market these crops. Investment in an emerging fruit crop could pay good dividends down the road.

DOMESTICATION

Domestication occurs when people select wild plants with desirable characteristics and propagate those plants. Berries and tree fruit are first selected for fruit quality, which includes flavor, yield, fruit size, and ease of harvesting. Other desirable traits such as disease resistance have often been neglected in the first rounds of selection. If people can't find wild plants with all the desired traits, they breed plants with specific traits to create the desired plants. Many species of plants have extremely complex genomes, and breeding and selecting can take decades in order to develop fruit with good flavor and decent size that is easy to harvest. Most of the fruit we buy today was selected for decades, centuries, or millennia in order to develop fruit with commercially acceptable quality.

Domestication of trees and shrubs can be grouped into four stages. In Stage 1, the crop is harvested without any varietal selection. Stage 2 starts when a person sees a wild plant in the field with desirable traits and propagates the plant without further breeding or selection. In Stage 3 plant breeders conduct simple first and second generation crosses to produce new varieties. At Stage 4, plant breeders establish breeding lines that continue for multiple generations. With Stage 4 breeding, people can develop varieties that look and taste quite different than wild plants. Nearly all fruit grown commercially in the United States is at the fourth stage of domestication, while many emerging crops are still at the second stage.

Table 1. Stages of domestication for some common and emerging perennial fruit crops.

Domestication Stage	Fruit species
Stage 1: Wild, no breeding or selection	lowbush blueberries, native black currants, wild plums, blue elderberries, mountain huckleberries (Northern Rockies), bilberries (Europe)
Stage 2: Wild plants selected and propagated	saskatoons, chokecherries*, black raspberries, American elderberries, Autumn olive, hardy kiwi, sand cherries, gooseberries (<i>Ribes hirtellum</i>) Nanking cherries**,
Stage 3: Simple first and second generation crosses to produce new varieties	Aronia, European elderberries, seaberries, cherry plums, Minnesota (half high) blueberries
Stage 4: Extensive breeding, varieties can look and taste different than wild plants	Currants, gooseberries (<i>Ribes uva-crispa</i>), honeyberries, pears, apples, European plums, Japanese plums, strawberries, red raspberries
*While there are about 8 cultivars of chokecherries, nearly all commercial harvest is from wild blocks **Most cultivars of Nanking cherries have been lost, so the species in the U.S. is at Stage 2	

A few emerging fruits, like currants, have been domesticated for hundreds of years, and have dozens of varieties suitable for many climates. Because some emerging fruit crops are still being domesticated, they have undesirable traits that were long ago bred out of other domesticated plants such as thorns, astringency, and male and female plants. Thorns were bred out of common crops like plums and apricots. Wild pears are naturally astringent, causing the same drying sensation in the

mouth that gives chokecherries and chokeberries (aronia) their name. Few pear consumers have ever eaten an astringent pear because plant breeders have developed varieties without astringency. Wild strawberries have female and male flowers on separate plants, but breeders rarely release strawberry varieties unless the flowers contain both male and female parts. Undesirable traits on emerging fruit crops could likewise be selected out in the future as new varieties are developed.

SCIENTIFIC NOMENCLATURE

All plants are designated by genus and species, which is how the scientific name is derived. Genus and species name are typically italicized and typically in Latin. For example, the black chokeberry or black aronia has the scientific name *Aronia melanocarpa*. Within one genus, there are often several closely related species which have obvious similarities. The species *Aronia melanocarpa* and *Aronia arbutifolia* (red chokeberry) belong to the same genus and are easy to confuse, but the two species have slightly different leaves and fruit color. In this case, knowing the species is critical, because

only *Aronia melanocarpa* has palatable fruit.

In some cases, cultivated plants are interspecific crosses, which are designated with an "x" between the genus and species name. A naturally occurring cross between the black and red aronia species is the purple aronia, often designated as *Aronia x prunifolia*. In a few cases, a plant will be crossed from two genera, and then the plant is designated with an "X" in front of the name. According to some sources, the aronia cultivar 'Viking' is a cross between the American *Aronia melanocarpa* and the European mountain ash, which

would put it in the genus *XSorbaronia*. The name *XSorbaronia* combines the genus for mountain ash (*Sorbus*) with aronia.

Scientists are constantly evaluating and reevaluating the relationship between different species of plants. For many emerging crops, there is some controversy about their genus, species or even family. One nursery or technical paper will use one species name, while another technical paper will use a different name for the same species. For example, the purple chokeberry is listed as both *Aronia x prunifolia* and *Aronia floribunda*, depending on the author and the nursery.

A cultivar is a group of plants within a species with distinct features that can be passed from one

generation to the next. The terms variety and cultivar are often used interchangeably. The word cultivar is coined from the words cultivated variety. Cultivars are usually propagated asexually. If propagated from seed, their distinctive traits are not always passed from one generation to the next. A true cultivar name is not italicized. The aronia cultivar 'Viking' is primarily propagated by seed and has consistent traits from one generation to the next. The scientific name most commonly applied to this cultivar is *Aronia melanocarpa* var. 'Viking'. 'Viking' aronia plants do fall into both the variety and cultivar categories, so the name can also be written *Aronia melanocarpa* 'Viking'. In the case of aronia, the genus name has become the common name, so it is not italicized in the remainder of this book.

PROPAGATION

The plants for many emerging crops are difficult to find in catalogs or nurseries, and some varieties are prohibitively expensive for a person who wants a small, commercially viable plot. Most people who want to grow these crops find themselves propagating many of their plants themselves.

Plants can either be propagated vegetatively or by seeds. Plants propagated vegetatively are identical to the parent while plants grown from seeds typically are not. A row of shrubs grown from seed will have plants that bloom at different times; fruit that ripens at different times; have different colored fruit, different fruit size, flavor, or productivity; have differing levels of winter hardiness; grow to different heights; and have variable resistance to diseases. Most fruiting trees, shrubs and vines are propagated vegetatively primarily to assure uniform fruit quality and ripening times. Vegetative propagation is almost always faster than using seeds, because some plants propagated from seed go through a juvenile period of several years before they bloom. Vegetatively propagated plants have no juvenile period and will bloom as soon as the plants reach sufficient size.

A few emerging crops consistently produce edible

fruit with good quality when propagated from seeds, including aronia, the various juneberry species, and autumn olive. Elderberry, chokecherry, and Nanking cherries seedlings produce good fruit about half the time, but often with variable ripening times. Other crops should not be reproduced by seed unless trying to develop new varieties.

To develop new varieties suitable for a climate or location, a large number of seeds (20 to 1000) are planted. The seedlings vary in growth rate, fruit quality and disease resistance. Most professional plant breeders start to eliminate unsuitable seedlings the first year by removing slow growing or disease-susceptible plants. Most perennial plants take five or more years before they bear fruit. With patience, new varieties can be selected, and then the new cultivar is propagated vegetatively.

Common types of vegetative propagation for trees and shrubs include:

- 1) Rootsuckers: shallow roots next to the mother plant that sprout and grow into new plants, which can be dug up in the spring and transplanted before the leaves sprout. This is a

- low-tech form of propagation easy for the home gardener, but is often too labor intensive and expensive for large nurseries.
- 2) Grafting: a small branch is placed into the wood or bark of a larger plant.
 - 3) Budding: a dormant bud is placed into the bark of a larger plant
 - 4) Layering: roots form on a stem while still attached to the mother plant. Layering often occurs naturally when a low branch sits on the ground and forms roots. Tip layering is where actively growing shoots spontaneously form roots
 - 5) Mound layering or stool beds: the dormant tree or shrub is pruned next to the ground to encourage new shoots to form. As the shoots grow, soil, mulch, or sawdust is piled over the plant before the shoots become woody. The new shoots send roots into the mulch. After the shoots have a good root system, the shoot can be cut from the mother plant and transplanted into a pot or in the field.
 - 6) Hardwood cuttings: dormant branches are cut into pieces containing at least one bud, placed in moist soil, and the dormant branches spontaneously form roots.
 - 7) Softwood cuttings: actively growing branches are placed in a moist environment and will form roots. This is usually done in a mist chamber.
 - 8) Micropropagation (tissue culture): the tips of actively grown shoots are placed in an artificial media, where they form roots and leaves. Tissue culture requires both expensive equipment and expertise by the operator. Large nurseries use tissue culture to rid plants of viruses or they may use it to propagate many plants quickly. With proper techniques, one growing tip of a plant can be used to make hundreds of small plants. Tissue culture is not genetic engineering. Tissue culture is a way to grow new plants from very small segments of a parent plant, but it doesn't change the genetics of either the parent or the new plants.

RESOURCES FOR MORE INFORMATION ON PLANT PROPAGATION:

Layering

<https://content.ces.ncsu.edu/plant-propagation-by-layering-instructions-for-the-home-gardener>

Stem cuttings

<https://content.ces.ncsu.edu/plant-propagation-by-stem-cuttings-instructions-for-the-home-gardener>

Propagation with softwood, semi-softwood, and hardwood cuttings

<https://unlcms.unl.edu/ianr/extension/hort-update/Cuttings1>

PLANT PATENTS

People who select and propagate plants from the wild or use artificial breeding often patent their new varieties. Once a plant is patented, it cannot be vegetatively propagated without permission from the person holding the patent. Most varieties mentioned here have no plant patent, or the patent has expired.

Many new haskap and saskatoon varieties are patented and should not be vegetatively propagated. Woody fruiting plants still covered by plant patents can be propagated by seed, but the new plants are almost always so different from the parent plants that they are a new cultivar.

EMERGING CROPS FOR COMMERCIAL PRODUCTION

Many fruit crops are easy to grow, but may not be suitable for commercial production. In order to be a commercially viable crop, the following traits should be considered:

- 1) Potential market
- 2) The number of uses for the fruit, including if it can be eaten fresh
- 3) Yield per acre
- 4) Harvest efficiency
- 5) Diseases and insect pests
- 6) Potential return on investment

The market for all emerging fruit crops is small but changing. Growers who are interested in investing in an emerging fruit crop should realistically assess its market potential before ordering plants. For instance, there is no reason to plant an acre of aronia berries if the market you can reach only buys 100 pounds per year. Crops with many uses will have a larger potential market than crops that can only be made into jelly. Crops that can be eaten fresh are easier to introduce to the public than crops that must be processed.

Prospective growers should always be on the lookout for new or unusual marketing opportunities. Some crops can be grown specifically for immigrant groups. In areas with a large Eastern European population, there is an existing market for black currants and seaberries. Even a small population of Eastern European immigrants could support an acre of pick-your-own black currants. The health benefits of some emerging crops may provide excellent marketing opportunities in the future.

With the growing popularity of craft beers, some breweries are producing small batches of fruit beers, often called "sours." Unusual fruits, with strong

flavors and high tannin levels, are well suited to this emerging market.

Before investing in a new crop, estimate both the yield and the time it will take to harvest the crop. Most fruit and vegetable crops in Minnesota are not commercially viable unless over \$5,000 an acre in product can be grown and sold. Many crops look good on paper until it is discovered that they either have low yields or cost more to harvest than the retail value of the crop. Most of the crops described in this publication are harvested by hand. In Europe, currants and aronia are harvested with machinery, but in Minnesota these crops have too small of a market to justify buying expensive mechanical harvesting equipment. Fruit that grow on clusters are usually easier to harvest by hand than fruit that are borne individually. Larger fruit are more efficient to harvest than small fruit. A few crops have fruit that sticks tightly to the plant. Some crops are tough to pick because of large thorns. Most of the emerging crops will become easier to harvest as new varieties are developed. Finding faster and easier ways to harvest these fruit will be a key in turning them into profitable crops.

Many emerging crops have few leaf or fruit diseases. Others have so many diseases in Minnesota that organic production may not be feasible. Always be skeptical of any crop that comes with the claim of "not susceptible to any insects or diseases." Every species is going to be susceptible to one or two diseases. The emerging crops are poorly studied, and their diseases may not have been identified. Farms in Minnesota are often surrounded by forests that can harbor unusual and largely unknown disease organisms. Growers who want to specialize in a particular crop should expect to find diseases or insect pests that aren't listed in any guidebook.

EMERGING CROPS FOR HOME GARDENERS

Most of the plants listed here have ornamental value in addition to producing fruit, making them ideal additions to the edible landscape. Crops that are not economically viable for commercial producers can be planted as ornamental shrubs, made into hedges, or even used as arbors.

Many of these crops, especially native plants, are already being incorporated into the pollinator

habitats that fruit growers are establishing throughout Minnesota to increase populations of native bees. For example, the native clove currant has marginal fruit quality but produces a first rate flower for bees. Elderberry flowers always provide excellent midsummer forage for bees and other pollinators. Growers interested in emerging crops can always add a few plants into a windbreak to see how they grow.

CLASSIFICATION

Many emerging crops are completely unrelated to common temperate fruit sold in stores. Nearly all the temperate fruit sold in the grocery store comes from species of two plant families: the rose family and the heath family. The rose family includes apples, cherries, peaches, plums, raspberries, blackberries, strawberries and pears. The heath family includes blueberries and cranberries. By contrast, emerging crops belong to more than eight families:

Rosaceae: rose family

aronia
saskatoons and juneberries
wild plums and cherry plums
chokecherries

Caprifoliaceae: honeysuckle family

elderberries
honeyberries

Elagneaceae: oleaster family

seaberries
autumn olive and goumi

Actinidiaceae: Chinese gooseberry family

hardy kiwis

Emerging fruit crops that are unrelated to more common fruits are often susceptible to entirely different diseases and insect pests. In some cases, we don't know the diseases on these crops, or we see new insect pests that haven't been previously described. Many of these crops have entirely different nutrients and health benefits than fruit commonly sold in the grocery store.

Solanaceae: nightshade family

goji berries

Moraceae: mulberry family

mulberries

Cornaceae: dogwood family

Cornelian cherry

Grossulariaceae: currant family

currants and gooseberries

Berberidaceae: barberry family

mahonia and barberry

HEALTH BENEFITS

One reason to look into emerging crops is the possible health benefit. The health benefits of fruit crops have been known for millennia, because emerging crops were incorporated into traditional diets around the globe, from Siberia to Montana. In Eastern Europe, Russia, and China, scientists started to study the health benefits of fruits in the middle of the twentieth century.

For most of the twentieth century, western scientists tried to narrow down the nutrients essential for humans to survive. Carbohydrates, fats and proteins were discovered first, because they are macronutrients needed in large quantities. Then micronutrients, which are only required in small quantities, were discovered. Micronutrients include vitamins and minerals. Scientists became so good at narrowing down the list of essential nutrients that science fiction writers of the 1960s and 70s often portrayed people in the future acquiring all of their nutrition from a pill.

For most of the twentieth century, the health benefits of fruits and vegetables were usually attributed to their vitamin content. Fruits were considered essential because they contained Vitamins A and C. Currants were found to be an important source of Vitamin C in northern climates, but when oranges became widely available and vitamin supplements were developed, currants were considered irrelevant. During the 1980s a prominent scientist summed up the attitudes of the time by frequently saying “Other than Vitamin C, most fruit is nothing but sugar and water.” We knew that berries were chemically complex, but most scientists assumed that the minor acids and pigments in fruit like blueberries were either broken down in the gastrointestinal tract or not absorbed into the body.

In the West, the first evidence that fruit may hold other health benefits started to emerge shortly after World War II, when stories emerged that English fighter pilots claimed to see better at night when they were regularly fed jam made from bilberries. Bilberries are close relatives of lowbush blueberries.

¹ Ames, B. N., M. K. Sigenaga and T. M. Hagen. 1993. Oxidants, antioxidants and the degenerative diseases of aging. *Proc. Natl. Acad. Sci.* 90:7913-7922.

² Block, G, B. Patterson and A. Subar. 1992. Fruit, vegetables and cancer prevention: a review of the epidemiological evidence. *Nutrition and Cancer*. Lawrence Erlbaum Associates.

In the early 1990s, several scientists published review papers that analyzed previously published work which compared cancer rates of people who consumed little fruits and vegetables with people who consumed a lot of fruits and vegetables.^{1,2} The papers only considered studies to be valid if they looked at cancer rates in people of one ethnic group or country. For example, the review cited a study comparing cancer rates among African-Americans in Louisiana who ate vegetables with neighbors who didn't eat vegetables. Rates of gastrointestinal cancer among Turkish men who ate citrus fruit less than once a month were compared to those who ate citrus once a week. When all the studies were considered, the authors concluded that those who ate fruits and vegetables more frequently had fewer health problems and lower cancer rates, and that vitamins only explained part of the health benefits.

There have been few studies comparing the health of people who eat or do not eat fruit, but available evidence points out that fruits are just as healthful as vegetables. In a study of post-menopausal women in Iowa, women who ate at least one serving of strawberries or blueberries a week had reduced mortality from cardiovascular diseases. Similarly, men in eastern Finland who ate berry products also had reduced risk of heart failure compared to those who ate no berries.

Many emerging crops have a diverse combination of healthy compounds, including vitamins, minerals, nonessential nutrients, and medicinal compounds. Medicinal compounds are specific chemicals within a fruit or vegetable which cure a specific disease or alleviate the symptoms of a disease. Nonessential nutrients are compounds which humans don't need to consume in order to survive, but have the potential to reduce or prevent diseases. The nonessential nutrients are alternatively called nutraceuticals or phytonutrients, and include the antioxidants.

The nonessential nutrients in the emerging fruits have been given the greatest attention by the public and provide the greatest potential for increasing sales. When nonessential nutrients are incorporated into a daily diet, they show the potential of slowing the aging process, reducing cancer, and decreasing cardiovascular diseases. The best known nonessential nutrients are the antioxidants. Antioxidants have the ability to neutralize free radical forms of oxygen that are formed during cell respiration. Free radical oxygen can react with and cause damage to cell membranes, proteins, and DNA. Some gerontologists believe that free radicals are a major factor contributing to aging. Our bodies have developed defense systems against free radical oxygen using a variety of enzymes. The antioxidants are believed to strengthen the defense system, especially when more free radicals are being produced than the enzymes can neutralize.

The most famous antioxidant is Vitamin C, but Vitamin C often only accounts for 15% or so of the antioxidant capacity in many types of fruit. The most common antioxidants in fruit are the anthocyanins; pigments that give most types of fruit their distinctive red or blue color. Generally, the darker the fruit, the higher the anthocyanin and antioxidant level. In many dark blue berries like juneberries or haskaps, the anthocyanins are in the skin, and are more difficult to digest. Red fruit like cherries and gooseberries have lower anthocyanin levels, but since the anthocyanins are dissolved in the fruit juices, they may be easier for the body to absorb. Anthocyanins are a diverse group of compounds. Some types of fruit may have four types of anthocyanins, while others have 20 types of anthocyanins. Some are certainly better than others, but we don't know which anthocyanins have the most health benefits.

Antioxidant levels are usually measured by the ORAC assay (Oxygen Radical Absorbance Capacity) which gives numbers in Trolox equivalents expressed in micrograms of Trolox equivalents per gram of fruit. ORAC tests have been conducted on most of the crops covered here (Table 2). The ORAC tests do not distinguish between antioxidants that are absorbed by the body and those that are not, but do give us an idea of which fruits have the highest

potential for increasing antioxidant consumption.

Scientists are still determining how cooking, canning, fermenting, or freezing fruit affect antioxidant levels. Some antioxidants are destroyed by heat, while others become available when the processing releases compounds from the cell walls and membranes.

Many consumers are trying to increase their antioxidant consumption, but some nutritionists are still skeptical, quickly pointing out that anthocyanin extracts have shown few health benefits in controlled studies. As a result, the FDA and other organizations frown on people making health claims about products made from fruit. Bilberries have been extensively examined, and only half of 30 studies showed that bilberry extracts improved vision. The studies were inconsistent, because some studies used extracts while others used bilberry jam. Some looked at vision in people whose eyesight was already good while others used test subjects with poor vision. Scientists have hypothesized that health benefits are increased when anthocyanins are absorbed with other compounds in the fruit such as ellagic acid. The health benefits of berries could thus be due to a synergism between naturally occurring compounds. In addition to anthocyanins, the seeds of some berries contain gamma linolenic acid, which some scientists believe helps reduce body fat by facilitating fatty acid oxidation in the liver.

Antioxidants are only one type of healthy compound found in fruit, and some species with the lowest ORAC levels have the most health benefits due to medicinal compounds. In many cases, the medicinal benefits of these fruit have been known for centuries or even millennia, but only recently have scientists found the modern chemical constituents responsible for the ancient cures. For some fruits, like goji or seaberries, the medicinal benefits were widely known in China, but not in the West. For elderberries, the medicinal benefits were written about in ancient Rome and Persia.

Some of the more extravagant health claims for berries will undoubtedly be proven wrong. On the other hand, the scientist who said that berries were only sugar and vitamin C was also wrong. The emerging fruits not only taste good, they are good for you.

Table 2. Vitamins and antioxidants in fruit, and proposed medicinal benefits.

Crop	Vitamins and Minerals	Beneficial Compounds	ORAC* values	Proposed Medicinal Benefits
Black Currants	Vitamin C, Iron	Anthocyanin	7,957 ¹	Increased blood flow
Red Currants	Vitamin C, Iron	Anthocyanin	3,387 ¹	
Gooseberries	Vitamin C	Anthocyanin	3,332 ¹	
Aronia	Vitamins A and E	Anthocyanin	16,062 ¹	Improved heart function
Juneberries	Vitamin A	Anthocyanin	1,731 ²	
Elderberries	Vitamin A	Anthocyanin	14,697 ¹	Antiviral, combats cold and fever
Honeyberries	Vitamin C	Anthocyanin		
Chokecherries	Vitamin K, Riboflavin	Anthocyanin, quercetin	3,504 ²	Diarrhea, abdominal cramps
Nanking cherries	Vitamin C	Anthocyanin		
<i>Actinidia</i> (Hardy Kiwi)	Vitamin C		1,210 ¹	
Goji berries	Vitamin A	Long chain Polysaccharides	3,290 ¹	Boost immune system
Autumn Olive/Goumi	Vitamin A	Carotenoids, Lycopene		
Seaberry	Vitamin E	Carotenoids, fatty acids	1,433 ²	Skin care, sunburn

*Oxygen Radical Absorbing Capacity; a measure of antioxidant activity

¹ From D.B. Haytowitz and S. Bagwhat, 2010

² From W. Li, F.S. Hosseinian, A.W. Hydamaka, L. Lowry and T. Beta. 2008

Table 3. Vitamin Content of Fruits¹

	Vitamin C, total ascorbic	Thiamin	Riboflavin	Niacin	Vitamin B-6	Folate , DFE	Vitamin A, RAE	Vitamin A, IU	Vitamin E (alpha-tocopher-	Vitamin K (phylloquinone)
Unit (Value per 100g)	mg	mg	mg	mg	mg	µg	µg	IU	Mg	µg
Aronia	0.8	N/A	N/A	0.40	N/A	N/A	N/A	900	3.3	20
Blueberries	9.7	0.037	0.041	0.418	0.052	6	3	54	0.57	19.3
Chokecherries	5.5	0.034	0.173	0.628	0.198	N/A	8	168	0.35	21.1
Currants, black	181.0	0.050	0.050	0.300	0.066	N/A	12	230	1.00	N/A
Currants, red	41.1	0.04	0.050	0.1	0.07	8	2	42	0.1	11.0
Elderberries	36.0	0.070	0.060	0.500	0.230	6	30	600	N/A	N/A
Goji Berries (dried)	48.4	N/A	N/A	N/A	N/A	N/A	N/A		N/A	N/A
Gooseberries	27.7	0.040	0.030	0.300	0.080	6	15	290	0.37	N/A
Haskaps or Honeyberries²	44	N/A	N/A	N/A	N/A	N/A	N/A	130	1.1	N/A
Kiwi	92.7	0.027	0.025	0.341	0.063	25	48.4	87	1.46	40.3
Mulberries	36.4	0.029	0.101	0.620	0.050	6	1	25	0.87	7.8
Oranges	53.2	0.087	0.040	0.282	0.060	30	11	225	0.18	0.0
Raspberries	26.2	0.032	0.038	0.598	0.055	21	2	33	0.87	7.8
Seaberries	360.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13	N/A
Sour Cherries	10.0	0.030	0.040	0.400	0.044	8	64	N/A	0.07	2.1
Strawberries	58.5	0.024	0.022	0.386	0.047	24	1	12	0.29	2.2

¹ USDA Food Composition Databases. <https://ndb.nal.usda.gov/ndb/> Accessed 04 April 2017.

² Cassells, L. 2016. Your essential honeyberry and haskap guide. Published by AgriForest Bio-Technologies Ltd.

perennial fruits

actinidia

HARDY KIWIS, KIWIBERRIES, BOWER VINE AND SILVER VINE

Hardy kiwis are cold hardy vines native to eastern Asia. There are multiple species that grow from southern China to the Russian Far East, including three species hardy enough for USDA Hardiness Zones 3 and 4. As a new crop with multiple species, English names are still being worked out. The original English name for the fruit was Chinese gooseberry. The name “kiwifruit” was given to a large-fruited subtropical *Actinidia* that was native to southern China and developed in New Zealand. After the subtropical kiwifruit became well known in the U.S., the hardy *Actinidia* species were easier to promote with the familiar kiwifruit name. In most cases, the fruit looks and tastes similar to the kiwifruit of the grocery store, only much smaller with smooth, edible skin that does not have to be removed prior to eating. Most hardy kiwis belong to two species, *Actinidia arguta* and *Actinidia kolomitka*. Kiwifruit commonly sold in the grocery stores belong to the subtropical species *Actinidia deliciosa*.

Most *Actinidia* varieties are dioecious, with male and female flowers on separate plants. The sex of a clone stays the same as long as it is vegetatively propagated. A few varieties contain both male and female flowers on the same plant, and are therefore self-fruitful.

Actinidia kolomitka is the hardiest species of kiwi, native to the boreal forest regions of the Russian Far East and northeast China, and appears to be hardy to Zone 2. Often called super-hardy kiwi or ‘Arctic Beauty’, it is also known as kolomitka, the indigenous name in Asia. Kolomitka flowers are small and somewhat green, while the fruit can be very small. One of the big draws for ‘Arctic Beauty’ is the variegated leaves, which are primarily found on the male plants, and have made the plant a desirable ornamental. The fruit usually ripens in August.

Table 4. Species and cultivars of *Actinidia* suitable for testing in Minnesota

Cultivar	Species	Hardiness	Vines	Fruit
Arctic Beauty	<i>kolomitka</i>	Zone 2	Males have variegated leaves – ornamental	Small, sweet
Issai	<i>arguta x polygama</i>	Zone 4 – 5	Marginally hardy in Minnesota	Male and female flowers on same plant
Anna Hardy (Ananasnaja)	<i>arguta</i>	Zone 3- 4	Vigorous vines	Pineapple flavor
Michigan State	<i>arguta</i>	Zone 4		Large elongated fruit
Ken’s Red	<i>arguta x melenandra</i>	Zone 4		Sweet with red flesh
Hot Pepper	<i>polygama</i>	Zone 4	Large flowers	Yellow, sweet, spicy
Pavel Male	<i>polygama</i>	Zone 4	Large male flowers – used as ornamental and pollinator	None
Vera’s Pride	<i>polygama</i>	Zone 4	White frosted leaves	Yellow, sweet



Figure 1. Arctic Beauty (*A. kolomitka*)



Figure 2. *Actinidia arguta* fruit (cultivar unknown)

Actinidia arguta holds the greatest promise for fruit production of the hardy species. Originally called bower vine when it was grown as an ornamental, it is usually called hardy kiwi now. It produces fruit that is significantly larger than kolomitka and significantly sweeter than the common kiwifruit of the grocery store. This is an extremely variable species found from Japan to the Himalayas in a wide cultivar of elevations and climate. The fruit is usually green or yellow, but the cultivar *purpurea* is red. Likewise, petioles are often red, which increase its ornamental value. It is usually listed as hardy to Zone 4 (-25°F), but individual clones may be hardier or less hardy depending on their origin. The fruit generally ripens in September-October.

Actinidia polygama has the common name silver vine due to leaves that often are gray towards the tips. The native habitat for silver vine is the mountains of Japan and China, and it appears to be hardy to Zone 4. Silver vine leaves contain compounds attractive to cats and many people report silver vine as being an alternative to catnip. Silver vine has the showiest flowers of any *Actinidia*, but some varieties produce tough, bitter fruit. In addition to 'Issai', which is a hybrid between silver vine and *A. arguta*, there are three named varieties of silvervine: 'Hot Pepper', 'Pavel Male' and 'Vera's Pride', which are all hardy in Zone 4 areas of Minnesota. 'Pavel Male' is only used as an ornamental or as a pollinator for female silver vines.



Figure 3. Inside of *A. arguta* fruit

HISTORY

In East Asia, *Actinidia* fruit has been eaten for thousands of years, but people preferred to gather the fruit from wild vines rather than grow it on farms. The species were not truly domesticated when European explorers in the 19th century brought seeds back to Europe and the United States to be used as ornamental plants. At the time, vines that grew up the sides of brick buildings were fashionable, and *Actinidia* vines were hardier and more adaptable than the commonly used English ivy. Bower vines were brought to Minnesota in the late

19th century, where they were planted as ornamental vines. Most plants were seedlings, so only half of the plants were females and produced fruit. People knew that the fruit was edible, and presumably people snacked on the berries of bower vines, but there was no effort to grow the vines for fruit production.³ In the middle of the century vines that climbed buildings fell out of fashion, bower vines slowly disappeared from ornamental plantings, and Minnesotans lost their knowledge of *Actinidia*.

³ Sando, L. 1935. Edible fruits from Minnesota wild and cultivated plants. *Minnesota Horticulturist*. March 1935.

Interest in *Actinidia* for commercial fruit production began in New Zealand, where an enterprising farmer began planting seeds of *A. deliciosa* in the early 20th century. By the 1930s he developed large-fruited cultivars, and over the next fifty years New Zealanders developed an export market, which was helped when the growers began calling their fruit kiwifruit. From New Zealand, kiwifruit was introduced to the U.S. and became widely planted in California. As kiwifruit became a staple in grocery

stores, people realized that fruit from hardy species could also be grown in cold climates like Minnesota.

In Minnesota, the development of hardy *Actinidia* for fruit production began in the 1980s. The primary driving force in developing this crop has been Bob Guthrie, who has engaged in several research projects with the University of Minnesota. Bob has been active in breeding and selecting plants as well as developing trellis and training systems.

USES AND HEALTH BENEFITS

Like their larger relatives, the hardy *Actinidia* are primarily consumed fresh. The fruit have small, edible seeds and can be dried. Flavor varies from identical to the store kiwifruit to intensely sweet. One popular Russian cultivar called 'Ananasnaja' reportedly has

the flavor of pineapples. The fruit is extremely high in Vitamin C. Some cultivars have a high enough sugar content to be made into wine, and some wines are said to resemble the best Rieslings.

PROPAGATION AND PLANTING

Actinidia can be propagated by seeds, grafting or cuttings. Fruit quality of seedlings is less variable than with other species, but since it is a dioecious plant, half of the seedlings will be male. *Actinidia* is usually propagated with cuttings. Softwood cuttings generally work better than hardwood cuttings. For softwood cuttings use green twigs between an eighth and a quarter of an inch in diameter. Dip twigs in a rooting hormone, remove most leaves, and place in sand or peat with a plastic cover until the roots form. When propagating male and female plants, always label the pots, because male and female plants usually cannot be distinguished until they begin to form flowers.

Actinidia are best grown as an intensively managed crop. One male plant should be put in for every six female plants. *Actinidia* should be planted in well-drained, slightly acidic soil with full sun. Low, wet areas can result in root rot. Care should be taken when fertilizing the plants, because the roots can be burned. The vines are not drought tolerant, and irrigation should be available. In commercial plantings, the vines are trellised. Growers have experimented with different types of trellises. More about trellis design and construction techniques can be found in the University of Minnesota Extension publication *Growing Hardy Kiwifruit (Kiwiberries) in the Home Garden*.⁴

⁴ Hoover, Emily E., James Luby, Emily S. Tepe, with Bob Guthrie. *Growing Hardy Kiwifruit (Kiwiberries) in the Home Garden*. University of Minnesota Extension. Web. 03 March 2017. <http://www.extension.umn.edu/garden/yard-garden/fruit/growing-hardy-kiwifruit/>

PRODUCTION PROBLEMS

The biggest problems home gardeners have had with hardy *Actinidia* species are plants that are slow to come into production, and inconsistent production. Growers who have put in test plantings have reported waiting eight years before eating their first berries. Production is delayed because vines frequently die to the ground the first few years. The vines regrow after dying to the ground, but there will be no fruit that year. Like most temperate fruit plants, *Actinidia* form flower buds in late summer for spring bloom. Protecting the plants from winter injury and minimizing pruning will often help plants bear earlier in their lifecycle.

Like many plants native to northeast Asia, some *Actinidia* cultivars start growing during warm spells in late winter, leaving them vulnerable to frost. The problem with early sprouting is most common in climates warmer than Minnesota, and does not appear to be a limiting factor here.

The market for hardy *Actinidia* needs to be developed. Most are curiosities sold in small quantities. Nobody knows for sure if they will ever become as popular as the kiwifruit of the wholesale market. The crop is not easy to grow, but could be rewarding for someone with energy and initiative.

HARVESTING

Actinidia are typically harvested by hand, and trellis systems should be designed to keep the fruit accessible to pickers. The most challenging part of harvesting is determining the correct time to harvest fruit. *Actinidia* fruit will ripen after picking, but the ripening only occurs if the fruit is at an acceptable stage of maturity when picked. The challenge is trying to determine when that “acceptable state of maturity” has occurred. Even large commercial kiwifruit growers sometimes pick fruit at

the wrong stage of maturity. If the fruit are picked too green, they will not ripen and will remain, sour, green, and tough. If the fruit are left on the vine too long, they often fall off. In Oregon, growers of the *A. arguta* cultivar ‘Ananasnaja’ have had some success using the starch iodine test for apples to determine the best time for harvest. For small-fruited Minnesota cultivars, some home gardeners put sheets on the ground and pick up fruit that falls off naturally.

EDIBLE LANDSCAPING

Just as bower vine became a desired ornamental in the 19th century, any of the three species can be a great choice for certain types of landscaping. The vines grow rapidly, and will cover a large arbor in a few short years. The vines can also be planted along fences. Kolomitka and silvervine have variegated

leaves and flowers in early summer, making them edible alternatives to clematis vines. Most home gardeners who plant *Actinidia* species as an ornamental vine are quite happy with their plants as ornamentals and see the periodic fruit production as an added bonus.

MINNESOTA EXPERIENCES

Apart from growers in the Victoria/Chanhassen area, few Minnesota growers have had commercial success growing *Actinidia*. Many beginning growers have planted hardy kiwifruit as an experiment without knowing the species or varieties, and few

people have seen enough promise to plant a second time. Yield has been inconsistent, some fruit fall to the ground before ripening, and the fruit is smaller than advertised.

aronia

Aronia fruit are black, about the size of medium blueberries, and borne on shrubs. Aronia are native to eastern North America, where they were known as chokeberries until the beginning of the 21st century. There are two major species, the black chokeberry (*Aronia melanocarpa*) and the red chokeberry (*Aronia arbutifolia*). Both species were primarily grown as ornamentals in the 20th century, but only *Aronia melanocarpa* was fully hardy in Minnesota. Since 2000, there has been a growing interest in *Aronia melanocarpa* for fruit rather than as an ornamental. The name aronia has largely replaced the name “black chokeberry”. Many landscapers still call the fruit chokeberries, but fruit growers only use the name aronia. Not only is the name “chokeberry” unappealing, but consumers understandably confuse chokeberries with chokecherries. Chokecherries are stone fruit similar to cherries and plums, while aronia are pome fruit related to apple, pears, and saskatoons. The similarity to apples is why an old German word for aronia translates to “apple berries.”

The firm, black fruit forms on small clusters with 8-12 fruit per cluster (Figure 4). The leaves are simple and elliptical, with a glossy, dark green color that turns bright red in the fall (Figure 5). The flowers are small, forming pretty clusters after the leaves emerge.

Aronia plants selected for fruit production are tall shrubs that grow to a maximum height of 14 feet. Branches sprout from the base of the plant and, left unpruned, a shrub will have up to twenty large, upright branches. The plants also produce some spreading branches. Branches can live over 20 years. The mother plant does send out a few suckers and unmaintained shrubs will form dense plantings consisting of the mother plant and small suckers.

Aronia plants have been selected for both fruit quality and as ornamentals. Ornamental varieties all have edible fruit, but the fruit is smaller and yields are lower than fruiting varieties. Most commercial aronia growers plant ‘Nero’ and ‘Viking’. ‘Viking’



Figure 4. Ripe aronia fruit



Figure 5. Aronia leaves in early fall

is taller and produces higher yields than ‘Nero’; but ‘Nero’ is probably better for growers who must harvest by hand. Most growers have noticed few or no differences between the two varieties regarding

fruit quality. Many European varieties have not been introduced to the U.S., including the common German cultivar ‘Hugin’.

Cultivar	Origin	Height	Primary Uses
Nero	Eastern Europe	5-6 feet	Fruit
Viking	Northern Europe	6-8 feet	Fruit
McKenzie	Iowa – North Dakota	7-9 feet	Shelterbelt plantings
Iroquois Beauty	Northeast U.S.	3-5 feet	Ornamental
Autumn Magic	Northeast U.S.	5-6 feet	Ornamental

HISTORY

Aronias are native to eastern North America. Henry David Thoreau summed up the attitude of most European settlers with the phrase, “Fair to the eye, but scarcely palatable...sweetish berries with a dry and so choking taste.” Instead of being domesticated for fruit production, aronia was domesticated as an ornamental shrub, with white flowers in the spring, dark green leaves in the summer, deep red leaves in the fall, and dark berries that stick on the plants over the winter.

In the 19th and 20th centuries, both the red and

black aronias were widely planted as ornamental shrubs across the U.S. In the 19th century, the species was introduced to Europe, and Eastern Europeans discovered that the shrubs could grow in extremely cold climates and that the fruit was healthful. By the early 20th century, Europeans were breeding the plant for fruit production resulting in taller shrubs with larger fruit. There is some evidence that the cultivar ‘Viking’ is an interspecific hybrid with mountain ash (*Sorbus aucuparia*), which may explain the large fruit and high sorbitol content. [See *Health Benefits* section below for more on sorbitol.]

Aronia became especially popular in Poland, Russia and the Ukraine. Europeans developed large-fruited varieties for fruit production including 'Nero'

(Czechoslovakia) and 'Viking' (disputed; Finland or Sweden) which are currently being planted in the United States.⁵

USES AND HEALTH BENEFITS

Aronia is easy to grow and remarkably free of diseases. Americans started to develop an interest in growing aronia for fruit after its health benefits became known at the beginning of the 2000s. By 2008, farmers in Iowa, Missouri and other states were planting aronia for the juice market. By 2014 the market collapsed, leaving many growers confused and frustrated.

In the U.S. aronia is primarily used by large food processors as an additive to energy drinks and fruit juices. The extract serves both as a coloring agent and to increase antioxidant content. In Europe, aronia has been used as a food coloring and is added to fruit syrups, teas, jellies, and jams. A number of wineries

throughout the U.S. are trying to develop dessert wines from aronia fruit. Wine makers often mix aronia with other fruit to add color to the wine.

When aronia is combined with other fruit, it can add a good flavor, color, and health benefits. Aronia can be mixed with many types of fruit, such as apples, pears, and plums. Jam made from aronia and plum is intense, dark, and fares well in taste tests. The future of aronia production largely depends on what uses people will find for this easy-to-grow fruit.

Eastern Europeans have long been interested in using aronia to reduce blood pressure. Scientists in the former Soviet Union started investigating the health benefits of aronia long before Americans became interested in phytonutrients.⁶ After learning about its impressive health benefits, Americans started planting aronia for fruit production. Some examples of health benefits found in the scientific literature:

1. Polish men with high blood pressure who drank 250 milliliters of aronia juice per day over six weeks saw a significant decrease in HDL cholesterol and triglycerides along with a decrease in systolic and diastolic blood pressure readings of 13 and 7 respectively.⁷ Similar results have been achieved in animal studies.
2. Patients who had previously suffered heart attacks experienced reduced blood pressure after consuming high-anthocyanin aronia extracts.⁸

Note from Thaddeus:

I once incorporated aronia jelly into a taste test (see chokecherry), using jelly made from only aronia and sugar. Aronia is naturally high in pectin, and the jelly had no added pectin. The jelly had a rich purple color with good firmness, but ranked the lowest of any jelly used in the taste test. The astringency disappeared during cooking, so the poor showing was not due to the "choking taste". People just didn't like the flavor of plain aronia.

⁵ Brand, M. 2008. Aronia: Native shrubs with untapped potential. *Journal of the Arnold Arboretum* 67(3): 14-25.

⁶ Jansky, S.H. and Bell, R.A.. 1994. Botanical Gardens of Russia, Ukraine, Belarus, and Georgia. *HortScience* 29: 938-1107.

⁷ Skoczyńska, A., Jędrychowska, I., Poręba, R., AffelskaJercha, A., Turczyn, B., Wojakowska, A., Andrzejak, R. 2007. Influence of chokeberry juice on arterial blood pressure and lipid parameters in men with mild hypercholesterolemia. *Pharmacological Reports* 59(1):177-182. ISSN 1734-1140.

⁸ Kulling, S. and Rawel, H. 2008. Chokeberry (*Aronia melanocarpa*) – A Review on the Characteristic Components and Potential Health Effects. *Planta Med* 2008; 74(13): 1625-1634. doi: 10.1055/s-0028-1088306

3. In laboratory studies and in at least one animal study aronia extracts appeared to prevent colon cancer or slow down the rate of cell proliferation⁹
4. Aronia likewise has been shown to prevent or reduce problems associated with Type II diabetes. Patients who drank 200 milliliters of aronia juice per day over three months saw a decrease in fasting glucose levels.¹⁰

As is the case with most fruit being touted for health benefits, scientists have not been able to determine exactly which compounds in the fruit improve health. Aronia has some of the highest antioxidant levels of any fruit, but a lower variety of anthocyanins compared to other purple fruit. Some studies show only three different anthocyanins in aronia.

Aronia fruit has an extremely high concentration of sorbitol, a sugar alcohol commonly found in fruit.

Sugar alcohols are chemically related to the alcohols, but function similar to the sugars in food. Sorbitol levels in aronia are as high as 8% fresh weight, and usually comprise about a third of the total soluble solid content or Brix.¹¹ Sorbitol is a natural sweetener found in many rose family fruit species and is often associated with sweet cherries. Sweet cherries typically have sorbitol contents between 2 and 4% of fresh weight. Sorbitol contains similar calories as regular sugar, but the bacteria that cause tooth decay cannot grow on sorbitol, and it is therefore frequently added to many brands of sugarless gum or other products where tooth decay is a concern. Humans metabolize sorbitol slowly. A small amount of sorbitol is easily digested and absorbed, while a large amount of sorbitol either gives people an upset stomach or works as a laxative. Most yeast strains used in wine making cannot metabolize sorbitol. Because sorbitol does not ferment with regular sugar, it is occasionally added to sweeten wine.¹²

Astringency

Chokeberries and the distantly related chokecherries received their unappetizing names because both fruits are astringent. Astringency causes the mouth to experience an unpleasant drying sensation, regardless of the amount of juice in the fruit. In addition to aronia and chokecherry, astringency is found in a wide cultivar of unrelated fruit, including green persimmons, seedling pears, Cornelian cherry dogwood, and several other species. Astringency is often confused with acidity, but the two are quite different. Astringency is a tactile sensation felt in the sides and back of the mouth as well as the tongue (hence the “choking”), while acidity is a taste detected on the tongue. Acidity in fruit is caused by the presence of organic acids, but astringency is caused by polyphenolic compounds which bind to proteins in the mouth. The exact mechanism of astringency is poorly understood, but astringency appears to be harmless. Fruit can be astringent and low in acid at the same time. Neither aronia nor chokecherries are very acidic. Most of the time astringency disappears during processing; however, there are times when astringency can be carried into wine, cooked juice, and even jelly.

Astringency either drops or disappears during ripening in most fruit. In aronia, astringency nearly disappears at the end of the long harvest window. In chokecherries, astringency drops after ripening but rarely disappears.

⁹ Lala, G., Malik, M., Zhao, C., He, J., Kwon, Y., Giusti, M., Magnuson, B. 2006. Anthocyanin-Rich Extracts Inhibit Multiple Biomarkers of Colon Cancer in Rats. *Nutrition and Cancer* Vol. 54(1):84-93. https://doi.org/10.1207/s15327914nc5401_10

¹⁰ Kulling, S. and Rawel, H. *ibid.*

¹¹ Snebergrova, J., Cizkova, H., Neradova, E., Kapci, B., Rajchl, A., and Voldric, M. 2014. Variability of characteristic components of aronia. *Czech J. of Food Sci.* 32: 25-30.

¹² Kulling, S. and Rawel, H. *ibid.*

Soluble solids, Sweetness and Brix

Soluble solids refers to the percentage of dissolved solids in fruit, and is usually measured using a handheld device called refractometer, which gives a reading in degrees Brix. A Brix reading is often used to quantify sweetness, and for most fruit, Brix and sugar content are closely tied together. The most common use of Brix is in wine production. Quite often grape growers receive premiums for batches of grapes with a higher Brix reading, because higher Brix means that the wine can have a higher alcohol content. Brix readings do not estimate sweetness or the potential to produce alcohol when a high percentage of the soluble solids are dissolved acids or sorbitol. Black currant, although very sour, can have a high Brix reading because the acids overwhelm the available sugars. Brix cannot accurately estimate potential alcohol production in aronia. Since a third of the total soluble solids in aronia is sorbitol, and yeast cannot convert sorbitol to alcohol, aronia juice with a respectable Brix of 18 will produce a very weak wine.

(D. Drummond, personal communication).

PROPAGATION

Aronia usually comes true from seed, which means that plants started by seed retain the traits of the parent plant. Traditionally, the ability to come true from seed was attributed to low genetic diversity within common varieties. Recently, researchers have speculated that aronia has the ability to form seeds without pollination, which makes seedlings identical to the mother plant.¹³ Aronia is one of the few perennial fruits traditionally propagated using seeds. In order to get good seed germination, macerate the fruit in a blender and store the mash of seeds and fruit at freezing temperatures for three months. Seeds are planted in early spring, kept in a nursery the first growing season, and planted in the field the following year.

Although aronia can be propagated from seed, plants propagated from root suckers will begin producing fruit a year or two before those started from seed. For small scale production, aronia suckers can be dug up from the mother plant during dormancy and planted in early spring or propagated from stool beds. Stool beds are made by piling wood chips or soil around the base of a multi-stemmed shrub. Roots form on the stems of the plant, and those rooted stems can be transplanted into containers during dormancy the next winter. Larger nurseries propagate aronia with softwood cuttings, tissue culture, and layering.

PLANTING AND CARE

Aronia can grow in both sandy and clay soils. It even appears to thrive in low, wet areas with acidic soils. Ideally, soil pH should be between 5.5 and 7.0. Aronia will survive in a variety of sites, but to produce large yields, it should be grown in full sun, properly fertilized, weeded, and pruned.¹⁴

Aronia can thrive in very poor soils and needs little or

no fertilizer in most cases. If the plants are putting on two to three feet of new growth every year, fertilizer is not needed. There have been cases where aronia grew and yielded poorly due to dry soils and low nitrogen in sandy soils of Minnesota. If the plants grow less than a foot each year, a high nitrogen fertilizer should be applied. Conventional producers can add one cup of granular fertilizer, like calcium nitrate, onto the ground

¹³ Brand, M. 2008. Aronia: Native shrubs with untapped potential. *Journal of the Arnold Arboretum* 67(3): 14-25.

¹⁴ Jensen, Jeff. Agroforestry on the Farm: Aronia Berry at Winding Creek, Belmond, IA. 2014. http://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=1010&context=leopold_pubspapers

in the spring. Organic producers should add two to five pounds per plant of a high nitrogen fertilizer, like blood or feather meal; or top-dress with high-quality compost in early spring.

Commercial growers have planted aronia anywhere from two to six feet apart within rows. Growers who plan to mechanically harvest typically plant two feet apart, while growers who plan on picking fruit by hand should consider planting aronia six feet apart. Rows can be spaced 12 to 20 feet apart depending on the width of equipment used to mow between rows or to harvest berries.

Most aronia plants are sold as 18 inch seedlings, and need to be kept free from weeds during the first three or four years to achieve maximum growth rates and early production. Large commercial growers often

plant into landscape fabric to reduce weed pressure, but wood chips also work.

Proper pruning is essential to keep aronia healthy and productive, and to facilitate picking. Growers often develop pruning systems for their own farms that take into account the vigor of the shrubs and the availability of labor. The goal of pruning aronia is to keep new fruiting branches sprouting and remove older, less productive branches while keeping plants open and narrow so that the fruit can be easily harvested. Root suckers should be mowed in the growing season or pruned out in early spring; otherwise the plants will grow into an impenetrable thicket within five years. Small producers should remove three or four canes near the crown each winter so that no canes are older than five years old. Many large producers with mechanized equipment cut entire rows down to three feet high every four years.

HARVESTING

In Europe, aronia is primarily harvested by machine. Several large producers in Iowa purchased blueberry harvesting machines and modified the machines to harvest aronia. Berries harvested by hand sell for a higher price than those harvested by machine. Picking rates by hand average between 15 and 20 pounds per hour. If picking by hand, always train and prune the plants so that all the fruit can be picked without ladders.

Aronia have an exceptionally long harvest window. The fruit turns dark in late August and will hang on the shrubs until hard frosts arrive in late fall. The fruit should be picked between the end of August and the end of September. If harvest is delayed too long, the fruit will start to shrivel. Commercial growers are still trying to determine the best time to pick, because the berries continue to change throughout the six-week harvest window. Pectin and astringency are still high in early September, while sugar levels peak later in the month. Anthocyanin levels continue to increase after the sugar levels have dropped, and astringency is reduced later in September. Sorbitol increases for the entire harvest season.¹⁵ For jelly, aronia could

be picked early, when pectin levels are still high. Wine makers prefer to pick when sugars levels reach their peak, while juice makers may want to wait until anthocyanin levels peak and astringency is reduced.

Note from Thaddeus:

I bought a bottle of pure aronia juice, hoping to give samples to friends and coworkers, but after one sip decided to not hurt the commercial potential of aronia by allowing anyone else to taste it. Aronia has potential in mixtures with other fruits, but products made out of pure aronia are a difficult sell. Another interesting tidbit: My enologist coworker told me that a winery was looking for aronia, but it was in February, and nobody had bothered to freeze any berries.

¹⁵ Bolling, B.W., R. Taheri, R. Pei, M. Yu, S.N. Durocher and M.H. Brand. 2015. Harvest date affects aronia juice polyphenols, sugars and antioxidant activity, but not anthocyanin stability. *Food Chem.* 187: 189-96.

PRODUCTION PROBLEMS

Aronia are remarkably trouble free in most parts of Minnesota. Due to a lack of insect pests and diseases, aronia have a high potential for organic production. Reports on bird pressure have been mixed. Some growers have had to net their plants,

while others never see bird damage in their hedges until late fall. Likewise, deer don't particularly like aronia, at least in some areas. Deer damage has been seen in Minnesota, and there are reports of deer browsing in Iowa.

EDIBLE LANDSCAPING

Aronia shrubs have pleasant flowers in early spring, dark green leaves in the summer and brilliant red leaves in the fall, making them ideal landscaping plants. They also make great living snow fences. Varieties selected as ornamentals have edible fruit, but the fruit is much smaller, and the plants are shorter. Cultivars selected for fruit have the drawback

of few leaves in the first two or three feet above the ground, giving the shrubs a "leggy" appearance. Aronia can work in edible landscaping either by placing a low-growing shrub or annual near the base of a cultivar like 'Viking', to block out the "leggy" appearance, or by planting a cultivar selected for ornamental value.

COMMERCIAL PRODUCTION

Large food manufacturers who blend aronia juice into energy drinks have created a huge market for aronia, but primarily use concentrate imported from Poland, Russia, or the Ukraine. Farm gate prices were very high when the first American producers started selling their berries to food processors, but the price plummeted in 2014. Several growers have reported prices so low that the aronia was not worth harvesting.

Minnesota growers have not jumped into the aronia market as much as Iowa, and therefore Minnesota does not have enough aronia growers to grab the attention of juice makers. Instead, there are a number of small patches of aronia planted throughout the state, producing for local wineries, breweries, and farmers' markets. Aronia is easy to sell in small quantities to curious people, but the overall market appears to be quite small.

Those interested in growing direct market aronia will need to increase demand among local consumers by developing new ways to use the fruit and giving

out samples. Those who are willing to search for aronia recipes in Europe or European websites can find a treasure trove of unusual ideas. Anyone interested in developing the market for aronia should experiment with different recipes, especially those which combine aronia with other fruits. When giving out samples of aronia products, care should be taken to not turn consumers off with a product that does not taste good.

Freezing berries for sale to juice and wine makers is an option for Minnesota producers. Farmers can do processing, including freezing, of their own fruits and vegetables for sale to any buyer, and are not required to have a license for that activity unless they are adding off-farm ingredients. The farmer's processing and cold storage facilities must be inspected and approved by a Minnesota Department of Agriculture inspector.¹⁶ See the Marketing of Perennial Fruits chapter in this book for more information and resources.

¹⁶ Minnesota Institute for Sustainable Agriculture and Minnesota Farmers' Market Association. *Selling Minnesota Produce*. 2017. Local Food Advisory Committee. http://misadocuments.info/LFAC_local_produce.pdf

chokecherries

Chokecherries are trees and shrubs of the species *Prunus virginiana*, which is one of the most widespread tree or shrub species in North America. Chokecherries produce fruit on long cylindrical clusters called racemes (Figure 6). Flowers are white and showy, but have a musky odor that differs greatly from the floral smell typical of fruit blossoms. The leaves are simple and oval. In Minnesota and points to the south and east, the range of chokecherries overlaps with the wild black cherry (*Prunus serotina*). Chokecherries and black cherries have leaves and fruit that are very similar. Black cherries grow into large trees valued for their wood, while chokecherries range anywhere from a small shrub to a small tree. Black cherry fruit is often bitter, while chokecherries are astringent, causing the mouth to feel dry when eaten fresh (see Astringency sidebar, p. 22). Ripe chokecherry fruit varies from bright red to almost black. In some parts of the U.S., red-fruited forms dominate; while in Minnesota, the fruit is most often black.

Some chokecherry cultivars have been selected to form trees, while others are shrubs that spread via underground rootsuckers. In harsh climates such as the high plains, chokecherries rarely grow over 3 feet tall, but in mild climates they usually grow into small trees.



Figure 6. Chokecherry fruit of the cultivar ‘Garrington’

Chokecherries have one of the widest ranges of any woody plant native to North America. They grow in the rich deciduous forests of the Northeast, on rocky hillsides on the Great Plains, and on the slopes of dry mountains in Nevada. In the Great Plains and Rocky Mountain regions, chokecherries were extensively used by Native Americans, who made pastes and dried the fruit. Dried chokecherries were commonly mixed with bison fat and dried meat to form pemmican. Some scientists have speculated that Native Americans scattered seed along trails for future food. European settlers in the High Plains and Intermountain West quickly learned how to use chokecherries in a variety of products.

In spite of high local demand, there has been little interest in domesticating the crop or selecting

varieties suitable for local conditions. The most common cultivar on the market is 'Schubert', also known as 'Canada Red', which was selected as an ornamental rather than for fruit quality. 'Canada Red' forms a small tree with leaves that turn red shortly after the leaves expand, and it does produce small amounts of black fruit. In the 1990s, 'Canada Red' was planted as a common landscaping tree, but the cultivar was extremely susceptible to the disease black knot, and many have been removed.

The Canadians have selected several varieties for fruit quality, including the black 'Garrington', the red fruited 'Lee Red', the yellow 'Boughen's Golden', and the red-leaved varieties 'Robert' and 'Goertz'. All these varieties are difficult to find in Canada and almost impossible to find in the US.

USES AND HEALTH BENEFITS

Chokecherries are used for wine, jelly, sauces, and syrups. When processing chokecherries, the extremely high ratio of seed to pulp in the fruit causes problems. Generally, the fruit is mixed with water and heated and simmered until the water is infused with juice. Chokecherries don't jell well, and sometimes extra acid or pectin needs to be added in order for the fruit to jell.

Chokecherries have a strong, unique flavor that many people find agreeable. Chokecherries are rarely mixed with other fruit, because people who like chokecherries want that unique flavor. People who grew up eating chokecherries tend to show a great deal of devotion to the fruit, which is why several towns throughout the Intermountain West have annual chokecherry festivals.

Chokecherry bark and leaves were believed to have medicinal properties. The bark was frequently used by Native Americans as a tea to cure digestive ailments. European settlers in the 19th and early 20th century likewise used chokecherry leaves and bark to help with fevers and colds. While Native

Americans extensively used chokecherry juice to cure a variety of ailments, such as diarrhea, post-partum hemorrhaging, and sore throats, these health benefits have not been demonstrated by modern science.

Tests have shown chokecherry fruit contains about half the antioxidants of aronia, elderberries and other blue fruit.

Like most stone fruit, the pits of chokecherries are poisonous if eaten raw. Both pits and bark contain cyanogenic glycosides, which release poisonous hydrogen cyanide when the pits are crushed (see elderberry), and chokecherry pits are easier to crush than plums, cherries or apricots. The cyanogenic glycosides are only found in pits and bark and are unrelated to the fruits' astringency. Most of the cyanogenic compounds are destroyed during drying or cooking, so tea made from chokecherry leaves or bark has no harmful effects. The few cyanide-producing compounds that leach into jelly and wine are at levels too low to harm humans while giving the final product an almond-like flavor.

PROPAGATION

Chokecherries are primarily propagated using seeds. Seeds work well for large nurseries that supply plants for conservation projects, but do not work for growers who want to harvest chokecherry fruit. There is little consistency in fruit quality and ripening times in plants grown from seed.



Figure 7. Chokecherries grown from seed, showing the variability in bloom time and flower production.

Chokecherries are fairly easy to propagate by digging up and transplanting rootsuckers that sprout near desirable plants. Chokecherry roots don't spread widely, and most daughter plants from rootsuckers are within five feet of the mother plant. Digging up chokecherry rootsuckers is different than plums and many other shrubs, because most daughter plants often have few roots. Therefore, it is recommended to cut the lateral root that connects the mother and daughter plants, with a sharp shovel, the summer before transplanting. This forces the daughter plants to form more roots. Rootsuckers should be dug in spring before sprouting. Chokecherries sprout extremely early in the spring, and can sprout before the ground thaws, creating a very narrow window for digging plants out.

Chokecherries are occasionally propagated through grafting. Some desirable varieties do not form rootsuckers readily, and some nurseries find grafting to be more cost effective than digging rootsuckers. Landscapers prefer grafted trees on rootstocks that have few rootsuckers. There has been little public research on different rootstocks, and currently most are grafted onto seedling chokecherry rootstocks. The 'Canada Red' cultivar sold by ornamental nurseries is usually grafted onto a cultivar that does not send up suckers.

PLANTING AND CARE

Chokecherries should be spaced three to four feet apart in the row to form a hedge. In heavier soils and milder climates, they can be spaced further

apart. Weed control is only critical for the first four years. They respond well to a wood chip or bark mulch, especially the first two years.

PRODUCTION PROBLEMS

In central and northern Minnesota, chokecherries have few pests and can be grown organically. The two worst problems in the northern half of Minnesota are black knot and eastern tent caterpillars, and both problems are best controlled through scouting and pruning.

Throughout Minnesota, the biggest problem with chokecherries is black knot, an unusual fungal disease that grows into the bark, slowly girdling branches. When black knot grows into the main trunk, the whole tree can be killed. Black knot is a bigger problem in Minnesota than in Western States, because rains in early summer help the fungus start new infections. The best way to control black knot is to remove sources of inoculum. Wild chokecherries near the planting should be killed. Branches with the disease should be pruned and removed as soon as the disease becomes visible. Black knot first shows up as a large swelling in July, but becomes most visible during the winter, when it should always be pruned out. Some varieties are more resistant

to black knot than others. ‘Garrington’ is fairly resistant. The widely planted ornamental cultivar ‘Canada Red’ is exceptionally susceptible.

Chokecherries are a major host for the eastern tent caterpillar or bag worm, which forms large, visible silk nests in the branches. The caterpillars leave the nests to feed on the leaves and can easily defoliate an entire tree. Adult moths lay eggs on branches in late summer. Caterpillars hatch in early spring. The best way to control the eastern tent caterpillars is to remove the nests as soon as they become visible. When the leaves first emerge, nests are often the size of a quarter and can be easily plucked off the plant by hand or scorched with a hand-held propane torch. Insecticides are marginally effective, because the silk protects the caterpillars from insecticides.

In southern Minnesota, chokecherry production appears to be limited by the cherry fruit gall. This insect lays its eggs in the developing fruit, causing large, deformed fruit.



Figure 8. *Black knot on chokecherry branch.*



Figure 9. *Eastern tent caterpillar nests in a chokecherry bush*

HARVESTING

Almost all chokecherries in the U.S. and Canada are harvested by hand from wild plants. Wild plants can be challenging to harvest, because most wild plants in Minnesota are over ten feet tall and most of the fruit is just out of reach from the ground. Wild chokecherries often grow next to roads, where the ground is too uneven to place ladders and where pickers are in danger of being hit by vehicles and farm machinery. With regular pruning, chokecherries can be kept at heights where all the fruit can be harvested from the ground. If the plants are kept short, chokecherries can be picked

faster than many other semi-wild fruit. Several people have reported picking over five gallons of chokecherries per hour.

With their short height, chokecherries show a potential for mechanical harvesting, and raspberry or blueberry harvesters could be adapted to harvest chokecherries. Mechanical harvesters will only work if a row only has one cultivar, and if the plants are pruned and trained to be small enough for a mechanical harvester.

COMMERCIAL POTENTIAL

Cost projections in Canada show that chokecherries could be extremely lucrative. Wineries report rarely having enough fruit for their needs. High picking costs means that fruit should be sold at about \$3 per pound in order to make a profit for the grower.

Currently, the market for chokecherry products in the Midwest is declining. The people who grew up making chokecherry jelly are not being replaced with children who know the crop.

EDIBLE LANDSCAPING

'Canada Red' was popular with commercial landscapers in the late 1990s due to its red leaves and extreme hardiness, but in the Midwest, the trees proved too susceptible to black knot. Other varieties with resistance to black knot have flowers in the

spring, good fall color and provide edible fruit. Most chokecherries have the undesirable trait of sending out too many rootsuckers, so they work best in a lawn or in a hedgerow or windbreak where root suckers are easily controlled by mowing.

MINNESOTA EXPERIENCES

In spite of there being several chokecherry cultivars that were selected for fruit quality, most chokecherries harvested in Canada and the United States are from wild plants. The Minnesota Department of Agriculture funded an on-farm trial to look at the feasibility of chokecherry production through their sustainable agriculture grant program

in 2008.¹⁷ Seedlings were purchased from northwest Montana and from Minnesota. A small number of plants of the cultivar 'Garrington' were purchased from a nursery in New York. Both Minnesota and Montana seedlings grew and produced fruit, but the Montana seedlings were more susceptible to black knot.

¹⁷ Andresen, Todd and Michelle. 2008. Chokecherry (*Prunus virginiana*) Production in Western Minnesota. *Greenbook*, Minnesota Department of Agriculture. <http://www.mda.state.mn.us/Global/MDADocs/protecting/sustainable/greenbook2008/fv-chokecherry.aspx>

The project showed that seedlings are not feasible for a commercial orchard. Some seedlings did not flower, while others were loaded with blossoms in the spring, giving large nonproductive areas to the orchard. Any grower interested in chokecherries must find suitable cultivar and a way to propagate

plants vegetatively. Garrington does appear to be suitable for commercial production, but the plants are no longer being sold by any nurseries in the United States. Several Minnesota producers have selected unique cultivars of chokecherries, but those cultivars are not being sold at this time.

Note from Thaddeus:

Does a chokecherry by another name taste just as astringent?

*Shortly after 2000, a few Canadian horticulturists recommended changing the name "chokecherry" to "wild black cherry." Although the proposed name change would have caused confusion in Minnesota, which does have native wild black cherries (*Prunus serotina*), I decided to gather information. In 2008 and 2009, I conducted taste tests at a farmers' market. I told the consumers that we were testing 4 new fruit jellies. Two of the samples were chokecherry from the same jar, with one labeled "chokecherry" and the other labeled "wild black cherry". The other two jellies were also new crops like red currant and aronia. Two people noticed the trick. One woman refused to do the taste test because she heard that chokecherries were poisonous. Everybody else rated the two chokecherry jellies with different names roughly the same, including a large group of teenagers who had never eaten chokecherry jelly. Chokecherry jelly was rated quite high by both new and old consumers.*

In the past thirty years, chokeberries have become aronia berries and Oregon filberts have become hazelnuts, but there doesn't appear to be a need to change the name of chokecherries. Changing the name would attract few new consumers while turning off many people from the Great Plains and Intermountain West who grew up eating chokecherry products. Lewistown, Montana is unlikely to change the name of their annual "Chokecherry Festival," for instance.

currants

RED, BLACK, AND CLOVE

Currants are small red, black, or white berries that grow dangling clusters that resemble grapes. The name "currant" is believed to be derived from "Corinth grape," a small grape cultivar that grew on the Greek island of Corinth.

Currants belong to the genus *Ribes*, which is the same genus as gooseberries. Currants and gooseberries both produce sour fruit on cold tolerant shrubs, but the two types of fruit are distinct. Currants are cold hardy shrubs that grow between two and six feet tall with upright canes, and the canes lack thorns. Currants are borne on small clusters that look like small grapes (Figure 10). Gooseberry fruit is three or four times larger than currants and the fruit is usually borne individually or in small clusters. Gooseberry bushes have a spreading growth habit with prominent thorns sticking out of the canes near the fruit.

Note from Thaddeus:

*Can You Dry Currants for Sale?
The dried Corinth grapes came to be called "currants" - a derivative of the word "Corinth" -- and the fruit of the hardy currant shrubs eventually acquired the same name, leading to confusion among American consumers. The "dried currants" sold in many grocery stores and used in specialty baking are actually small dried grapes. Black and red currants are rarely dried due to a combination of intense resinous flavors and prominent seeds.*



Figure 10. Fruit of the black currant. **Figure 11.** Fruit of the white currant. **Figure 12.** Fruit of the red currant.

Currants are native to North America, Europe, and northern Asia and were incorporated into local diets wherever they grew. Currently, currant production is most common in Russia, Poland and Germany. There are many different species of currants, and the edible species are grouped into three different

sections: the black currants, the red currants, and the clove or golden currant (Table 6). There are four species of red currants, about ten species of black currants, and one species of clove currant. White and pink currants belong to the red species.

Currant type	Representative species	Number of species	Origin of most cultivars	Primary uses
Black	<i>R. nigrum</i> , <i>R. americanum</i> , <i>R. ussuriensis</i>	10	Eastern Europe	Jelly, wine, juice ingredient
Red and White	<i>R. rubrum</i> , <i>R. multiflorum</i> , <i>R. triste</i>	3	Scandinavia/Holland	Juice, cooking, wine
Clove or Golden	<i>R. aureum</i> *	1	Midwest North America	Ornamental with edible fruit

*A second species *R. odoratum*, is often mentioned as a clove current, but most scientists classify *R. odoratum* as the cultivar *R. aureum* var. *villosum*.

All types of currants live several decades, producing new canes each year. Canes have few branches and lack thorns. Individual canes can live up to five years, depending on insect and disease pressure. Most fruit is borne on second- and third-year canes.

Black currant bushes reach a maximum height of about 6 feet in rich soils in Minnesota. The leaves have angled lobes that superficially resemble maple leaves (Figure 13). Black currant fruits have a strong, resinous flavor with small edible seeds. Even the leaves produce a pleasant smell similar to the fruit. Black currants, as

a rule, are more susceptible to the disease white pine blister rust than other currant species.

Red currants are slightly shorter than black currants, usually growing to a height of five feet. The leaves have rounded lobes and are smaller than black currant leaves (Figure 15). Red currants are generally more resistant to white pine blister rust. Red currants have a sour taste similar to lemons, without the resinous taste of the black currants. Some red and white currants have large seeds that must be removed during processing.



Figure 13. Leaf of a black currant



Figure 14. Black currant flowers



Figure 15. Red currant leaf.



Figure 16. Clove, golden, or buffalo currant, *Ribes aureum* var. *villosum*

Clove currant bushes have branched, arching canes rather than the upright canes of black and red currants. The leaves are small and lobed. Clove currants produce showy, fragrant flowers with a spicy smell that resembles cloves (Figure 16). Clove currants usually produce black berries on small clusters, but there are wild plants with yellow fruit. Clove currants are native to the American Midwest, are resistant to most diseases, and handle hot weather better than black or red currants. Clove currants are more difficult to harvest than black currants and many people do not pick the berries.

Most currant cultivars were developed in Europe, and many cultivars have never been introduced to North America. In the 20th century, currant breeders began to combine traits from different species to develop larger fruit on longer clusters as well as resistance to white pine blister rust and powdery mildew. Scientists in Northern Europe and Russia continue to breed currants, but few new cultivars are reaching the U.S. There is only one registered cultivar of clove currants.

Table 7. Black currant cultivars suitable for testing in Minnesota

Name	White Pine Blister Rust	Powdery Mildew	Height	Other
Ben Alder	Susceptible	Resistant	4 feet	Late ripening, good juice quality
Ben Lomond	Susceptible	Moderate Resistance	4.5 feet	Uneven ripening, good juice
Ben Sarek	Resistant	Mod. Susceptible	3 feet	Very large fruit, productive
Black Down	Susceptible	Resistant	4 feet	Large fruit, strong, musky flavor
Black September	Susceptible	Resistant	4 feet	Large, mild fruit, late
Consort	Resistant	Susceptible	4 feet	Small fruit, possible poor fruit quality
Crusader	Resistant	Susceptible	5 feet	Needs pollinator, preferably Consort
Hilltop Baldwin	Susceptible	Resistant	4.5 feet	Old English cultivar, heavy yields
Invigo	Susceptible	Resistant	4 feet	New German release, even ripening, late
Titania	Resistant	Resistant	6 feet	Large fruit, good fruit quality

All listed currant varieties belong to the species *R. nigrum*, except Consort and Crusader, which are hybrids between *R. nigrum* and *R. ussuriensis*.

Table 8. Red, pink, and white currant varieties suitable for Minnesota

Name	Color	White Pine Blister Rust	Powdery Mildew	Fruit Size	Comments
Jonkheer van Tets	Red	Resistant	Mod. Susceptible	Medium	Vigorous
Rovada	Red	Mod. Susceptible	Susceptible	Large	High yielding and easy to pick
Red Lake	Red	Susceptible	Mod. Resistant	Medium	Bred in Minnesota
Tatran	Red	Resistant	Mod. Resistant	Large	Long fruit clusters, late ripening
Blanka	White	Susceptible	Resistant	Large	Heavy yields
Pink Champagne	Pink	Mod. Resistant	Mod. Resistant	Med	Considered best for fresh eating
Primus	White	Susceptible	Resistant	Medium	High yielding, sweet

CLOVE CURRANTS

‘Crandall’ is the only registered cultivar of *R. aureum* and is often listed as *R. odoratum*. ‘Crandall’ has large black berries on small clusters, but was primarily selected for fragrant, yellow flowers. Many

nurseries list ‘Crandall’ as a black currant, but the fruit tastes very different, and is more suitable for fresh eating.

HISTORY

Europeans domesticated black currants about 400 years ago, while red currants were domesticated 500 years ago. Red currants were commonly grown in Scandinavia and the Netherlands, while black currants were more common in Germany, Eastern Europe, Russia, and Siberia. From Eastern Europe through Siberia, black currants became a staple part of the diet and a critical source of Vitamin C prior to the widespread consumption of orange juice and other citrus products. Cultivars of both red and black currants were brought to North America by the first European settlers. For several hundred years currants were planted in homesteads as European settlers moved west.

In the Great Plains, Native Americans regularly put clove currants into pemmican, a mixture of lard, dried meat and berries that was a winter staple. Clove currants were domesticated in the 19th century as an ornamental. In the first half of the 20th century, the cultivar 'Crandall' was widely planted in yards across the United States for its fragrant flowers, but lost favor with landscapers towards the end of the century.

In the 19th century the disease white pine blister rust came to North America on infected white pine seedlings, and by the early 20th century, the disease was killing whole white pine forests across

the northern U.S. White pine blister rust infects five-needle pines, including economically important eastern white pine, western white pine, and sugar pine. The fungus that causes white pine blister rust needs to spend part of its life cycle on a *Ribes* leaf in order to complete its life cycle. Early control efforts concentrated on eliminating currants and gooseberries. Laws were passed restricting transport of any *Ribes* plants in 1916, followed by prohibitions against *Ribes* production in the 1920s and a nationwide law prohibiting all production enacted in 1933. During the Great Depression, the U.S. Forest Service hired large groups of men to march through white pine forests in Idaho, the Midwest, and Northeast and pull every *Ribes* plant. Neither the prohibition nor attempted eradication of *Ribes* stopped the disease, and after 1966, states were free to permit or outlaw the planting and cultivation of currants and gooseberries. While several northeastern states continue to restrict *Ribes* to this day, Minnesota now has no restrictions on currant production.

Because currants were outlawed in Minnesota from the 1920s to the 1960s, many of the traditional recipes that would have been transferred from immigrants to their children and grandchildren were lost. When restrictions for growing currants were lifted, few people even knew how to use them.

USES AND HEALTH BENEFITS

Currants are rarely eaten raw. Black currants are sour with a strong, resinous taste that turns many people off. Red currants are sour, and some cultivars have large seeds. Clove currants also have a resinous, sour taste, although not as intense as black currants. There are a few white cultivars such as the champagne currants that were selected for fresh consumption, but even champagne currants are best used as a garnish rather than eaten in large quantities.

Processed currants have a wide variety of uses. Black and red currants can be made into jellies, jam, or

wine. Currant syrup can be used to flavor and color ice cream. Black currants are used to make the cassis liqueur or crème de cassis. Both black and red currants can make juice rich in Vitamin C. Red currant juice has a tart flavor similar to pink lemonade, while black currants are added to other juices to add color and flavor. Purple candies in the U.S. are grape-flavored, but in other parts of the world, purple candies are typically currant-flavored because currants are so popular and well-known. All currants are sour, so a sweetener and water are usually added to currant juice. Both black and red currants can be made into flavorful

wines. In Europe, black and red currants are used in a variety of cooking recipes, from braised meat to cooked cabbage.

Currants are among the most nutritious of all commonly cultivated fruits, containing a rich assortment of vitamins, minerals, and unusual phytonutrients. Black currants were commonly used in traditional medicine across Eastern Europe and Russia. Before phytonutrients were described by modern chemists, the health benefits of currants were attributed to their high Vitamin C content. Currants have three times as much Vitamin C per ounce as oranges, and they have high levels of Vitamin A and folic acid.¹⁸

When phytonutrients were first being discovered, scientists realized that the health benefits attributed to black currants could be due to their high levels of antioxidants and other compounds. Black currants have some of the highest levels of antioxidants measured in any cultivated fruit, and the antioxidants in currants are highly diverse. Black currants contain over twelve types of anthocyanins along with gamma linolenic acid. The primary health benefit of black currants appears to be associated with improvements in blood flow, especially to extremities. In clinical trials, patients who ate black currants or black currant extracts had improved circulation. Currants are even believed to improve vision in the dark, which is attributed to increased blood flow to the eyes.¹⁹

PROPAGATION

Currants are easy to propagate vegetatively. Nearly all currant species send out canes close to the mother plant. Homeowners can dig up and transplant young dormant canes. For growers who want to propagate large numbers of plants, both hardwood and softwood cuttings will root and transplant easily. For hardwood cuttings, canes can be cut in late winter, cut into sections containing two or three buds and placed into potting soil or damp peat moss. After a few weeks, the cuttings will sprout and start forming new roots. The new plants can be transplanted into the field after they develop a root system.

Growers can sometimes skip the nursery by cutting dormant currant canes and placing hardwood cuttings directly into the field. If placing dormant cuttings directly into the field, only use dormant first year canes and make sure that the soil is properly prepared and free of weeds. About three inches of the cane should be placed in the soil, and there should be anywhere from 1 to 4 buds above the soil. The soil needs to remain moist until a sufficient root system is established. Good references for propagating currants can be found in the publications "Uncommon Fruits for Every Garden"²⁰ or "Growing Currants, Gooseberries and Jostaberries in the Inland Northwest and Intermountain West".²¹

PLANTING AND CARE

Most currant cultivars are hardy through USDA Zone 3. Red and black currants grow best in a cooler soil, and mulch can help keep soils cool in a warm climate. Currants will survive and produce crops on poor soil, and they are one of the few crops that can be grown in partial shade. In order to obtain the highest yields, currants should be grown in good soils and in full sun. Currants grow in soils with a pH from 5.5 to 7.5.

Currants can grow either as individual shrubs or as a hedge. Black currants are more vigorous than red currants and should be placed further apart. When growing currants as shrubs, place red currant plants 3 feet apart in the row and black currants 4 to 5 feet apart in the row. If growing as a hedge, currants should be planted 2 feet apart. Rows can be planted 8 to 10 feet apart depending on space required for any equipment that will be used for spraying, weeding, etc. A typical mature shrub will be 4 to 5 feet high and 3 to 4 feet wide. Some black currant varieties are self-infertile, which means that the flowers of one cultivar cannot pollinate flowers of the same cultivar. Two or more varieties should be planted in a patch to ensure pollination.

Currants will survive with no care, but in order to have good quality fruit every year, the plants should be fertilized and pruned. Pruning is critical to maintain consistent production. Currants send up new canes from the crown each year, and each cane can live up to 5 years, but the most productive canes are second- and third-year canes. In order to keep new canes sprouting, some old canes should be cut

near ground level each year in late winter or early spring. A healthy currant plant should have between 5 and 12 canes per plant, and one fourth to one third of the canes should be removed each year.

On rich soils, currants can grow for years with no fertilizer. Fertilizers should be added if canes are too short (less than three feet tall) or if the plants are not producing enough canes. There should be about 12 canes per plant. If vigor is starting to lag, plants should be given about two ounces of actual nitrogen each year. Conventional growers can supply two ounces of nitrogen with eight ounces of ammonium sulfate or ten ounces of calcium nitrate per plant. Organic growers can supply two ounces of nitrogen with two pounds of high quality compost or one pound of feather meal per plant. All fertilizers should be spread six inches away from the plant. Granular fertilizer should be added in early spring, while organic fertilizers can be added in late fall or early spring.

Note from Thaddeus:

About Actual Nitrogen...

"Actual nitrogen" is a common agronomic term referring to the amount of pure nitrogen. Ammonium sulfate is about 25% nitrogen, so two ounces of actual nitrogen would be eight ounces of ammonium sulfate.

EDIBLE LANDSCAPING

Several currants are sold as ornamentals. The most common currant used in Minnesota landscaping is the alpine currant (*R. alpinum*), which produces no fruit. In other parts of the country, currants selected for flowers are grown, but those species are not hardy in this area. Black and red currants can be incorporated into landscaping as a hedge, but lack showy flowers. Some cultivars lose all their leaves to powdery mildew or white pine blister rust in late summer.

The golden currant or clove currant (*Ribes aureum*) has great potential for edible landscaping, as it is the only currant species suitable for Minnesota with both showy flowers and edible fruit. Clove currants have arching canes compared to the upright canes of other currant species, which works well as a shrub in a lawn. The cultivar 'Crandall' was selected for large, fragrant flowers that emit a pleasant scent so strong it can be detected twenty yards from the plant. In late summer,

the shrub produces edible berries that can be used in pies or juice. 'Crandall' is found in many garden

catalogs, but fruit quality and productivity varies from plant to plant.

PRODUCTION ISSUES

All species of currants grown for fruit production are extremely hardy, and can survive even the coldest Minnesota winters. Many growers in the far northern reaches of the state report having no insect or disease problems, which gives currants a high potential for organic production in northern and western Minnesota. Even deer seem to mostly avoid currants although deer browsing in late winter has been reported. Disease and insect pressure increases in southern and eastern Minnesota.

The two most important diseases in currants are white pine blister rust and powdery mildew. Both diseases can cause the leaves to fall off by the end of summer. White pine blister rust is easy to identify because infected leaves develop prominent red pustules. White pine blister rust is most common in forested regions and primarily infects black currants. White pine blister rust shows up in farms that are surprisingly far from any white pine forests because the type of spores that move from pines to infect currants can travel much farther than the spores that move from currants to pines.

Powdery mildew often infects young leaves, causing the leaves to be deformed. In the late stages of infection, the leaves are partly covered with a powdery substance. Powdery mildew is found statewide and primarily infects red currants. Leaf spot also appears to defoliate some plants.

The best way to control leaf diseases is to plant

resistant cultivars. Diseases can also be reduced by rigorous pruning and removing leaves that fall from currant plants to prevent the fungi from overwintering. Leaf diseases do not occur every year. Currants can produce a crop even after being defoliated the previous summer.

So far, two insect species have caused problems with currant plants: the imported currant worm or currant sawfly and the currant borer. The currant sawfly hatches in early to mid-May in the Twin Cities area, and small green larvae quickly start devouring the leaves. The currant sawfly has one generation per season. Because the plants are defoliated early, the plants will sprout leaves after being defoliated, but there will be no crop on defoliated plants. Sawflies don't appear in large numbers most years, but in peak years they can defoliate an entire field. In southern Minnesota currant borers are quite common, but there are few reports of currant borer in northern Minnesota. Borers lay their eggs in the young currant canes. The larvae hatch, burrow into the canes and slowly kill the canes over the following growing season. Canes with currant borer will often have yellow leaves, and sometimes the holes can be seen in the cane where the borer entered. The best way to control currant borers is to remove and burn infested canes, and by consistently removing 4-year-old and older canes. Stumps can be sprayed with a *Bacillus thuringiensis* (Bt) solution to enhance control. For detailed information on currant pests, see USDA publication "Currant and Gooseberry Pests".²²

HARVESTING

In Europe, currants are usually harvested with machines that shake the canes and gather the falling fruit. The tall, straight canes of the black currant make the crop ideal for mechanical harvest, but the

industry in North America is not large enough to justify the cost of expensive equipment.

Picking currants is slow, but not so slow as to be cost

²² Hummer, Kim and Joseph Postman. *Currant and Gooseberry Pests*. USDA-ARS National Clonal Germplasm Repository, March 2000. Web. 03 March 2017. <https://www.ars-grin.gov/cor/ribes/ribsymp/ribsymp.html>

prohibitive. Currants can be picked either as whole clusters or individual berries. Black currants are often stripped off the strigs, because they ripen unevenly in the cluster. Red currants are often picked as whole clusters, especially if they are being sold for fresh markets, because picking can damage the fruit and

lower the shelf life. Estimated average harvest time for a good crop of currants is 4 pounds per hour for black currants to 8 pounds per hour for red currant.²³ Harvesting will be faster if all the berries on a cluster are ripe and the berries on the cluster can be stripped at one time; or if the fruit is large.

COMMERCIAL POTENTIAL IN MINNESOTA

Currants have the potential of becoming a large, commercially important crop in Minnesota. Northern Minnesota has some natural advantages for growing currants, with cooler summers and lower disease pressure than in surrounding states. The market for currants is small but growing. The demand for currants jumped dramatically in the 1990s with the arrival of immigrants from Eastern Europe and the former Soviet Union. Immigrants primarily buy black currants. American-born customers are more likely to buy red currants, but red currants remain largely unknown for most consumers. Interest in red and black currants among people who were born in the United States is growing as customers look for novel flavors and healthful foods. Growers who want to raise currants commercially have opportunities to build markets by giving potential customers samples of currant products like pies and jellies. Some people have started putting black currants in smoothies to add color, flavor, and health benefits.

There are a handful of growers producing currants for local markets throughout Minnesota and in surrounding states. Most currant growers are enthusiastic supporters of this little-known crop, due to relatively low pest pressure and potential health benefits. Some grow black currants for immigrants who pick their own fruit. Others grow red and black currants for sale at local farmers' markets. Many growers are seeing rising sales with the increased interest in local foods. Because of their superior resistance to white pine blister rust, and the tendency for consistent ripening within clusters, most growers prefer to raise red currants.

Safe Food Sampling

Vendors providing samples at farmers' markets must comply with the 2014 Minnesota Safe Food Sampling Law. More information and resources can be found at UMN Extension: <http://www.extension.umn.edu/food/food-safety/food-entrepreneurs/>

Note from Thaddeus:

I have shared many meals with friends from Russia, and they rarely served an evening meal without black currants incorporated in some way. Russians go beyond the pies and jams used by Americans when using their favorite fruit. They make a paste of black currants that is put on cooked cabbages or meat the same way others use ketchup or salsa. A staple in the German diet is red cabbage, which is cabbage cooked in the juice of red currants, apples and spices.

²³ Hummer, K.E. and D.L. Barney. 2002. Currants. *HortTechnology* 12: 377-387

elderberries

Elderberry plants are tall shrubs with fast-growing, hollow, short-lived canes that produce white flowers in distinct clusters known as cymes (Figure 17). There are elderberry species that produce red fruit, yellow fruit, or fruit that ranges from blue to black in color, referred to here as “blue/black.” Only the species with blue/black fruit are edible. The species that produce blue/black fruit tend to have flat or slightly round cymes, whereas red elderberry species tend to have conical or pyramidal cymes. While some species of elderberries can grow twenty feet tall, the canes usually live only a few years, and new canes are constantly sprouting from the mother plant’s crown or spreading rhizomes. Red elderberries are native to Minnesota and found across the state, while the edible American elderberry’s historical natural range was just south of the Minnesota-Iowa border. Observations suggest the range may be moving north.

Elderberries are easy to grow, produce high yields, have few diseases, and are easy to harvest. Interest in elderberries for fruit and flower products has been rising rapidly since 2010 due to recently rediscovered health benefits.

The two main species of elderberry used in commercial elderberry production are the European elderberry, *Sambucus nigra* and the American elderberry, *Sambucus canadensis*. The American elderberry is found along the east coast from Florida to Quebec and west to Kansas and Nebraska. In the Midwest, the northern range of wild *S. canadensis* is close to the Iowa/Minnesota border. Both *Sambucus canadensis* and *Sambucus nigra* have dusky black fruit with a purplish cast that produces a dark purple juice. Some *S. nigra* cultivars are considered hardy to Zone 4 (-25°F). *S. canadensis* is considered hardy to Zone 3 and is currently being used for commercial production in Minnesota.



Figure 17. Elderflowers of an American elderberry

A third species, the blue elderberry *Sambucus caerulea*, is native to North America west of the continental divide from Montana to British Columbia to California. The blue elderberry is distinguished by a waxy coating on the fruit skin, giving the berry a light blue color. In spite of large, edible berries and cymes that can reach two feet in diameter, the blue elderberry has not been grown commercially to any extent. Blue elderberries ripen evenly within the cyme, making wild collection easy and could make the species desirable for commercial production. *S. caerulea* has never been domesticated. *S. caerulea* grows naturally in parts of Montana with a Zone 4 climate, but has not been tested in Minnesota.

In some books and articles, the three major species of blue and black-fruited elderberries are lumped into one species, *Sambucus nigra*, which would make the

American elderberry *S. nigra* subspecies *canadensis*. The aggressive lumping of different elderberry species into one species was due to the work of one taxonomist who did his work in the 1990s. His conclusions were not accepted by many scientists who studied elderberries and will not be used here. The two domesticated species of black elderberry have critical differences that influence how the crop is grown and processed. European elderberries only flower on second and third year canes, while many American elderberries can form flowers on first year canes in addition to older canes. Chemical differences between the fruit of the European and American elderberry species change how the fruit can be processed. Finally, the two species do not readily hybridize.

Elderberry canes leaf out early in the spring but do not bloom until June in Minnesota. As a result,

Table 9. Elderberry species names, common names, ranges, and important traits.			
Species	Common Name	Range	Important traits
<i>Sambucus nigra</i>	Black Elder	Europe, western Asia	Few rhizomes; tall, upright shrubs
<i>Sambucus canadensis</i>	American elderberry	East Coast to Great Plains	Produces fruit on first year canes, spreads by rhizomes
<i>Sambucus caerulea</i>	Blue elderberry	Rocky Mountains to Pacific Coast	Blue fruit ripens evenly in cyme, tall shrubs



Figure 18. Elderberry cyme with ripe fruit (photo courtesy of P. Otten, Natura Farms)

the leaves could be occasionally damaged by hard frosts if they sprout early. Frost injury to the blossoms is rare due to the summer bloom times. Elderflowers on second year canes will bloom for over a month, and many cultivars of *S. canadensis* will bloom on first year canes. In plants with new and old canes, bloom and harvest can last two months. Some cultivars that bear on first year canes are determinant, producing flowers at one time, while other cultivars are indeterminant and continue to produce flowers through fall.

Most cultivars of elderberries, whether *S. canadensis* or *S. nigra*, are selections of wild plants that have been propagated vegetatively. There are about 35 cultivars from both species. Several *S. nigra* cultivars

were selected for ornamental value with yellow leaves or purple flowers and edible fruit, but have productivity too low for commercial fruit production.

All the current *S. canadensis* cultivars available for the U.S. market come from breeding and selection programs in New York, Nova Scotia, and Missouri. The New York and Nova Scotia programs were active during mid twentieth century, while the Missouri program started in 1998. The only true breeding program was Nova Scotia, which used New York cultivars as parents. There are no known interspecific hybrids of elderberries between the European and American species. The Missouri program primarily uses wild selections from Missouri and will be releasing more new cultivars in the next few years.

Table 10. Zone 4 Elderberry cultivars				
Cultivar Name	Species	Origin	Characteristics	Yearly Mowing?
Samdal	<i>nigra</i>	Denmark	Vigorous, tall shoots, large cymes	No
Samyl	<i>nigra</i>	Denmark	Productive, good flowers, pollinates Samdal	No
Adams	<i>canadensis</i>	New York	tall shoots, upright canes	Yes
Bob Gordon	<i>canadensis</i>	Missouri	shorter, bending canes	Yes
Wyldeewood	<i>canadensis</i>	Missouri	shorter, bending canes, early ripening	Yes
Johns	<i>canadensis</i>	Nova Scotia	Large cymes, vigorous upright canes	Yes
York	<i>canadensis</i>	New York	Large berries, late ripening, shorter canes	Yes

HISTORY

Elderberry fruit have been used both in Europe and North America for millennia. In North America, all blue and black elderberry species were consumed by Native Americans. In arid valleys of the west, blue elderberries were the most common wild fruit available, and so became a critical part of the diet. In addition to the fruit, the leaves, flowers, and occasionally the roots have been used throughout the world to cure a variety of ailments. The hollow stems were used to make flutes.

Europeans and European settlers in North America collected wild fruit from plants growing in waste areas near roads and swamps to be used for jelly, juice, and wine. Because all edible species of elderberries are easily harvested from the wild, there was little interest in selecting cultivars and growing elderberries in commercial operations.

Interest in commercial elderberry production in the United States increased during the early 2000s as

the public started to show an interest in consuming elderberry products for their health benefits. At first, the health benefits attributed to elderberries were primarily rediscoveries of ancient knowledge. Since 2010, many scientists have been showing that the ancient uses of elderberries to cure diseases are based on solid science. As the demand for elderberries grew, processors wanted a more consistent supply and quality than can be acquired through wild plants. Researchers in Missouri began to release new, productive cultivars.

In the past decade, elderberry cooperatives have been established in seven different states, including Missouri, Iowa, New York, and Minnesota. Within each state a group of growers have organized to share knowledge on the best ways to grow and market the crop. Although elderberries are an old product, it is a new crop for fruit growers, and American scientists and producers are still developing new systems to grow the fruit profitably.

USES AND HEALTH BENEFITS

Fresh elderberries are not acceptable for fresh eating, due to low sugar content, bitter flavors and small levels of cyanide producing compounds (See Anthocyanins and Cyanogenic, below). When properly processed, elderberries have a unique flavor that most consumers find quite pleasing, along with a pleasant purplish color. Most elderberries are processed into jellies, syrups, sauces, juices, and wine. Elderberry juice is often mixed into other juices, such as apple or pear to give a unique flavor, a purple color, or to increase antioxidant levels of the product.

Elderberries have little natural pectin, and elderberry jelly does not jell easily. Use of a pectin that interacts with added calcium powder, such as Pomona's Universal Pectin²⁴, might be more successful than

the more commonly available pectins that interact with sugar. Elderberries are low in acid, so jelly or juice tastes better when lemons or another acidic fruit is added. Elderberry juice is fairly similar to chokecherry juice, which also jells poorly, so recipes for chokecherry jelly could be tried with elderberry juice. In the book, "Stalking the Wild Asparagus" Euell Gibbons promoted the idea of mixing elderberry juice with tea from the sumac fruit. Sumac tea is highly acidic, with a taste similar to lemonade, and it gives a nice zing to the elderberry juice.

Elderberry flowers or "elderflowers" are edible and have many healthy attributes. Elderflowers can be used to flavor wines and liquors, make syrup, make tea, or simply dipped in batter and fried.

²⁴ The Minnesota Institute for Sustainable Agriculture does not endorse particular commercial products, but is providing this product name because of its unusual properties that may make it suitable for use with low-pectin perennial fruits.

Elderberries and elderflowers are being incorporated into over-the-counter medicines. The Sambucol® brand includes many patented products made from elderberries that are being sold as a cure for colds and flu based on brand-funded research.

Elderberries are rich in essential nutrients and antioxidants and contain medicinal compounds. In addition to Vitamin C, elderberries are one of the few blue fruits with Vitamin A, and they even have Vitamin B6 and iron. Much of the current interest in elderberry production has been driven by potential health benefits from the medicinal compounds in all parts of the plant.

One of the first recorded uses of elder for health purposes comes from Hippocrates, circa 400 BC who referred to the elderberry bush as his medicine chest because of the wide variety of uses. Four hundred years later, the Roman physician Dioscorides and Pliny the Elder wrote about its widespread use. Some home remedies that include elderberries were written alongside cures that contain pig manure, which may not inspire confidence. However, the universal use of elderberries on all continents indicates many legitimate health benefits. Prior to the advent of modern medicine, all parts of the elderberry plant were used to treat a large variety of ailments. The leaves were used as a poultice to treat aches and speed up healing. The pith was used to cure diseases and ease the pain of childbirth. Many different parts of the plant, including the flowers, were used as a laxative.²⁵

Like all blue fruit, elderberries are rich in anthocyanins. Most anthocyanins are chemically unstable compounds that easily break down during processing. Food manufacturers have avoided using anthocyanins in food dyes because the blues or reds often disappear in cooking and storage. American elderberries have unusually stable anthocyanins called acylated anthocyanins, which

consists of a normal anthocyanin with a smaller molecule attached to it. The acylated anthocyanins give the juice of American elderberries stable purple color and high antioxidant levels that are retained even after extensive processing. The anthocyanins in European elderberries are the normal unstable types.²⁶

Both the flowers and fruit contain substances that appear to kill some types of bacteria and even help keep viruses from replicating, suggesting that elderberries can help cure the common cold.²⁷ Elderberries contain the active ingredients for an herbal medicine called Sambucol®, which people drink as a syrup to recover from colds. The fruit of some species contains valeric acid, which can help control asthma. Another substance in the fruit stimulates insulin secretion while enhancing glucose absorption, which suggests that it could be used in treating the symptoms of diabetes.



Figure 19. Elderberry cyme with ripe fruit

²⁵ Charlebois, D., P.L. Byers, C.E. Finn and A. L. Thomas. Elderberry, Botany, Horticulture, Potential. 2010. *Horticulture Reviews*. Volume 37, pp. 213- 280

²⁶ Bakowska-Barczak. 2005. Acylated anthocyanins as stable natural food colorants. A review. *Polish Journal of Food and Nutrition Sciences*. 14: 107-116

²⁷ Charlebois, D. et al. 2010; *ibid.*

ANTHOCYANINS AND CYANOGENIC

All types of fruit are extremely complex chemically, and sometimes very different chemical compounds in the fruit have similar names. The words *anthocyanin*, *cyanide*, and *cyanogenic* all sound similar, but the first word in some ways is the opposite of the second two words. The term “cyan” refers to a blue color, and cyanide was first isolated from blue-green algae, which are also called cyanobacteria.

Anthocyanins are chemical compounds that make fruit blue or red. Anthocyanins are beneficial with no harmful side effects.

Like many medicinal plants, elderberries can be toxic. Most parts of the plant contain cyanogenic glucosides that can release the poison hydrogen cyanide. Levels of the cyanogenic glucosides in the fruit vary greatly between cultivars, and some cultivars have none. As a general rule, raw elderberries can be eaten in small quantities. Stems have high levels of cyanide, and therefore during processing, berries should be removed from the cyme as much as possible. Although roots and stems have been used in traditional medicines, their consumption is not recommended due to high cyanide levels.

Cyanogenic glycosides are sugar compounds that contain cyanide, and are found in the tissues of about 2000 plant species from many different families. Cyanogenic glycosides are stable and harmless in living plant cells. Cyanides are released when the cell structure is broken down allowing cyanogenic glycosides in one part of the cell to

come into contact with enzymes from another part of the cell. The most common ways cell structure is broken down are when leaves are frozen and thawed, chewed, or ground up. Cyanide is an extremely toxic compound that plants use to discourage animals from eating certain parts of the plant. Cyanide can kill people if moderate amounts are eaten. Common plant tissues that have cyanide include cassava, sorghum leaves, stone fruit pits, and apple seeds. Among the emerging crops, elderberries, aronia, chokecherry, wild plums, and juneberries all contain cyanogenic compounds in seeds and leaves. A small amount of cyanide is harmless. Humans can absorb 50 to 60 ppm cyanide per hour with no consequences.²⁸ A person would have to eat and thoroughly chew at least 22 apple seeds in an hour to exceed 60 ppm cyanide and 143 apple seeds to reach harmful levels (calculated from Bolarinwa et al. 2015 using maximum cyanide levels).²⁹ Lethal doses occur at about 200 ppm per hour (Bolarinwa et al.) With stone fruit, the danger from cyanides is low, because the cyanogenic glucosides are in the pit and pits with high levels of cyanogenic glucosides are too bitter to eat. There are apricots with “sweet pits” that are edible and contain edible concentrations of cyanogenic glycosides. Almonds (a stone fruit closely related to peach and apricot) have been bred to contain low cyanide. Juneberries contain enough cyanogenic glycosides to give cooked products an almond flavor but not enough to harm anyone’s health.³⁰

²⁸ <http://extoxnet.orst.edu/faqs/natural/cya.htm>

²⁹ Bolarinwa, I.F., C. Orfila, and M.R. Morgan. 2015. Determination of amygdalin in apple seeds, fresh apples and processed apple juices. *Food Chem.* 170:437-442

³⁰ Vetter, J. 2000. Plant cyanogenic glycosides. *Toxicon* pp. 11-36.

Elderberries can be propagated by seeds, hardwood cuttings, rhizomes and simply by digging up and replanting whole dormant suckers. Seed propagation occurs wherever there are birds and elderberries, but seedlings vary in fruit quality, vigor and productivity. The variability due to seed propagation can be beneficial for people trying to find new cultivars suitable for various climates and soils. Plants started from seed take one or two years longer to come into production than plants started from cuttings.³¹

People who want to retain all the characteristics of the mother plant must use vegetative propagation. For those who want to make five or so plants, digging up dormant suckers works quite well. Growers who need many plants in a short period of time can use hardwood cuttings. Dormant first-year canes can be cut either at the beginning of winter and put in cold storage for the winter or taken at the end of the winter and planted directly in the

ground. Considering the potential for winter injury in Minnesota, cuttings probably should be taken in late November or early December and put in cold storage for two months or until the buds start swelling. The temperature in cold storage should be between 32° and 40°F, with high humidity. As soon as the buds swell, the cuttings should be put into soil and placed in full sunlight. Cut canes into sections containing two to three buds and place them in a propagation bed consisting of sand, peat, or good garden soil. Rooting hormones are advisable but not necessary. Cuttings can be put in a nursery bed outside, planted in pots in a greenhouse, or planted directly in the field in early spring. By planting in pots or an outside nursery bed, the field can be prepared or used for another crop the first year. Putting cuttings directly in the field avoids the extra step of transplanting, but the field must be kept weed free the first summer. Not all cuttings sprout, so be prepared to fill in spots the following year or in late summer if planting directly into the soil.

PLANTING AND CARE

Elderberries grow in a wide range of soils. In Missouri and other states elderberries commonly grow in ditches next to roads where the plants tolerate short term flooding. Depending on the species and cultivar, elderberries will grow in soils with a pH between 5.5 and 7.5, with some reports of berries growing in soils with a pH of 8.0. Elderberries are tolerant of soils fairly high in clay. In their native habitats, elderberries rarely grow in sandy soils. If growing elderberries in sandy soil, irrigation is necessary.

Elderberries should be planted further apart than other berries. Plant from two to four feet apart within the row for a hedge and further apart for individual shrubs. Rows should be at least ten feet apart. Once established, elderberry plants grow rapidly and can

spread easily, creating a thicket that is difficult to walk through. Growers who planted their rows too close together (eight feet) usually wished that they had planted their rows further apart. Plant spacing should be adjusted according to plant height.

Perennial weeds such as quackgrass and Canada thistle should be killed before planting elderberries. After becoming established, elderberries can outcompete weeds; but for the first two years, the plants should be kept completely weed free. Elderberries grow well when mulched the first two years after planting. Controlled studies that compared different types of mulch showed no difference in weed control or growth between wood chip mulch and plastic mulch. Durable landscape fabric and heavy plastic mulches that last more than

³¹ Byers, Patrick. *Elderberry Propagation*. University of Missouri Extension. <http://extension.missouri.edu/greene/documents/Horticulture/Elderberry/ElderberryPropagation.pdf>

two years should be avoided, because they inhibit new shoots from sprouting near the mother plant.

Elderberries can be grown on a one-year (annual) cane system, a two-year (biennial) cane system, or a three-year (perennial) cane system. In the one year or annual cane system, the canes are mowed to the ground every year. The annual system can only be used on selected *S. canadensis* cultivars which flower and fruit at the tip of first year canes. The biennial cane system can be used for both *S. canadensis* and *S. nigra* cultivars. Most European varieties only produce flowers on canes that have gone through one or more winters, which means that best yields are accomplished with a biennial or perennial cane system. In the perennial system, canes older than three or four years are pruned out each winter, which allows plants to grow 15 to 20 feet high. Berries on three- and four-year-old canes ripen unevenly within the cyme, while berries on second year canes ripen evenly within the cyme. Many European producers use a modified biennial system where plants are pruned every other year to a height of three feet, which means that most fruiting canes are in their second year.

American growers have had more success growing all of their elderberries on first year canes, although not all named cultivars or wild plants are suitable

for this practice. Each spring, the shrubs are mowed or cut to ground level, leaving no overwintering canes. The annual cane system is more suitable for mechanization, and the berries on cymes of first year canes ripen evenly. In Minnesota, growers using the annual cane system do not have to worry about losing a crop if the canes die from winter injury.

In a study conducted in Missouri, three cultivars of elderberries were grown with four different pruning systems: the annual cane system mowed every year, a biennial system where plants were mowed to the ground every other year, a system where the older canes were selectively removed, and plants that were never pruned. Plants of the cultivar 'Netzer' that were mowed every year had half the yield of those that were selectively pruned, while 'Adams II' yield in the annual system was nearly identical to other types of pruning. 'Bob Gordon' had the highest yields overall, and annual mowing reduced yields about 25% compared to biennial mowing or selective pruning. Cymes of 'Adams II' and 'Bob Gordon' in the annual system were nearly twice as big as cymes from other pruning systems. The larger cymes, increased harvest efficiency, and lower labor costs for 'Bob Gordon' with the annual system made up for the reduced yields.³²



Figure 20. Elderberries grown in the annual cane system in early June. (Photo courtesy of P. Otten)

³² Finn, C. E., A. L. Thomas and P.L. Byers. 2008. Evaluation of American (*Sambucus canadensis*) and European (*S. nigra*) elderberry genotypes grown in diverse environments and implications for cultivar development. *HortScience*. 43:1385-1391.

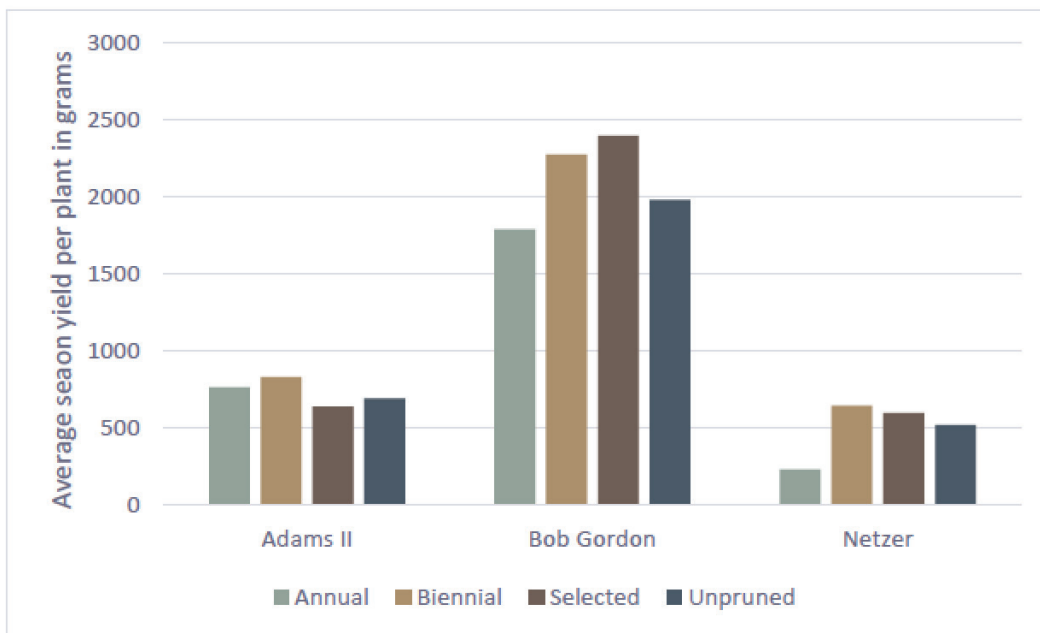
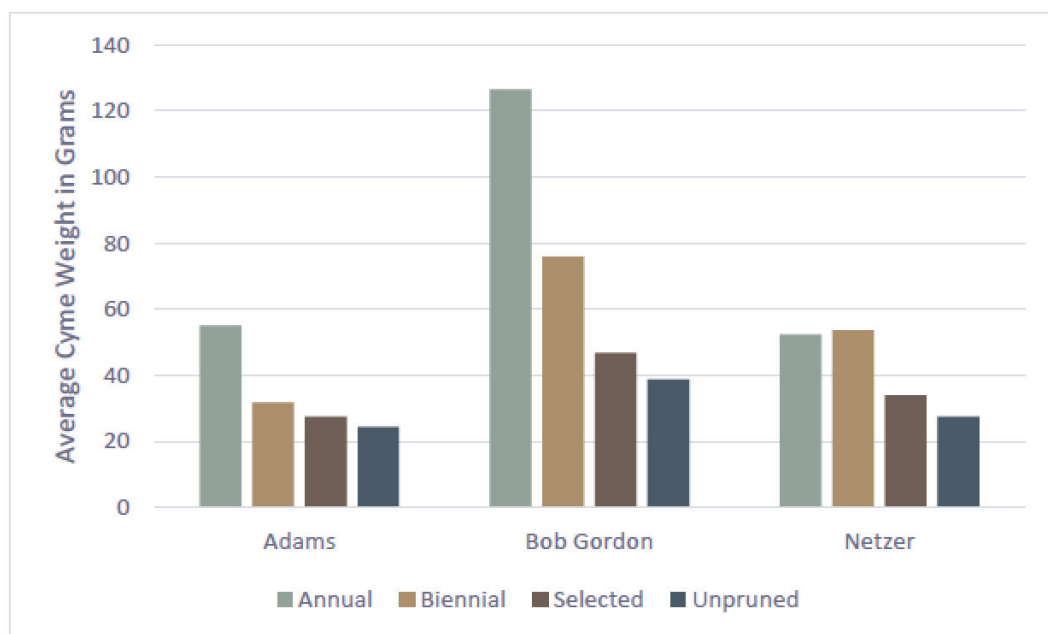


Figure 21. Average yield for three American elderberry cultivars that were either mowed every year, mowed every other year, selectively pruned or left unpruned. The berries were grown in two sites in Missouri from 2003 to 2007. Figure from Finn et al., 2008.

Figure 22. Cyme weight for three American elderberry cultivars that were either mowed every year, mowed every other year, selectively pruned or left unpruned. The plants were grown in two sites in Missouri from 2003 to 2007. Figure from Finn et al., 2008.



PRODUCTION PROBLEMS

Elderberries have few diseases or insect pests in most of Minnesota. Problems with elderberry rust, powdery mildew, and mites become more likely as you move south and east. Deer occasionally feed on elderberries, especially on young plants and succulent growth. The two biggest issues elderberry growers face are bird pressure and Spotted Wing Drosophila. Elderberries appear to be a preferred host for Spotted Wing Drosophila, a pest which showed up in the state in 2012. Currently, Minnesota elderberry growers are

still trying to figure out how to control Spotted Wing Drosophila. Spotted Wing Drosophila numbers appear to peak in late July and often drop to minimal levels by early September, so late ripening elderberries may escape severe infestations.

Some growers find it necessary to net their plants to protect their crop from birds, while others are able to harvest a crop with minor bird damage and no nets.

HARVESTING

Elderberries are typically harvested by cutting the cymes from the plant and separating the berries from the cyme after picking. Ladders are rarely used, because elderberries are typically trained to be 10 feet tall or

less. Removing berries from the cymes is usually the most labor-intensive step in harvesting elderberries, so most large processors have machines that shake the cymes and remove the berries.

EDIBLE LANDSCAPING

If properly pruned and maintained, any of the major cultivars of elderberry can be an attractive addition to a landscaped yard or the edge of a garden. All elderberries have flowers that bloom in early summer when few other flowers are open. Elderberries have long been a part of ornamental gardens in England as well as in the U.S. Several European cultivars have been selected as ornamentals yet still produce edible fruit. 'Black Beauty' has black

leaves, contrasting pink flowers, and produces black, edible fruit. 'Black Lace' also has deeply cut black leaves and edible fruit. 'Variegated' has variegated white and green leaves, but slower growth and lower productivity. The western species *Sambucus caerulea* has an upright growth habit, giving the plant good form, and has light blue fruit that stays on the plant for several months, adding an unusual blue color to the fall landscape.

COMMERCIAL POTENTIAL IN MINNESOTA

Although elderberries have been eaten in North America for thousands of years, most Americans have never heard of the crop. Even in parts of the U.S. where elderberries grow wild, only a fraction of the fruit is harvested and processed. In a 2011 survey, only 33% of consumers nationwide had heard of elderberries.³³ In Minnesota, that number is probably smaller because the state lies north of the natural range for the American elderberry, and there is no tradition of making elderberry wine or jelly among rural Minnesotans. In spite of the low visibility, demand is higher than supply, primarily from people who claim that a cold or flu was cured by elderberry tea, juice, or jelly.

The market for elderberries has huge potential, due to a combination of health benefits and good flavor. Elderberries have the benefit of edible flowers in addition to edible fruit, which can add a delicate flavor to fruit juices, cordials, wines and jellies. In some cultivars, the flowers can be harvested without a reduction in total yield, because canes will produce extra cymes.

The Minnesota Elderberry Cooperative (MEC) was started in 2012 to promote elderberry production and find uses for the product. The cooperative members changed the name to Midwest Elderberry Cooperative in 2016 (<http://www.midwest-elderberry.coop/>). Participating members are successfully growing, harvesting, and marketing local elderberries. Currently, Minnesotans are seeing the highest yields using *S. canadensis* varieties that flower and fruit on first year canes, rather than the biennial or selective pruning systems. Yields are likely high enough to support an elderberry industry.

Elderberries appear to be best suited for the southern third of the state. Experimental plots in Staples, Minnesota and Carrington, North Dakota have produced weak plants with poor yields. Growers in northern areas can either experiment with annual production or experiment with perennial culture using hardy *S. canadensis*, *S. nigra*, or even *S. caerulea* seedlings.

³³ Mohebalian, P.M. and F.X. Aguilar. 2013. Conjoint analysis of U.S. consumer's preference for elderberry jelly and juice products. *HortScience* 48:338-346.

goji berries

WOLF BERRIES

Goji berries (*Lycium barbarum*) grow on semi-erect, perennial vines. The fruit is native to northern China, where it was traditionally grown for leaves and fruit. In the 19th and 20th century, they were usually called wolf berries or matrimony vines. As interest in the fruit developed, Americans slowly adopted the name “goji” which is believed to be derived from the Chinese word for the plant.

Goji plants are native to China, where they grow from the subtropics in the south to the cold, dry climate of Inner Mongolia. Commercial fruit production is concentrated near Inner Mongolia. In addition to *L. barbarum*, other species being looked at for fruit quality are often confused with each other, including *L. chinensis* and the black goji (*L. ruthenicum*).

Gojis are one of the few members of the tomato family (Solanaceae) that produce dessert quality fruit. The fruit are red like a tomato, with a green calyx near the stem. Seeds are small and edible, similar to tomato

seeds. Flowers open a purple color which fades to yellow. Gojis are one of the few perennial fruits which have the ability to produce flowers and fruit on current season’s growth. The plants resemble poisonous perennial black nightshade vines and have the potential to become invasive weeds, due to their ability to spread via birds and because they are a perennial vine that can be difficult to remove or kill.



Figure 23. Goji plant with support structure.



Figure 24. Goji vines and flowers



Figure 25. Goji fruit

HISTORY

Goji plants were first introduced into the United States in the 19th century by Chinese laborers who worked in the mines and railroads of the Intermountain West.³⁴ The Chinese primarily grew the plants for their leaves, which were used to make tea or to add to stews. In the early 20th century, the Chinese were tragically forced out of the Intermountain West, but the plants in certain mining areas slowly spread. Few people outside the Chinese community had learned to eat the plants, and naturalized “wolf berries” became classified as an invasive weed in Montana and Wyoming.³⁵

Goji berries were first introduced to the broader American population as a juice with purported

health benefits in the early 2000s. The commercial success of the juice concentrate was followed by a number of imitators, and goji juice was added to a number of juices sold in large grocery stores. By 2010, several major food processors started adding dried goji berries from China to a variety of products, including tea and chocolate.

Most commercial production of goji berry occurs in the Ningxia province of China, which has a continental climate similar to Minnesota. Several producers across the U.S. tried to start their own goji plantations, but none have been able to profitably raise and sell goji berries. Goji production in the United States remains in the experimental stages.

USES AND HEALTH BENEFITS

Goji berries can be consumed fresh, dried, or made into juice. In China, the plants are grown as much for their leaves as their fruit, and the leaves are put into teas and stews. In the U.S., goji berries are

primarily added to juices, chocolates, and pastries or consumed as dry fruit. Goji seeds are similar in size and texture to tomato seeds, and are barely noticeable when eaten. The berries can be eaten

³⁴ Thorogood, Rachel. “The Simple, Safe and Secure Way to Order Organic Goji Berries Online.” *Forgoijberries.com*. N.p. Web. 03 March 2017. <http://www.forgoijberries.com/>

³⁵ Karp, David. “Goji taunts North American farmers.” *Los Angeles Times*, 5 August 2009. Web. 03 March 2017 <http://www.latimes.com/food/la-fo-goji5-2009aug05-story.html>

fresh and have a pleasant flavor with a good sugar/acid balance that resembles no other fruit. The market for fresh goji berries has not been tested. Goji berries have been used in herbal remedies in Asia for nearly 2000 years to treat a variety of ailments, including diabetes and impaired vision. When used in herbal medicines, goji fruit was usually mixed in with other beneficial herbs. The orange and red color of the fruit is due to several different carotinoids, including zeaxanthin dipalmitate,

as well as lycopene. The carotinoids have been used to reverse age-related macular degeneration and other problems with the eyes. The berries contain an unusual polysaccharide-peptide complex that may promote the formation of T-cells and help the immune system.³⁶ Like all members of the nightshade family, goji leaves contain some alkaloid compounds which could be toxic if eaten in large amounts, but the toxicity of goji alkaloids has not been tested.³⁷

PROPAGATION AND PLANTING

Currently, there are only about four varieties of goji berries available in North America, including one that is being grown exclusively in Saskatchewan. One cultivar that was released for the 2016 growing season is rated for Zone 3.

Goji plants can be started by seed, softwood cuttings, or hardwood cuttings. Goji berries are related to tomatoes and although about 90% of tomato seedlings are identical to the parent plant, goji berry seedlings are too variable in growth form and fruit quality for commercial fruit production. People who want to grow goji berries for sale need to use plants that were vegetatively propagated from plants with known fruit quality.

Hardwood cuttings of some varieties root readily, while other varieties will not. Softwood cuttings are

more reliable. Green branches are clipped in the middle of summer and placed into a peat/perlite or sand medium. Dipping the cuttings in a rooting hormone is highly recommended. The cuttings are placed in either a closed plastic bag or a mist chamber for three weeks.

Goji berries grow best in a sandy loam or a sandy soil, and they tend to be tolerant of drought. Most varieties are a type of vine, and the plants need some type of support structure.

Goji plants are related to tomatoes, peppers, eggplant, and potatoes; and are susceptible to some of the same diseases, so growers may want to plant gojis twenty or more yards away from these plants. Always avoid planting goji in areas that have been previously planted into these related species.

PRODUCTION PROBLEMS

Goji plants are susceptible to *Alternaria*, which is a fungus that can kill leaves and young shoots. In tomatoes, *Alternaria* is usually called early blight, and goji plants appear to be more resistant than tomatoes. In a test block, only half of the seedlings were damaged by *Alternaria*.

Goji berries are bright red when fully ripe, have soft skins, and ripen in the middle of summer. All of these traits are attractive to Spotted Wing Drosophila which means that the fruit will almost certainly be susceptible to attack.

³⁶ Dharmananda, Subhuti. Lycium Fruit: Food and Medicine. *Institute for Traditional Medicine*, August 2007. Web. 03 March 2017. <http://www.itmonline.org/arts/lycium.htm>

³⁷ Goji Berry Uses, Benefits & Dosage – Drugs.com Herbal Database. Web. 06 Apr. 2017. <https://www.drugs.com/npp/goji-berry.html>.

COMMERCIAL POTENTIAL IN MINNESOTA

Goji plants can grow in Minnesota. Growers interested in gojis should either look for cold hardy varieties or develop new productive varieties from seedlings. Due to potential problems with Spotted Wing Drosophila and *Alternaria*/early blight, organic production may be difficult.

The commercial potential for gojis is unknown. Goji consumption in the U.S. is increasing rapidly, but nearly all the goji products are imported from

China. Minnesota growers interested in producing goji berries must find niches that can compete economically with Chinese imports. Due to higher labor costs, Minnesotan-grown goji may be unable to compete in the Chinese import market. Once varieties are found that are suitable for Minnesota's climate, concentration will have to be on locally made products such as juice or the fresh market. (See Marketing of Perennial Fruits chapter.)

EDIBLE LANDSCAPING

Goji berry plants can grow on arbors like *Actinidia*, but otherwise have marginal ornamental value. The flowers are pretty but small, and the plant has a

drab, gray color with an excessive number of small twigs in the winters. Goji plants could be trained to fences to provide support for the plants.

MINNESOTA AND REGIONAL EXPERIENCES

In 2008, a consortium in Saskatchewan tried to start a goji berry business, but the venture failed about three years later.³⁸

The Minnesota Department of Agriculture sponsored a project looking at the feasibility of goji berries in Chisago County, northeast of the Twin Cities metro area, through its Sustainable Agriculture Demonstration Grant³⁹. Instead of testing known cultivars, the growers started all their plants from seed. The original goal of assessing the viability of goji plants turned into a project more like a breeding program similar to tree fruit like apples and pears. People who breed apples and other tree fruit must sort through hundreds of seedlings before finding one that has commercial potential. The goji seedlings in the project had more variability than apple seedlings. Growth rates the first year varied from 1 foot to 8 feet. Winter hardiness appeared to be a minor concern, with nearly all seedlings surviving the first winter. The fungal disease

Alternaria was a bigger concern than winter hardiness, with half the plants losing leaves to *Alternaria* in June. Most seedlings flowered and set fruit during the first growing season, which is unusual for a perennial fruiting plant. Fruit quality varied from yellow, bitter fruit to red berries with good flavor. Many of the weakest plants had the poorest quality fruit. Out of 70 seedlings, one appeared to have the vigor, disease resistance and fruit quality acceptable for commercial production (the plant in Figures 23-25), but the project was discontinued before the plant could be tested for yields and propagated.⁴⁰

The project demonstrated that goji plants can grow and produce fruit in Minnesota, but the first step is to develop or find varieties with acceptable fruit quality, high yields, disease resistances and cold hardiness. There should be seedlings suitable for Minnesota within any large population of seedlings.

³⁸ Mintenko. A., personal communication.

³⁹ Minnesota Department of Agriculture, Sustainable Agriculture Demonstration Grant Program. <http://www.mda.state.mn.us/grants/grants/demogrant.aspx>

⁴⁰ Vang, Koua, and Cingie Kong. 2010. Growing the Goji Berry in Minnesota. *Greenbook*. Minnesota Department of Agriculture. Web. http://www.mda.state.mn.us/protecting/sustainable/greenbook/~/_/media/Files/protecting/sustainable/greenbook2010/gb2010-vangkong.ashx.

gooseberries jostaberries

Gooseberry plants are small, thorny shrubs that produce oval, tear-drop, or round berries that vary in size from that of a pea to a small plum. Ripe fruit can be green, yellow, orange, or dark red. Most cultivated gooseberries are the size and texture of seedless grapes with prominent dried petals at the tip of the fruit. Gooseberry seeds are small and edible. Gooseberry fruit are usually sour and firm with a unique, pleasant flavor. The plants tend to be quite hardy and grow best in areas with cool summers.

Like currants, gooseberries belong to the genus *Ribes*. Although closely related, gooseberries have different plants and fruit than currants. Gooseberry canes have prominent thorns at each node, and gooseberry fruit are borne singly or in small clusters. Gooseberry fruit is three to four times larger than currant fruit, and many varieties can be eaten fresh. Gooseberries lack the intense resinous flavors of black currants. Gooseberry bushes are shorter than

currant bushes, with arching, rather than upright canes. In addition to the prominent thorns on the canes, some wild species even have small spines on the skin of the fruit. There are no commercial cultivars with spines on the fruit, but some cultivars have vestigial hairs.



Figure 26. 'Hinnomaki Red' gooseberry

Gooseberries have many similarities to currants, including being very hardy and adaptable to a wide variety of soils. They are also susceptible to the same diseases and pests including white pine blister rust, powdery mildew, and currant sawflies.

There are several species of gooseberries native to Europe, Asia, and North America. The large-fruited, European cultivars primarily belong to the species *R. uva-crispa* (crispy grape) which is listed in many sources as *R. grossularia*. The species native to eastern North America is *R. hirtellum*, and

tends to be more disease resistant than European species. Gooseberry cultivars suitable for Minnesota are primarily hybrids between *R. uva-crispa* and *R. hirtellum*. The Canadian cultivar, 'Jahn's Prairie', is a selection of *R. hirtellum*.

Jostaberries are a cross between black currants and gooseberries that were developed in Germany. Like black currants, jostaberry plants are tall and vigorous shrubs without thorns. The fruit of jostaberries has the large size of gooseberries and are borne in small clusters like currants.

HISTORY

Gooseberries were originally domesticated on the European continent and introduced to England in the 16th century. Gooseberries eventually became quite popular in England, where they thrived in the cool summers. The British developed many large-fruited gooseberry cultivars, and by the 19th century, gooseberries had become the quintessential British fruit. Early attempts to grow domesticated European gooseberry cultivars in North America largely failed, primarily because European cultivars were susceptible to powdery mildew and other diseases and therefore often died when grown in eastern North America.

In the late 19th century, scientists began to breed the American species *Ribes hirtellum* with the European *R. uva-crispa* and developed several cultivars that combined the disease resistance of wild American plants and large fruit quality of European cultivars.

Gooseberry production gradually spread in the U.S. until the early 1920s. Like currants, gooseberries are an alternate host to white pine blister rust, and transport of gooseberries between states was outlawed in the early 1920s. A small group of growers in western Oregon continued to produce gooseberries for processing throughout the 20th century.

After restrictions were loosened in the 1960s, gooseberry production remained stagnant due to poor demand. Gooseberry consumption declined in Europe as well because gooseberries could not compete with imported grapes. The gooseberry's reputation in the U.S. was further hurt because the only cultivar most Americans had ever eaten was the North Dakota cultivar 'Pixwell', which is very sour and develops an off flavor when it ripens.

USES AND HEALTH BENEFITS

Gooseberries can be eaten fresh off the plant or put into pies and pastries. Gooseberry jelly is easy to make, because the fruit contains a large amount of pectin and can jell with little or no added pectin. Pie filling from red gooseberries is similar to cranberries, but with a unique and pleasant flavor. Many professional cooks prefer green gooseberries for processing. There is little agreement among gooseberry growers about whether or not to remove

the prominent dried petals at the end of each berry prior to cooking. Some cooks automatically remove the dried tips, while others process the berries as is.

Gooseberries are sour. There are many varieties that have been selected for fresh eating, but people who don't like sour fruit will struggle to eat the sweetest gooseberry. Gooseberries are one of the rare fruits that can be picked green or very ripe. As a general

rule, fruit destined for jam or jelly can be picked when green. Fruit for fresh eating should be left on the plant as long as possible. Many gooseberry varieties have a very long picking window of two to three weeks, and the berries continue to sweeten until they shrivel or rot.

Jostaberries can be eaten fresh, but many varieties appear to be too sour and strong for most people. Jostaberries can be used in all types of cooking for currants and gooseberries. Otherwise one of the primary uses for jostaberries is as a rootstock for gooseberries. Gooseberries grafted onto

jostaberries tend to be more vigorous and upright than gooseberries started by cuttings. There are five listed varieties of jostaberry, including two that were bred in Oregon and three from Germany. The most common cultivar is called, appropriately, 'Josta'.

Gooseberries will give the same health benefits of eating any other fresh fruit. Gooseberries contain Vitamin C and minerals just like currants, but at lower concentrations. Gooseberries are many times larger than currants, and the nutrient content is diluted. Green gooseberry cultivars lack the high antioxidant levels of black currants.

Name	Fruit Color	Uses	Advantages	Problems
Pixwell	Green/pink	Cooking	Widely available	Poor fruit quality when ripe, difficult to harvest
Invicta	Green-gold	Fresh	Large size, productive	Fruit has small hairs, leaf spot susceptible
Hinnomaki	Red or yellow	Cooking	Productive, good color	Thorns interfere with harvest
Tixia	Red	Fresh, cooking	Attractive, semi-thornless, mildew resistant	Untested in MN
Jahns Prairie	Pink	Fresh, cooking	Disease resistant, few thorns	Untested in MN
Captivator	Red	Cooking, fresh	Large size, few thorns, mildew resistant	Untested in MN
Poorman	Pink	Cooking, fresh	Large size, disease resistant	Thorns

PROPAGATION AND PLANTING

Growers should consider propagating their own gooseberry plants. Many gooseberry varieties are difficult to find, especially in quantities large enough for a commercial planting. Gooseberries tend to be more difficult to propagate than currants because they require more specialized techniques such as tip layering, mound layering (stoolbeds), and hardwood cuttings. Due to the wide genetic variability of gooseberries, some cultivars will root more easily than others. Fortunately, the American species *R. hirtellum* is easier to propagate than the European species, and most suitable cultivars for Minnesota are hybrids of *R. hirtellum*.

Tip layering is one of the surest ways to start plants. Branches are bent over to the ground in late summer, and a small area of the branch, about four inches

below the tip, is covered with soil. Over the next few months, roots form in the area of the branch covered with soil. The following spring, the branch can be cut below the soil and transplanted. Make sure that roots have formed, because some cultivars may need two growing seasons before they can be transplanted. Hardwood cuttings should be taken in the fall when there are still leaves on the canes. Cut canes into 9 inch lengths and remove the growing tip. Place the canes in potting soil or sand for the winter. The cuttings should then be stored in a cool, but not freezing area for the winter, which can be a challenge in Minnesota. According to some sources, jostaberries and some American varieties of gooseberry will, like currants, propagate from hardwood dormant cane cuttings placed directly into potting soil.

Enterprising growers in Europe have successfully grafted gooseberries onto vigorous rootstocks such as jostaberries or clove currants, which produce a more vigorous and upright plant. Vigorous plants can then be trained to a trellis. When canes are growing onto a wire, the fruit hangs below the canes, and away from the thorns. Gooseberries grow well on a cordon-type trellis, with two or three guide wires. A good guide for growing gooseberries on a trellis can be found in the University of Idaho publication "Growing Currants and Gooseberries in the Inland Northwest and Intermountain West."⁴¹

Gooseberries are tolerant of a wide variety of soil types and conditions, but will grow best in a rich,

sandy loam soil. Gooseberries should be planted three to five feet apart, depending on the vigor of the cultivar and the soil conditions. Gooseberries vary from two to five feet tall, prefer cool soil, and respond well to bark mulch. As with all perennial fruiting plants, gooseberries need to be fertilized every year or two in order to stay productive. Mature plants need about two ounces of actual nitrogen each year in order to maintain good cane growth and productivity. The fertilizer can be applied in the form of several pounds of manure each year, or with commercial fertilizers. Eight ounces of ammonium sulfate or calcium nitrate fertilizer per plant is enough to maintain vigor in a gooseberry planting.

EDIBLE LANDSCAPING

Most gooseberry varieties have little ornamental value, with white, thorny canes and inconspicuous flowers. Some varieties have good fall color, provided that the leaves are not killed by diseases first. Gooseberries have their greatest landscaping utility when planted on property borders where the thorny canes will discourage unwanted visitors.

Jostaberries are large and have a good upright growth habit which makes them an edible alternative to many *Viburnum* species. Jostaberries work well as a tall shrub in a lawn, and the leaves turn a pretty red each fall. Jostaberries appear to be more resistant to leaf diseases than gooseberries, which improves their ornamental value.

PRODUCTION PROBLEMS

Gooseberries have few insect and disease problems in most parts of Minnesota, but there are years when the plants will be defoliated by sawflies or leaf diseases. Gooseberries are especially susceptible to powdery mildew and leaf spot, which is the primary reason that large-fruited English cultivars have never been commonly planted in the U.S. Like currants, gooseberries are susceptible to white pine blister rust, which kills leaves and causes unappealing red lesions to form on the fruit.

The most common insect pest in gooseberries is the currant sawfly. Currant sawflies are the larvae of a fly that lays its eggs on the leaves and the larvae eat the

leaves. Sawfly larvae emerge in June and only have one generation per year. In many cases, sawflies will completely defoliate shrubs. Many insecticides will control sawflies, including organically acceptable Bt sprays. Jostaberries are quite susceptible to currant stem borer.

Spotted Wing Drosophila could be a problem in some gooseberry varieties. Gooseberries are known for being crisp. If the fruit does soften after ripening, it should be examined for small maggots. In the future, growers may need to harvest gooseberries early in order to avoid these flies.

⁴¹ Barney, Danny L. and Esmaeil Fallahi. *Growing Currants, Gooseberries & Jostaberries in the Inland Northwest and Intermountain West*. University of Idaho Extension, 2009. Web. 03 March 2017. <http://www.cals.uidaho.edu/edcomm/pdf/bul/bul0855.pdf>

One of the limiting factors with jostaberries is poor fruit set due to inadequate blossom formation or pollination. Poor fruit set occurs inconsistently in different parts of the country. Like many hybrids between distantly related species, jostaberry flowers do not pollinate easily, while some varieties don't produce sufficient numbers of flowers. Always plant

more than one jostaberry, and make sure there are other plants that belong to the genus *Ribes* nearby that could serve as pollinators. Jostaberries often "bleed" when picked. The stem pulls out of the fruit, letting the juice leak out. This limits their shelf life after harvest.

COMMERCIAL POTENTIAL IN MINNESOTA

Minnesota growers who want to profitably raise gooseberries can have good production, but still struggle with low markets and poor picking efficiency. The market for gooseberries is still being developed and few potential customers even know what they are. Some of the people familiar with the fruit have eaten poor quality fruit and are no longer interested as a result. When consumers taste well ripened berries or good quality products made from gooseberries, they are more likely to buy this little-known crop.

Gooseberries can be painful to pick due to the sharp thorns. 'Pixwell' was selected so that fruit clusters hang below the thorns, but several growers have reported that 'Pixwell' is as difficult to pick as other varieties. 'Invicta' and 'Hinnomaki' have thorns that are close to the fruit. The recent selections, 'Jahn's Prairie' and 'Tixia', show promise of having fewer thorns. The best way to facilitate picking is to train grafted plants onto a trellis, so that the fruit hangs below the thorns. A few Minnesota growers have minimized blood loss during picking by using gloves made from synthetic material, and are reporting harvest rates that are commercially viable.

There are probably hundreds of gooseberry varieties, but only a handful have been tested in Minnesota. Those interested in growing gooseberries should try several varieties to see what grows best at their site. With its diverse soils and sites, some areas of Minnesota will have a greater problem with white pine blister rust, while other areas may have a problem with mildew or leaf spot. Varieties that do best in the clay soils and hot summers of southwest

Minnesota will probably not be best for northeast Minnesota. When testing a cultivar for a specific site, always wait until the plant has been producing fruit for at least two years before deciding if the cultivar is suitable.

Note from Thaddeus:

I have been growing the cultivar 'Hinnomaki Red' for 14 years, and I regularly prepare gooseberry pastries for potlucks and other meetings. The fruit has a dark red color similar to cranberries, and they are almost as sour as cranberries, but the flavor is unique. People who like sour fruit generally love gooseberry desserts that are properly prepared. I once did a taste test of fresh berries using fresh 'Hinnomaki Red' and 'Invicta'. Most people preferred the 'Hinnomaki Red', even though 'Invicta' was sweeter and was selected for the fresh market. One small grower with an eighth of an acre of gooseberries has 'Pixwell', 'Hinnomaki', and 'Jahn's Prairie', and has been able to sell all the fruit to restaurants.

honeyberries

HASKAPS

Honeyberries, also known as haskaps, are the recently domesticated fruit of the blue honeysuckle (*Lonicera caerulea*), a small shrub with light green leaves. The blue honeysuckle is considered a circumboreal species, with a native range from northern Norway to Labrador in Canada. The plant produces cream to light yellow, trumpet-shaped flowers that are borne in pairs (Figure 27). The fruit starts ripening in June, shortly before the earliest strawberries. Fruit are dark blue with light colored flesh. The berries form odd, irregular shapes that vary from hearts to purple caterpillars depending on cultivar (Figures 28-30). The largest fruit has the same weight as an average strawberry. The fruit is usually sour, with a taste that resembles a combination of blueberries and raspberries. Those that promote honeyberries as a crop have yet to agree on a common name. The word “honeyberry” is used because the plant is a close relative of the common honeysuckles. Most

domesticated cultivars come from the northern Japanese island of Hokkaido and the Kuril Islands north of Japan, where the indigenous Ainu people called them haskaps. Many people prefer “haskap” to denote the Japanese origin for the plants. Recently, haskaps have been touted as an alternative to blueberries because haskaps are hardier and tolerate a wider range of soils than blueberries. All haskap varieties are hardy to Zone 2, and haskap flowers have the unusual ability to survive temperatures as low as 17°F even in full bloom.

Like many emerging crops, the scientific classification of honeyberries is still being debated. While some nurseries have sold honeyberries under different scientific names, such as *Lonicera kamschatika* and *Lonicera emphylocalyx*, most scientists treat all honeyberries as the same species with distinct subspecies in different countries. The plant called *L. kamschatika* in some publications is



Figures 27 Haskap blossoms

usually written *L. caerulea* ssp. *kamschatika*, while the large-fruited plants from Hokkaido belong to the subspecies *L. caerulea* ssp. *emphyllocalyx*.

Haskaps are so closely related to the mountain fly honeysuckle *Lonicera villosa*, a native of the northeast U.S., that the two have hybridized. Haskaps are only distantly related to the invasive species Tartarian honeysuckle, a tall shrub common in windbreaks and homesteads throughout Minnesota. Like other honeysuckles, haskap seeds are small and unnoticeable when eaten with the fruit.



Figures 28–30. Diverse shapes of haskap fruit.

HISTORY

Although haskaps are circumboreal, most subspecies are marginally edible with berries that are bitter and small. In boreal areas, blue honeysuckles were not eaten as frequently as lowbush blueberries, lingonberries, or cloud berries by indigenous peoples. In East Asia the wild plants produced a larger and more consistently edible product, and they became important in both the Russian Far East and northern Japan.

Russians tried to develop haskaps as a crop as early as 1915, using plants from the Kuril Islands north of Japan, but breeding did not occur in earnest until 1950s in Russia and the 1960s in Japan. Both breeding programs only used fruit from their respective countries. By the 1990s, farmers on Hokkaido were growing haskaps for the commercial market, and gardeners throughout Russia were planting improved cultivars. Low yields and low harvest efficiency proved to be a problem on the Japanese island of Hokkaido. In spite of a good market, land devoted to haskap production sharply dropped after peaking in the mid 1990s, mainly because the farmers could not economically harvest the fruit.

In North America, new cultivars of haskaps are being released by groups in Oregon, Arkansas,

and the University of Saskatchewan. The Oregon group is led by Dr. Maxine Thompson, a retired horticulture professor from Oregon State University. Dr. Thompson has been breeding varieties from Hokkaido in collaboration with Dan Barney, a horticulturist in the Idaho panhandle, to develop cultivars suitable for mild climates. Although selected for mild climates, the Oregon cultivars appear to be hardy in Minnesota. The Arkansas group is led by Lidia Delafield who primarily uses material from the Russian Far East.⁴²

In the early 2000s, Dr. Robert Bors at the University of Saskatchewan began an extensive breeding program for haskaps using seeds from Dr. Thompson's program as well as the Kuril Islands, Russia, and Canada. One goal of the University of Saskatchewan breeding program was to develop varieties suitable for commercial production. Dr. Bors released his first cultivars in 2007, and the first commercial plots in the U.S. were planted a few years later.

The programs in Saskatchewan, Arkansas, and Oregon continue to release new cultivars of haskaps each year. Currently, there are dozens of cultivars, and most are so new that they have not been properly tested in Minnesota.

USES AND HEALTH BENEFITS

The earliest haskap cultivars ripen when no other fresh local fruit is available. A few people are promoting haskaps as a new crop that can be consumed fresh. Most varieties are too sour for fresh consumption and often contain bitter flavors, especially shortly after the berries turn blue. Many varieties have a long harvest window. Berries that are bitter when they first turn blue often develop a decent taste two weeks later. Not every cultivar

can be left on the plants because some will fall off shortly after turning blue, and because haskaps are susceptible to birds.

Haskaps are best used in processing. Haskaps can be used in any recipe that uses blueberries or raspberries, such as pies, jams, wines, and pastries. Because of the intense blue color and strong flavor, there is interest in using haskaps in dairy products

⁴² Berries Unlimited. <http://www.berriesunlimited.com>

like ice cream and smoothies. Since they have small seeds, haskaps can be dried and used in baking as a replacement for raisins or dried cranberries.

High demand for haskap products in Japan was partially driven by the perceived health benefits, beliefs that go back hundreds of years on Hokkaido.

Haskaps are high in Vitamin C and antioxidants. Preliminary research shows that domesticated haskaps have antioxidant levels similar to other dark fruit like currants and elderberries. Further research on the specific health benefits of haskaps is being conducted.

PROPAGATION, PLANTING AND CARE

All haskap varieties available in the U.S. are patented, and vegetative propagation of those varieties is illegal. Haskap plants are widely available from a number of different nurseries and dealers in the United States.

Haskaps grow low to the ground, which makes them susceptible to competition from quackgrass and other perennial weeds. Always plant into soil that is free of quackgrass and Canada thistle. Haskaps grow well in mulch, which reduces pressure from most annual weeds, with the exception of quackgrass and Canada thistle. Mulch also keeps the soil cool during hot spells, which reduces stress on the plants.

The tallest haskaps grow to about six feet tall and spread to about the same distance. Therefore, they should be planted six to eight feet apart within the row. Some cultivars like 'Indigo Gem' are tall and narrow, while others are short and spreading, so some cultivars may require different spacing. Since the crop has been available for less than one

decade we don't know what their final size will be in the milder climate of Minnesota, and we don't know how old they will live to be.

Haskaps grow anywhere, but do best in a sandy loam soil with a neutral pH and soil organic matter above 5%. Haskaps also appear to grow well in soils with a slightly alkaline pH. Bark mulch will help to increase organic matter over the life of the planting. Haskaps have small root systems, and the plants will stop growing in early June if there is not enough water. Irrigation systems are advisable in areas with less than ten inches of rain between July and September. Guidelines for nitrogen fertilization are still being worked out, but the plants do appear to need less nitrogen than other fruiting shrubs, especially in fields with sufficient organic matter.

Pruning systems are still being worked out. Many haskap promoters claim that the plants never need to be pruned, while in Japan they are extensively trained to tall rows.

PRODUCTION PROBLEMS

As with many plants from extremely cold climates, haskaps will sprout during a warm spell in late winter. While sprouting early has been a serious problem in Oregon, it has not been a problem here in Minnesota, especially when the temperature stays below freezing most of the winter. During the mild winter of 2012 haskaps began to grow in March, but they still produced a crop.

Haskaps are such a new crop that we don't know which problems will arise as more acreages are planted each year. Although promoted as disease-resistant, growers have encountered several serious diseases. Botrytis has killed whole branches in wet areas of Oregon. Plants in Minnesota also have developed leaf diseases during wet summers, including powdery mildew. Some diseases have not been conclusively identified. Spotted Wing

Drosophila will probably not cause crop losses in haskaps because they ripen long before the fly population reaches threshold numbers.

Birds have caused serious losses in both Saskatchewan and Oregon, especially when cedar waxwings start to form large flocks around haskap fields. Bird netting is highly recommended.

Finding efficient ways to harvest haskaps is a high priority for everyone trying to grow this new crop. Minnesota producers who have tried to harvest the crop by hand quickly became discouraged. In Japan, the berries are picked by hand. In Europe and Canada, the fruit is shaken off either with machines or by hand. Growers who cannot afford an expensive machine to harvest fruit have had some success by developing manually powered picking machines. The picking machines have trays which can be moved below the plant canopy while the plants are shaken by hand. These manually powered harvesters are based on a blueberry harvester called the "Easy Harvester", and the first model was called the "Mark One." Five Hundred to 750 pounds of berries can be harvested per day with two people using the "Mark One." Other growers have placed tarps below the canopy and shaken the plants by hand.

Low yields have plagued a number of test plantings in Minnesota. Growers in Poland are finding yields between six and ten pounds per plant, but most growers in Minnesota have yet to see one pound per plant. The low yields are due to a combination of poor pollination and poor blossom production. Pollination is an issue because the tube-shaped white flowers can only be pollinated by insects, preferably bumble bees, and because every cultivar released so far is self-incompatible. Self-incompatible means that pollination and fruit set only can occur when a flower is pollinated with pollen from a different cultivar. Mixing different cultivars is critical in order to get maximum pollination. Even when there are multiple varieties side by side, the flowers often open before many bees have emerged, and different varieties don't always sprout at the same time. Poor blossom formation appears to be the larger problem, at least among cultivars tested in Minnesota. Flowers are formed in the nodes of the previous season's growth, and there just aren't enough blossoms to make a commercially viable crop. The low yields in Minnesota may be because the right cultivars have not been found.

EDIBLE LANDSCAPING

With its inconspicuous white flowers and plain green leaves, haskaps are neither especially striking nor particularly ugly. In landscapes, they could play a role similar to barberries as foundation shrubs planted near taller trees.

Some people worry that haskaps could become invasive like the closely related Tartarian honeysuckles or the vine honeysuckles. In many test plantings throughout the center of North America, there has not been any suggestion that they could be invasive.

COMMERCIAL POTENTIAL IN MINNESOTA

Haskaps are currently being promoted as the crop of the future. The crop has traits that justify a profitable future, including great flavor, easy processing and health benefits. Haskaps lack the disease susceptibility of saskatoons and are easier to process than Nanking cherries, both of which were promoted as the “crop of the future” at one time. Haskaps should become profitable for wholesale markets and local markets if growers can find varieties and develop cultural practices that can deliver yields of six pounds per plant. Haskaps that are planted on a six by ten-foot spacing that produces six pounds of fruit per plant would produce 4356 pounds per acre, which is lower than blueberries, and would require a farm gate price of \$3 per pound to be economically viable. Currently, wholesale prices vary from \$2.50 to \$5.00 a pound, depending on quality. Local markets have not been developed, and we don’t know if a grower could sell 4000 pounds of haskaps as pick-your-own or at farmers’ markets in most parts of the state. Demand should grow in upcoming years, but haskaps remain unknown for most people.

Minnesota does appear to have natural advantages for haskap production compared to other parts of the U.S. In southern states, the shrubs are often defoliated by leaf diseases shortly after harvest, while haskaps in Minnesota hold their leaves all summer. Plants do not bloom during warm spells in late winter here as they do in Oregon.

Haskaps exhibit huge differences among cultivars in fruit size, fruit shape, flavor, and productivity. New cultivars are being released each year, and growers interested in haskaps should test new cultivars. Of the cultivars that were available in 2011, ‘Indigo Gem’ appears to have the greatest potential for either large scale or small scale commercial production. Its large fruit and an upright growth habit facilitate hand picking or mechanical harvest. Anyone interested in growing haskaps should plant multiple cultivars in order to find a cultivar that can produce six or more pounds per plant and is easy to pick.

nanking cherries

Nanking cherries (*Prunus tomentosa*) are shrubs that grow from three feet up to ten feet tall with twigs that usually occupy an area twice as wide as the plant is tall. Up to 20 canes can grow out of one crown, but the plants do not sucker, nor do they spread aggressively. In milder climates, plants can live as long as 60 years, but in Minnesota they appear to live between 15 and 20 years.

The plants bloom very early in the spring, with large, pink buds that turn into white or pink blossoms. The blossoms are resistant to light frost. In early to mid-July the shrubs produce small, red, round to oblong cherries, formed as single fruit on short stems (Figure 31). Nanking cherries are closely related to both the sweet cherry and the sour cherry. Although related to plums, the fruit lacks the thick, sour skin of plums, and the seeds are round. The fruit have very short stems that usually detach from the fruit during picking. Fruit size varies from $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter, and there are many reports of cultivars with fruit up to 1 inch in diameter.

Nanking bush cherries are from eastern Asia, with a range from Mongolia to Kashmir in India. They have been called numerous names, including Manchu cherry, Mongolian cherry, downy cherry, and Chinese bush cherry. The term “Nanking cherry” appears to have taken hold after they were heavily promoted in the 1970s. Like all plants with a widespread natural range, Nanking cherries from different areas have different traits. In the U.S. some of the plants come from seeds collected in northeast China near Beijing, which has a milder climate than Minnesota, and most Nanking cherries grown in the Upper Midwest have marginal winter hardiness.

In Minnesota, Nanking cherries are typically planted along fence lines, hedge rows, and as part of conservation plantings. Currently almost all Nanking cherries are propagated by seeds, which results in shrubs that show a great deal of variability in fruit quality, yield and winter hardiness.



Figure 31. *Nanking cherries*

HISTORY

Nanking bush cherries were first introduced to the U.S. from China at the end of the 19th century. At the time many settlers were moving to the Great Plains, and there was a great deal of interest in developing hardy fruits that could survive the cold winters and periodic droughts of the northern plains. By 1935, Nanking cherries were being promoted as “the crop of the future.” Several cultivars were developed in the early 20th century, including

selections from the University of Minnesota, but those cultivars disappeared by the late 1950s. Interest in Nanking cherries surged again during the Back to the Land movement in the 1970s, and nurseries once again touted them as “the crop of the future.”⁴⁴ Markets never developed, and interest in Nanking cherries quickly tapered off by the 1980s. Later the crop settled into a niche of being used for conservation plantings and windbreaks.

USES AND HEALTH BENEFITS

Nanking cherries are best eaten fresh off the shrub. Eating quality ranges from decent to very good, and there are rarely plants with fruit too sour for eating fresh. Nanking cherries ripen shortly after strawberries and are a welcome treat in early summer. Nanking cherries can be processed into pies or jam, but they are too small for most

mechanical pitting machines. There are a number of reports of people making good wine out of Nanking cherries, and presumably good fresh juice as well.

Nanking cherries are an excellent source of Vitamin C, and likely have similar phytonutrients to pie cherries.

⁴⁴ Sando, L. 1935. Edible fruits from Minnesota wild and cultivated plants. *Minnesota Horticulturist*.

PROPAGATION AND PLANTING

Nanking cherry branches growing next to the ground will often sprout roots, which is a natural type of layering. Plants with desirable traits can be propagated with softwood cuttings or grafted onto numerous suitable rootstocks. In the U.S., Nanking cherries are almost always propagated from seeds. According to one source seedlings form a large taproot, while plants propagated by layering form shallow roots. Plants with desirable fruit quality can be grafted. Although compatible with a number of cherry species, the most desirable rootstock appears to be Nanking cherry seedlings.

Nanking cherries are drought tolerant, and can be grown in a variety of well-drained soils. Heavier soils in low spots are not recommended. Most plants are self-sterile, and two or three different strains are usually required for adequate pollination.

Shrubs are typically sold as seedlings up to three feet tall. They should be planted about five to six feet apart for a hedge and further apart for individual shrubs. Once established, the plants send out many rapidly growing canes and can crowd out most weeds next to the crown.

Nanking cherries frequently receive little or no care. For reliable fruit production, the canes need to be regularly pruned. Nanking cherries should be pruned before bloom, and since they are one of the first shrubs to bloom in the spring, they should be pruned in late March or early April. Dead canes as in Figure 32 can be removed any time of year. Growers should keep about ten healthy canes per plant to maximize fruit quality.

PRODUCTION PROBLEMS

Nanking cherries are usually promoted as being hardy to Zones 2 or 3. The hardiness of the flower buds is closer to Zone 4. Like all stone fruit, flower buds are the most susceptible part of the plant to winter injury. Branches with moderate winter injury will leaf out normally with no blossoms. Because Nanking cherries are primarily propagated by seed, the level of winter injury always varies from plant to plant within a row. The unacceptable levels of winter injury in 2013 may be due to an improper seed source going back many generations. Growers interested in growing Nanking cherries for fruit should consider looking for seedlings with an origin of northeast China or Mongolia.

Nanking cherries have surprisingly few disease or insect problems. Deer appear to avoid Nanking cherries. They acquire few leaf diseases. Unlike plums and sand cherries, the disease brown rot has not been observed in Nanking cherries. Birds love Nanking cherries, and growers should prepare to protect their plants against birds. Birds also spread seeds, and Nanking cherries can

become a weed in areas near the patch where birds often perch.

Note from Thaddeus:

For over a decade, I have observed Nanking cherries in many parts of central and northern Minnesota. About a third of the time plants show some winter injury. The most common type of winter injury occurs when the cold damages all flower buds except the ones below snow level. Because the snow protected the flower buds, fruit only developed less than a foot or so above the ground. After the cold winter of 2013, the canes of many seedlings died.

Nanking cherries are not commercially viable with current varieties and growing methods. They are too prone to winter injury, too slow to pick for the fresh market, and most seedlings have poor yields and small fruit. If all the seedlings in a hedge had fruit as large and abundant as the shrub in Figure 31, the plant may have some potential, but that shrub produced better cherries than ten other plants. The plant in Figure 33

was more typical for the entire row.

Nanking cherries could become commercially viable if a producer is motivated to identify and propagate hardy, productive varieties with large fruit. There are numerous reports in the literature that speak of Nanking cherry varieties that produced fruit up to an inch in diameter, but those varieties were lost.



Figure 32. A row of Nanking cherry seedlings, showing variability in height and winter injury. Dead canes on plants on the right were due to winter injury.



Figure 33. Dead branches from winter injury that occurred a year earlier.

⁴⁵ Howard, R.A. and A.I. Baranov. 1964. The Chinese bush cherry – *Prunus tomentosa*. *Arnoldia*, 24: 81-86

EDIBLE LANDSCAPING

Nanking cherries are a superb landscaping plant, with pretty blossoms that open early in the spring and brilliant red fruit on a bright green shrub in the summer. They can be planted as a hedge along

property borders, which also works for wildlife habitat or as a flowering shrub in a lawn. A small percentage of seedlings have pink flowers which further enhances their value to the landscaper.

MINNESOTA EXPERIENCES

Interest in Nanking cherries has always been highest in Minnesota and surrounding states. Several cultivars were developed and described by the University of Minnesota in the 1940s and 1950s, but those cultivars were lost by 1964. At times when Nanking cherries were being promoted, people planted small blocks, usually of seedlings, hoping to sell the fruit as either pick-your-own or at farmers

markets, but neither the market nor the production materialized. Most commentators say that the crop did not succeed because there were no suitable cultivars. Several people have reported making great wine from Nanking cherries, but the fruit is small and difficult to pick. As in 1935, Nanking cherries remain the “fruit of the future.”



Figure 34. *Flowers and buds of Nanking cherries.*

saskatoons juneberries serviceberries

Juneberries and serviceberries are members of the genus *Amelanchier*. On the east coast, they are also known as shadbush or shadblow. The term 'saskatoon' primarily refers to juneberries from the Canadian prairies. We will use "juneberry" as the common term in this chapter. All juneberries are shrubs and small trees, native to North America, that produce blue, edible fruit. There are about twenty species of juneberries belonging to the genus *Amelanchier*, found in every part of North America, six of which have been domesticated. All domesticated *Amelanchier* have edible fruit. The species most commonly grown in the U.S. is the ornamental Allegheny serviceberry (*Amelanchier laevis*). A second species commonly used in landscaping is the thicket serviceberry or shadblow, *A. canadensis*. The two species have been crossed to form *A. X grandifolia* or the apple serviceberry, which is also widely planted. Although these three species have edible fruit, the fruit has not been developed

for commercial production.

The only juneberries that have been selected for commercial fruit production are the saskatoons. Saskatoons are cultivars of *A. alnifolia* from the prairie provinces of Canada that have been selected for fruit quality. The Canadian plants had a few traits that made them more suitable for fruit production than Midwestern juneberries. Minnesota juneberries grow in forests as an understory shrub. Canadian saskatoons grow in large groves in full sun and produce larger fruit on shorter plants than Midwest juneberries. Some saskatoon varieties produce fruit the size of a quarter or larger, while native juneberries produce fruit similar in size to a large blueberry. Saskatoon varieties grow between 10 and 20 feet tall. Native juneberries are small trees that grow up to 25 feet. Saskatoons tend to sucker more easily than native juneberries.

Juneberries are pome fruit related to apples, pears, and aronia. Like apples and pears, the sepals of the flower stay on the fruit at harvest, and look like blue petals at the tips of the fruit (Figure 35). Blueberries also have sepals at the tips of the berries, and these superficial similarities are one reason why some nurseries mislabel saskatoons as “saskatoon blueberries.” Saskatoons are unrelated to blueberries: they require different soils, are susceptible to different diseases, ripen differently, and taste very different. A more accurate term would be “saskatoon juneberries.”

Saskatoons produce 6 to 12 fruit per cluster. Some



Figure 35, 36. Ripe wild juneberry fruit (*A. alnifolia*).

cultivars have a waxy coating that gives the fruit a light blue appearance while others without the waxy blush are dark blue or purple. The flesh is a light green. The fruit have low acidity with prominent edible seeds. The leaves are small, elliptical, and slightly serrated, with a light, almost bluish green color. New leaves tend to have a silvery red color (Figure 37). The plants bloom in early spring before the leaves emerge with showy, white flowers.

Being that juneberries are newly domesticated, there are relatively few cultivars (Table 12). All *A. alnifolia* cultivars listed here are saskatoons from Canada.



Figure 37. Saskatoon leaves that are just starting to emerge, with distinctive reddish color and small hairs.

Table 12. Juneberry and saskatoon varieties suitable for Minnesota.

Name	Species	Fruit Size*	Fruit Quality	Plant Height	Other
Honeywood	<i>alnifolia</i>	Medium	Tangy	14 Feet	Large clusters, but uneven ripening
Martin	<i>alnifolia</i>	Large	Mild	10 Feet	Uniform Ripening
Nelson	<i>alnifolia</i>	Medium	Tangy	15 feet	Some disease resistance
Northline	<i>alnifolia</i>	Large	Sweet, mild	13 feet	Spreads by root suckers
Pembina	<i>alnifolia</i>	Med	Sweet	16 feet	Upright, few suckers
Smokey	<i>alnifolia</i>	Med	Sweet, mild	15 Feet	Many root suckers
Thiessen	<i>alnifolia</i>	Large	Sweet	16 Feet	Few root suckers, uneven ripening
Autumn Brilliance	<i>grandiflora</i>	Medium	Sweet		Disease resistant, red leaves in fall
Prince William	<i>canadensis</i>	Small	Sweet	10 feet	Heavy producer, good fall color
Princess Diana	<i>grandiflora</i>	Small		20 feet	Good fall color
Standing ovation	<i>alnifolia</i>	Small		15 feet	Columnar tree form

*Large = fruit > 1/2 inch in diameter, Medium = fruit < 1/2 inch in diameter but > 3/8 inch. Small = < 3/8 inch.

HISTORY

People have been eating juneberries in North America for thousands of years. Although found across North America, juneberries were most popular in the northern plains, where little other fruit grew. Juneberries were a key ingredient in pemmican, a mixture of bison meat, bison fat, and dried berries. Pemmican was a winter staple for Native Americans in the center of the continent, and an important source of Vitamin C. The Cree word for juneberries is "misass-kutu-mina" which European settlers shortened to "saskatoon". Settlers named the town that would become the provincial capital of Saskatchewan, "Saskatoon" after the abundant shrubs that grew along the Saskatchewan River.

In eastern U.S., European settlers domesticated the Allegheny and thicket serviceberries as well as the hybrid *A.x grandifolia* as ornamentals in the 19th century. The fruit of ornamental juneberries was only occasionally eaten so they weren't planted for fruit production. Interest in growing juneberries for

Note from Thaddeus:

In western Colorado where I lived as a child, "sarvisberries" (serviceberries) were not eaten. In that part of Colorado there were wild apricots, cherries and apples, but people still made chokecherry jelly and wine. Sarvisberries were left for the birds. I have eaten serviceberries and juneberries from many parts of the U.S. and have found little difference in flavor. Some of the eastern species have a little higher acidity, which makes them more acceptable for fresh eating.

fruit began in the middle of the 20th century when Canadian horticulturists started selecting wild *A. alnifolia* plants which were commercially promoted as saskatoons. All saskatoon varieties registered so far have been plants selected from the wild and propagated vegetatively. There has never been a breeding program for saskatoons in which scientists cross different plants with selected characteristics. Attempts to breed saskatoons with related species in order to improve disease resistance or develop fruit with smaller seeds have had few successes (*Anthony Mintenko, personal communication.*)

In the 1980s and 90s, saskatoons were planted in large orchards in the prairie provinces of Canada. At the time, food processors hoped to export berries to European Union. The export market never fully developed, primarily due to the untimely death of one of the exporters, so growers started building local markets. Over time local markets have been able to buy most of the saskatoon production in Canada. Currently there are over 2600 acres of

saskatoons in Alberta, Saskatchewan, and Manitoba that are grown for local markets, including pick-your-own and small scale food processing.

In the U.S., there have been several waves of interest in saskatoon production. The first wave occurred in the 1980s when improved saskatoon varieties were introduced into Minnesota. More than a half dozen berry growers planted test parcels of a tenth of an acre. A fungal disease defoliated the trees and birds ate all the fruit. The plants were largely neglected after the first few years, although many growers kept the plants around as a wind break or as a trap crop for birds.

The second wave of interest occurred in the early 2000s, when Canada was developing saskatoons for export to Europe. Once again, several Minnesota growers planted saskatoon parcels, and none of them became profitable due to the same problems in the 1980s; including birds, deer, and leaf diseases.

USES AND HEALTH BENEFITS

All juneberries and saskatoons can be eaten fresh, and have a unique flavor that can't be compared to other fruits. Saskatoons have an unusual problem that keeps them from being popular as a fresh crop: the fruit is too low in acidity. Many saskatoons and juneberries are sweet but bland, lacking the sour flavors that give fruit a balanced taste. The second problem with saskatoons is large seeds that turn consumers off. The seeds are high in protein, which is partly why the berries are so attractive to birds.

Saskatoons are best when processed or used in cooking. They can be made into pies, pastries, syrups, and jams or canned. Due to the fruit's naturally low acidity, saskatoons taste the best when combined with rhubarb or a high acid fruit. Saskatoon-rhubarb jam is excellent, while saskatoon-currant jam has great potential. Cooking causes the seeds to release an intense almond flavor that infuses the whole dish.

The almond flavoring of processed juneberries is due to two compounds found in the seeds called amygdalin and prunasin, which are cyanogenic glycoside: sugars that can release cyanide (see the Elderberry chapter for more detail.) Some people believe that amygdalin provides health benefits, but both compounds are toxic when consumed at high levels. The highest level of amygdalin measured in saskatoons was 129 mg/kg fresh weight.⁴⁶ Amygdalin can be harmful if around 500 mg is consumed per day, on a daily basis, in a pure form. There are no verified cases of people being hurt by amygdalin from eating fresh or processed fruit. Not only are levels in fresh fruit too low to harm people, but amygdalin breaks down rapidly during processing.

Because saskatoons historically are a minor crop grown almost exclusively in remote parts of Canada, and because other types of juneberries have been

⁴⁶ Mazza, G., and T. Cotrell. 2008. Carotenoids and cyanogenic glucosides in saskatoon berries (*Amelanchier alnifolia* Nutt.) *Journal of Food Composition and Analysis*: 21:249-254.

grown as ornamental shrubs, their health benefits have received little scientific research. Like most fruit with blue color, juneberries are high in anthocyanins. Scientists in Manitoba have measured both the total anthocyanin content and identified the different types of anthocyanins in saskatoons. The total anthocyanin content in saskatoons is about the same as aronia, but saskatoons have a greater

diversity of anthocyanins. Saskatoons boast about 15 different anthocyanins compared to four different anthocyanins in aronia. There are no human trials that look at the health benefits of saskatoons, but preliminary studies suggest that they will prove to be as good as aronia and other fruits that are promoted as “super foods.”⁴⁷

PROPAGATION

Home gardeners can easily propagate saskatoons by digging out suckers that sprout near the original plant. The best time to dig suckers is in late winter or early spring after the ground thaws but before the plants start sprouting. Saskatoons sprout early in the spring, so the window for transplanting suckers is small. Always make sure there are enough roots for the plant to survive and be aware that digging suckers is labor intensive. Details on propagation can be found in the guidebook, “Saskatoon Production Manual,” which is available at several different Canadian provincial agricultural websites.⁴⁸

Juneberries grown from seed nearly always produce good fruit on productive plants, which means that juneberries are one of the few perennial fruit plants that can be propagated by seeds. Juneberry flowers do not need cross pollination with other varieties, and about 70-80% of seedlings are similar to the parent stock of most cultivars. Even juneberry

seedlings that are not identical to the parent plant nearly always produce edible fruit. The saskatoon cultivar ‘Northline’ almost always comes true from seed. Juneberry seed must be stratified: the fruit is macerated, and the seeds left in the fruit. The macerated fruit is stored at temperatures near 40°F for 4 to 5 months, and is planted in late winter or early spring. Seedlings grow rapidly, and are typically planted in the field after spending a year or more in a seedling bed. Seedlings go through a juvenile period, which delays fruit production a year or two later than those propagated vegetatively. For large scale nurseries propagating juneberries for revegetation projects, seed propagation is more cost effective than vegetative propagation, and these nurseries often have juneberry seedlings of two or three species. Those who want edible landscaping, and do not need trees that ripen at the same time, can easily buy seedlings for a fraction of the cost of registered varieties.

PLANTING AND CARE

Those interested in growing saskatoons for fruit production should look at the crop as an intensively managed crop, like apples and blueberries, rather than a plant that can be thrown into the ground and neglected. Those planting saskatoons for commercial production should develop a plan for bird, deer, and disease control before the first shrub is in the ground.

Like apples and other tree fruit, saskatoons need to grow two to three feet the first year after planting to be commercially viable. Unfortunately, saskatoon plants tend to stop growing very early in the season if the soil dries out, if there is weed competition, or if there are leaf diseases. Be prepared to water the plants during the first two years if there is a dry spell in the months of June or July.

⁴⁷ Bakowska-Barczak, A.M., M. Marianchuk and P. Kolodziejczk, 2007. Survey of bioactive components in Western Canadian berries. *Can. J. Physiol Pharmacology*. 85:1139-52

⁴⁸ Spencer, Robert, et al. *Saskatoon Production Manual*. Edmonton: Alberta Agriculture and Rural Development, 2013. Web. [http://www1.agric.gov.ab.ca/\\$Department/deptdocs.nsf/all/agdex14362](http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/agdex14362)

Saskatoons should always be planted in soil that is free of weeds, and the weeds controlled as much as possible the first three years after planting. Soil preparation should be started the summer before planting. Quackgrass is best controlled with a spray of the herbicide glyphosate the fall before planting. Organic growers can attempt to control quackgrass by using a field cultivator to bring quackgrass roots to the soil surface, allowing them to dry out. The summer after planting, weeds can be controlled mechanically or with woodchip mulch. After the plants are established and approaching full size, weeds can be controlled by mowing next to the plant.

Saskatoons are relatively tolerant of heavy soils, alkaline soils, and conditions where other fruit struggles. Low sites should be avoided, both to reduce the chance of frost injury and to minimize the risk of flooding. While tolerant of heavy soils, saskatoons will grow best in a well-drained soil with a pH between 7.0 and 7.5. *A. laevis*, *A. canadensis*, and *A. stolonifera* can grow in slightly acidic soils. Frost pockets – areas that often see frost in spring and fall when surrounding areas do not - should be avoided because juneberries bloom very early in the season.

Saskatoons can be planted as close as three feet apart within a row to form a hedge, or more than six feet apart if grown as individual shrubs. Saskatoons grown as a hedge will have a higher yield and will be easier to cover with bird netting, but shrubs that are separated will have lower disease pressure.

Some varieties sucker extensively and will form a solid row similar to raspberries.

Provided the soil is naturally fertile, juneberries require only a small amount of nitrogen and phosphorous, but require high amounts of potassium. Mature plantings should receive a maintenance program of 30 to 50 pounds of nitrogen per acre per year, preferably applied in spring, similar to the process for apples. Phosphorus should only be applied after planting if a soil test shows a deficiency. Organic producers can apply potassium with greensand, a natural product from Canada. For conventional producers, the best source of potassium is potassium sulfate, or sulfur of potash. 100 pounds of sulfur of potash per acre applied once every four years is sufficient to maintain potassium levels on a productive planting. Potassium sulfate is also allowed in organic production.

Pruning saskatoons is critical to reduce disease pressure, maintain shrub size, and optimize fruit quality. Pruning should begin three to five years after planting when the shrubs have started to fill in their space. Pruning should be done in late winter or early spring before bud break. The most productive branches are on one and two-year-old wood. Older, unproductive branches should be removed to make room for newer branches. Diseased branches should be removed, and branches should be pruned to keep the shrubs at the ideal height of about eight feet tall.

Note from Thaddeus:

Help for Protecting Crops from Wildlife...

The Minnesota DNR offers guidance and solutions for wildlife exclusion on their website including fence design, materials, sources, safety, and maintenance:

http://www.dnr.state.mn.us/livingwith_wildlife/fences/index.html

PRODUCTION ISSUES AND PROBLEMS

Saskatoons are susceptible to a wide variety of large pests, small pests, and diseases. Deer will browse on saskatoons at any time of the year. Saskatoons may be the most susceptible to bird damage of any commercially grown fruit, and they are one of the only fruits that birds eat before they ripen. The extreme susceptibility of saskatoons to birds may be due to the high protein content of the seeds. Birds start eating saskatoons as soon as the berries turn red, which is usually more than a week before they are ripe. Bird netting should be installed while the fruit is still green.

Many insects also like saskatoons. The moths of eastern tent caterpillars lay their eggs on saskatoon canes in late summer. The eggs hatch in early spring, and the caterpillars form distinct silk tents on the branches about two weeks after hatching and leave the tents to feed on leaves. Tent caterpillars will defoliate entire shrubs in May if not controlled. The best way to control eastern tent caterpillars is to remove the tents, or quickly scorch the tents with a hand-held propane torch. Spraying tents directly with insecticide may work, but the silk protects the caterpillars and reduces effectiveness of insecticides. Round headed apple tree borers burrow into canes, where they feed on the wood and bark. Borers can kill entire canes, but since there are multiple canes, they rarely kill the entire plant. In Canada, the apple curculio has occasionally destroyed crops by laying eggs in developing fruit, which deforms the fruit or causes the fruit to fall off. Apple curculios are common throughout Minnesota. Integrated pest management (IPM) techniques developed for Minnesota apple growers may be helpful in saskatoon production.⁴⁹

Saskatoons are susceptible to a wide array of leaf and fruit diseases including cedar-apple rust, quince rust, and other diseases that are poorly understood. Some leaf diseases that regularly defoliate

saskatoons are rust fungi that use conifers as alternate hosts. Therefore, planting saskatoons near pines or red cedars should be avoided. In areas with high disease pressure the leaves start falling off in early July, and some cultivars have been completely defoliated by early September. Plants that lose their leaves early are often stunted or unable to set fruit. The extreme susceptibility of saskatoons to diseases may be a result of using genetic material selected in the Canadian prairies, where disease pressure is lower than Minnesota. Defoliation can be prevented with one or two applications of synthetic fungicides in June. *A. x grandifolia* varieties like 'Autumn Brilliance' appear to be more resistant to leaf diseases than any *A. alnifolia* selections, even when plants of the two species grow side by side. The Saskatoon Production Manual is a source of information about pest and disease control⁵⁰.



Figure 38. An unidentified leaf disease in 'Northline' saskatoon. The plants were completely defoliated by September.

⁴⁹ McCamant, Thaddeus. 2007. *Integrated Pest Management Manual for Minnesota Apple Orchards*. Minnesota Department of Agriculture. <https://www.mda.state.mn.us/news/publications/pestsplants/pestmanagement/ipm/ipmapplemanual.pdf>

⁵⁰ Spencer, Robert, et al. *Saskatoon Production Manual*. Edmonton: Alberta Agriculture and Rural Development, 2013. Web. [http://www1.agric.gov.ab.ca/\\$Department/deptdocs.nsf/all/agdex14362](http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/agdex14362)

EDIBLE LANDSCAPING

Those who are interested in using juneberries in landscaping should consider varieties of the eastern species *A. laevis* or native juneberries instead of saskatoons. Juneberry blossoms are very attractive to a wide variety of native pollinators. Saskatoons have a poor potential for edible landscaping due to the leaf diseases that defoliate plants by early September.

A number of eastern juneberries have been selected

for landscaping with large blossoms, excellent tree form, little suckering, good fall color, and are naturally resistant to fungal diseases common to the eastern U.S. Many of these ornamentals have very good fruit and are labeled as hardy to Zones 3 and 4. A *x grandifolia* cultivars with good fruit include 'Autumn Brilliance', 'Forest Prince', and 'Princess Diana'. Two recent selections out of Wisconsin, suitable at least to Zone 4, include 'Prince Charles' and 'Prince William'.

COMMERCIAL POTENTIAL IN MINNESOTA

Saskatoons are often promoted in areas where the conditions are unsuitable for blueberry cultivation. Saskatoons are more suitable where soils are either too alkaline or too heavy, or in areas too cold for blueberry production. Saskatoons are harder to market in areas where blueberries are abundant. In 1860, Henry David Thoreau foresaw this problem, noting that local juneberries or shad bushes were underutilized, but summed up their taste by saying, "Though an agreeable berry for a change, they are hardly so grateful to my pallet as huckleberries and blueberries."

Currently, there are three farms attempting to achieve commercial success growing saskatoons in Minnesota. Saskatoon growers report high demand for their product at farmers' markets, but they have been unable to see a profit due to the numerous production problems. Several producers have gone years with no crop. Saskatoons can probably be grown profitably in Minnesota, but growers need to avoid the pitfalls of those who have been unsuccessful.

People who want to grow saskatoons or juneberries commercially in Minnesota have two possibilities for dealing with defoliating diseases. The first would be to plant common saskatoon varieties, but be prepared to spray fungicides each summer. Organic production of saskatoon varieties out of Canada is highly unlikely in Minnesota.

The second possibility is to experiment with eastern juneberry species such as *A. laevis* and *A. grandifolia*. The fruit on those species is not as large as the common saskatoon cultivars, but is still the size of large blueberries, and many plants are quite productive. The flavor of eastern species tend to be as good or better than common saskatoon cultivars, and the plants keep their leaves all summer, so may be better suited for organic production.

Note from Thaddeus:

In one test site, I was able to control a leaf disease completely with one fungicide application in late June. I have not seen any leaf diseases on A. x grandifolia varieties like 'Autumn Brilliance'.

seaberries

SEA BUCKTHORN

Seaberries (*Hippophae rhamnoides*) are shrubs native to Eurasia. They are most common in the semi-arid steppes that stretch from northern China through Russia. In Europe, they are primarily found in sand dunes near the ocean, hence their common name in English. Since 2000, they have primarily been sold under the name seaberry instead of sea buckthorn, to distinguish them from the distantly related common buckthorn, which is an undesirable invasive species in the deciduous forests of eastern North America.

Seaberry shrubs grow from eight to 30 feet tall, depending on the soil and cultivar. The leaves are small and slender with a silvery sheen. Fruit vary from yellow to light red, with most cultivars being orange. The plants have small, sharp thorns that are often hidden in the foliage. The species has two highly unusual traits that distinguish it from other species that produce edible fruit. First, the plant

has the ability to fix nitrogen through symbiotic bacteria that live in its roots, which is a common trait among plants of the family Eleagnaceae. Second, the flowers are wind pollinated. The ability to fix nitrogen has made the seaberry a desirable plant for reclamation projects on the Canadian prairies. Like many wind pollinated plants, seaberries have small inconspicuous flowers and the male and female flowers are found on separate plants.

Seaberries are extremely cold tolerant. Many varieties are able to survive temperatures lower than -40°F. The flowers are likewise frost tolerant, which is common in wind pollinated flowers. Native to semi-arid climates, the plants are tolerant of both high pH and clay soils, with reports of some plants growing in soils with a pH as high as 8.5.



Figure 39. Seaberry



Figure 40. Seaberries

HISTORY

Seaberries have been used by humans for thousands of years. The scientific name *Hippophae* means “shining horse” because the plants were said to give horses a healthy coat of hair. Throughout the Eurasian steppe, the plants were used by indigenous people for food, forage and medicine.

In the 1930s, seaberrries were introduced to Canada for shelter belts and reclamation projects. The plants have an extensive, rapidly growing root system, can grow on extremely poor and alkaline soils, fix nitrogen, and are drought tolerant, making them ideal for erosion control. The Canadians primarily planted seedlings with poor quality, and seaberrries were not harvested. In the United States, seaberrries

remained largely unknown. In Minnesota, seaberrries were occasionally planted as an ornamental in urban lawns. The berries were considered to “have a rather disagreeable flavor, but make a great sauce.” (Sando, 1935)

The commercialization of seaberry fruit began in the 1940s in the Soviet Union. Soviet scientists began developing new products to take advantage of the health benefits of seaberry oils. At the end of the 20th century, most of the production and processing of seaberrries switched to Mongolia and China, and China currently has between 150 and 200 factories that process seaberrries.

USES AND HEALTH BENEFITS

Seaberries are rarely eaten fresh. Seaberries can be made into juice, jams, and jellies. The juice tends to be cloudy, primarily due to the high protein content of the fruit. Processing the juice is difficult, because heat destroys some proteins and oils which give seaberrries their health benefits. Pulp left over from juice extraction can be used as animal feed or yellow dye. For Americans not familiar with seaberrries, they may work best when mixed with

familiar fruit in juices or added as an ingredient to protein snacks or granola.

Seaberry fruit is remarkably rich in a variety of medicinal compounds and nutrients. The berries are high in Vitamins C and E and even have a fairly high concentration of both protein and unsaturated oils. The oils are often extracted and used as medicine. Similarly, vitamins can be extracted from seaberrries

for a natural source of vitamins.

Seaberries have been used in Chinese and Tibetan medicine for over 1000 years and are common in Asian pharmacies. The list of ailments rumored to be cured by seaberries is extremely long, but some of the

best documented uses have been for skin care. Oil extracted from seaberries has been used to prevent sunburn, cure sunburn, cure burned skin, and cure skin damage from malnutrition. In addition, seaberry oil can reduce inflammation, reduce bacterial counts, and promote regeneration of tissues.⁵¹

PROPAGATION AND PLANTING

People interested in growing seaberries for fruit should only buy named, female plants. Most of the seaberries sold in North America are seedlings that produce sour, foul-tasting fruit, and half of all seedlings will be unproductive male plants. When buying seaberry plants, try to find sources with named varieties (all named varieties are female clones), so that Minnesota growers can compare the performance on known varieties. One male plant can pollinate 6- 8 female plants. Male seedlings will work as pollinators, provided their flowers open at the same time as the female flowers.

There are hundreds of seaberry varieties, but only a handful are available in the U.S. The most common cultivar in the U.S. is 'Leikora', a German cultivar that was originally sold as an ornamental with bright orange, sour berries and silver leaves that fit well into floral arrangements. In recent years, some nurseries have started selling varieties specifically chosen for fruit quality, including varieties that can be eaten fresh. Plant height, fruit color and fruit quality vary greatly between varieties. Several thornless and nearly thornless varieties have been developed in Russia and Germany, but are not available in North America.

Cultivar	Shrub Height	Fruit
Leikora	8-10 feet	Orange, intensely acidic
Amber Dawn	4-6 feet	Orange, sweet
Baikal Ruby	4-6 feet	Bright red, possibly sweet
Golden Sweet	12 feet	Yellow with sweet/acid flavor
Titan	12 feet	Large, light orange, less acidic
Siberian Splendor	Not Available	Light orange, suitable for fresh eating

Seaberry plants are difficult to find but are easy to propagate. Hardwood cuttings can be soaked in water and planted directly into a prepared bed. Softwood cuttings can also be used, but require a longer time in the nursery before being planted into the field. Once the plants are established, they spread rapidly in bare soil, and any shoots that sprout from roots can be dug up and transplanted.

Seaberries are native to cold deserts, and like most plants of the desert, they grow best in full sun. Plants in shade will stop producing flowers and fruit and

can slowly die. Shrubs must be pruned regularly to allow sunlight to penetrate the plant, which will increase flower bud formation.

In the prairie provinces of Canada, there have been reports of seaberries becoming invasive, with one plant that became a thick stand covering an acre. The invasive nature does not appear to be a concern in humid climates. Seaberries do not grow in the shade, and once native trees grow over the seaberry plants, the plants slowly die. There are few reports of seaberries becoming invasive in the Midwest.

⁵¹ Li, T.S. and Schroeder, W.R., 1996. Sea buckthorn (*Hippophae rhamnoides* L.): a multipurpose plant. *HortTechnology*, 6(4), pp.370-380.

PRODUCTION PROBLEMS AND COMMERCIAL POTENTIAL

The biggest barrier to commercializing seaberries is harvesting. Seaberries do not form an abscission layer, and therefore the fruit will stay on the plant until the middle of winter. The plants have spines that interfere with picking and the berries have to be pulled off the plants with force. The lack of an abscission layer complicates mechanical harvesting, which in most species works by shaking the fruit off the tree. The most common way to harvest seaberries is to cut off and freeze the branches and then shake off the berries by hand. The fruit hang onto the branches through the winter, so there is the potential of cutting and shaking branches in early winter.

So far, there have been no diseases found on seaberries, and the fruit does not attract Spotted Wing *Drosophila*.

There is a market for seaberries among Russian immigrants, and most Russian and Ukrainian immigrants are willing to pick their own fruit. Growers interested in selling to Russians should research varieties that immigrants want. There is a concern that the cost of picking seaberries is too high for the product to be sold at farmers' markets for a profit. Processed seaberry products are usually sold through health food stores, which rely on a supply chain from Chinese factories.

EDIBLE LANDSCAPING

One of the seaberry's greatest production problems provides its potential for edible landscaping: the berries hang on the shrubs for months after ripening, even during winter. The orange fruit and silver leaves will lighten up a landscape and work in floral arrangements.

wild plums cherry plums sand cherries

Wild plums, sand cherries, and cherry plums have the distinct plum characteristics of sour skins, sweet flesh that sticks tightly to the pit, and pits that are flatter than they are round. Plants vary from shrubs to small trees.

Wild plums (*Prunus americana*) are native to much of the U.S. North America is host to a variety of distinct plum species, but the only species widely planted in Minnesota is *P. americana*. Wild plums are typically large shrubs or small trees that sucker profusely, often sending out root suckers that sprout 20 or more feet from the mother plant. The fruit flesh is yellow, while the skin color varies from yellow to red, with the most common color being a red blush. Like most wild plants that are propagated from seeds, fruit quality varies tremendously. The best quality fruit has thick, sour skins, with sweet flesh that clings tightly to the pit. Some trees produce fruit with the texture of a golf ball that does not soften during

ripening. Fruit varies from 1 to 1 ½ inch in diameter, and fruits with soft, sweet flesh tend to be larger.



Figure 41. *Edible wild plums*

Sand cherries are small, native shrubs which produce a small fruit that is closer to plums than cherries. In some literature, all sand cherries are put into the species *Prunus besseyi* while other writers put the western sand cherry into a separate species, *Prunus pumila*. Sand cherries are native to southern Canada and the northern U.S. from Labrador to Utah, and are seldom found south of Iowa. As their common name suggests, sand cherries grow best in sandy soils and were particularly common in the Sand Hills of Nebraska. Sand cherries are very short lived shrubs that grow up to six feet tall. In Minnesota, plants rarely grow more than three feet tall. There is one cultivar of sand cherry called 'Hansen', but those who have grown 'Hansen' report variable characteristics typical of seedling plums.

Cherry plum is kind of a catch-all term for a number of small fruited plums that belong to several related species. Most produce red or purple fruit. The species *Prunus cerasifera* is often called a cherry plum and is hardy in Minnesota. Varieties of cherry plum include 'Newport', 'Red Diamond', and 'Thundercloud'. Hybrids between sand cherries and another unknown species of plum include the varieties 'Sapalta', 'Deep Purple', and 'Compass'. 'Sapalta' has the deep purple color of the sand cherry, a sour skin, pits that free from the flesh, a pleasant flavor, and long lived shrubs the size of a sand cherry. Other varieties called cherry plums sold in catalogs may belong to other species. Most cherry plums are small trees grafted onto a plum rootstock. 'Sapalta' is a small shrub that is not grafted.



Figure 42. Sand cherry fruit.



Figure 43. Sand cherry fruit.



Figure 44. Mature sand cherry shrubs.

Table 14. Cultivars of cherry plums and sand cherries			
Cultivar	Species Name	Tree characteristics	Fruit
Wild plum	<i>americana</i>	5-10 foot tree with root suckers	Red fruit, yellow flesh, thick sour skin
Hansen	<i>besseyi</i> – sand cherry	2-4 foot shrub	Small black fruit
Sapalta, Deep Purple	<i>besseyi</i> x unknown	4-6 foot shrub can be trained as 8' tree	Medium purple fruit
Compass	<i>cerasifera</i>	8-10 foot tree	Small red fruit
Red Diamond	<i>americana</i>	8-12 foot tree	Purple fruit
Thundercloud	<i>cerasifera</i>	12 – 20 foot tree, red fruit, pink blossoms	Small red fruit

Sand cherries and wild plums were frequently consumed by both Native Americans and European settlers. Native Americans dried the fruit, ate it fresh and planted plums near their dwellings. European settlers canned wild plums and made plum wine.

By the end of the 19th century, plant breeders began to crossbreed native sand cherries and wild plums with European and Japanese dessert plums to develop large plums suitable for the fresh market that could be grown in the northern Great Plains. In the first half of the 20th century, over a dozen hardy American hybrid plums were released. The hardy dessert

plums developed a devoted following among home gardeners who appreciated the plants as much for their spring flowers as for their summer fruit. By the middle of the 20th century interest in growing plums for local markets decreased as Japanese-type plums grown in California dominated the market.

The local foods movement of the 21st century has sparked a renewed interest in all types of plums that can grow in the Upper Midwest and Great Plains. Many people are rediscovering the hybrid dessert plums as well as finding new uses for the smaller wild plums and cherry plums.

USES AND HEALTH BENEFITS

All of the plums described above can be eaten fresh, but the sour skins tend to turn away all but the hardiest customer, and the small fruit size makes separating the sour skins from the sweet flesh a challenge. Sand cherries are usually grown from seed, leading to a variety of tastes from sweet and pleasant to astringent. Sapalta is probably the best for eating straight off the tree and its intense flavor is matched by its vibrant purple color.

All of these plums can be processed into jelly. Although jams and sauces would also taste good, the pits are difficult to remove. Any of these plums can also be used to make very good wines or steeped in wine to make a cordial. Most of these plums taste quite good canned.

Wild plums are often planted near the hardy dessert plums as pollinators. The dessert plums are hybrids between distantly related species and many different cultivars are incompatible with each other, but all dessert plums can be pollinated by neighboring wild plums.

All plums are rich in Vitamin C and many are rich in Vitamin A. The dark color of sand cherries and Sapalta plums indicates a high level of anthocyanins and therefore antioxidants. Plums are probably very

healthful, but the health benefits of plums have received little attention from the scientific community.

“Canning for Fruits and Berries”

A Minnesota State Fair winner makes fruit and berry canning as easy as washing dishes. It gives much fruitier, fresh fruit flavor. It saves time and sugar. No unused syrup left over. It is 100% in keeping. Use for plums, cherries, berries and all fruits that require no peeling or other than washing to prepare them. Works on peaches, too.

1. Fill the clean fruits or berries into boiled jars.
2. Add $\frac{1}{2}$ or $\frac{2}{3}$ cup sugar to each quart, depending on ripeness of fruit. Well-ripened and sweet fruit require less sugar, $\frac{1}{4}$ cup per quart.
3. Fill jars with cold water.
4. Apply jar lids to jars, cover with water in a canner with $\frac{1}{2}$ inch to 1 inch of water over tops of jar lids. After water boils, process berries 15 minutes. Process fruits 20 minutes.
5. At the end of processing there will be undissolved sugar in the bottom of the jars, but it will dissolve within a day or two.

Recipe submitted by Joyce Grimsbo to the Bethel Lutheran Church, Palisade, MN cookbook of 1979

PROPAGATION AND PLANTING

Sand cherries and wild plums are typically planted as seeds for conservation plantings. All plantings of seedlings will contain a high percentage of plants with marginal fruit quality. Most cherry plums are grafted. The most commonly used rootstock is wild plum, which is hardy and compatible, but does sucker extensively.

Homeowners interested in wild plums and sand cherries for fruit production should consider propagating their own plants by digging up root suckers from trees with good fruit quality in early spring. Select trees with good fruit quality in late summer and try to determine which root suckers

belong to which trees. If a tree with large, sweet plums is growing twenty feet from a tree with poor quality plum, any sprout between could belong to either tree. Fortunately, the leaves tend to be distinct, and in some cases, you can determine which sprout belongs to which tree by leaf characteristics. Mark the desirable sprouts in late summer and dig up the plant in early spring before bloom. Often, the root suckers have few roots, so pruning the roots during the summer before transplanting may force more roots to grow. The best way to root prune is to take a shovel and cut all lateral roots around the tree to be transplanted.

PRODUCTION PROBLEMS

All plums are susceptible to plum curculio. Plum curculios lay eggs in young plum fruit, and in most cases the larvae eat through the developing fruit, causing the fruit to drop off (Figure 45.) Plum curculios cause fewer problems in wild plums than in dessert plums. All plums are susceptible to brown rot, a disease that covers the fruit with white spores and causes fruit to rot on the tree (Figure 46.) Brown rot will often move into branches and small twigs, making the plant more susceptible to winter injury and death.

Wild plums are susceptible to the disease plum pocket (Figure 47), a bizarre fungal disease that causes the green fruit to grow abnormally large. Since wild plums are not a commercial crop, the disease has received little scientific attention. The fungus that causes plum pocket is closely related to the fungus that causes peach leaf curl, a devastating disease for peach producers. Control measures for peach leaf curl should control plum pocket, including a late winter copper spray on trees that have the disease. More information about diseases,



Figure 45. Plum curculio larva in a 'Sapalta' plum



Figure 46. Brown rot in sand cherries



Figure 47. *Plum pocket*

insect pests, and control measures can be found in the University of Minnesota Extension publication: *Pest management for the home stone fruit orchard*.⁵²

Possibly the biggest problem with sand cherry and wild plum production is the genetic diversity associated with all seedling shrubs. Within one small row of sand cherries there will be astringent cherries, sweet cherries and even an occasional green-fruited cherry. Wild plums may have sweet, soft fruit

or bitter, tough fruit. People interested in growing sand cherries should buy the cultivar 'Hansen'. A number of people have selected improved strains of wild plums, but those selections are difficult to find. By contrast, cherry plums are usually consistent. 'Sapalta' and the closely related 'Deep Purple' almost always come true to form from a nursery. The cherry plums 'Compass' and 'Newport' are grafted and therefore consistent between nurseries.

COMMERCIAL POTENTIAL

Wild plums with good fruit quality can be sold to wineries and to jelly makers. The demand for wild plum jelly is quite good. Other plums are a little tougher to sell. 'Sapalta' and 'Deep Purple' could have a limited

market for fresh sales. Due to the presence of both astringent and sweet fruit from the same row of fruit, sand cherries exhibit too much variation in fruit quality to be suitable for the fresh market.

EDIBLE LANDSCAPING

Cherry plums and sand cherries make superb landscaping plants. The fragrant white blooms early in the season are a welcome addition to any yard. They attract orioles, Cape May warblers and other desirable song birds; as well as many native pollinators. Sand cherries work well as a low growing hedge on property borders, especially

in sites with no irrigation and a harsh climate. Wild plums are best planted in turf that is mowed regularly. The sprouts from those root suckers will grow through lawn grass, and if the grass is not mowed regularly, the entire lawn can turn into a wild plum patch.

⁵² University of Minnesota Extension. *Pest management for the home stone fruit orchard*. <http://www.extension.umn.edu/garden/yard-garden/fruit/integrated-pest-management-for-home-stone-fruit-growers/>

Two varieties of the true cherry plums (*Prunus cerasifera*) have purple leaves in addition to pink flowers and purple fruit. Both 'Newport'

and 'Thundercloud' are primarily planted as ornamentals, but will produce fruit some years.

MINNESOTA EXPERIENCES

Scientists in Minnesota and surrounding states have played a major role in breeding cherry plums and selecting wild plums with good fruit quality. Interest in northern grown plums dropped in the second half of the 20th century, but has been rising in recent years. Currently, there are about a dozen farms in Minnesota selling plums, and one which specializes in plum production. Growers report good sales at farmers markets. Many new growers are expressing an interest in growing plums. There is a high demand for wild plums from local wineries. One challenge facing plum growers is that all plums are difficult to grow organically in Minnesota. Brown rot starts out slowly. For the first two years many growers don't pay attention to moldy plums, but after a few years, the infections have spread to the tree itself, and the disease can no longer be controlled without fungicides. Similarly, plum curculio populations start out low and after several years reach levels that are difficult to control without harsh insecticides.

Note from Thaddeus:

I have a mixture of wild plums, cherry plums, and 'Sapalta' that came with my property. I once brought good quality wild plums to the farmers' market and sold everything right away. I have not tried to sell 'Sapalta', partly because I treasure every plum that escapes plum curculio and brown rot. I typically skin the plum and the flavor is still as intense as its deep purple color.

crops listed in many catalogs

BUT ARE NOT READY FOR COMMERCIAL PRODUCTION

CORNELIAN CHERRY DOGWOOD

Cornelian cherry is not a true cherry, but a slow growing, globe-shaped, ornamental species of dogwood (*Cornus mas*). The fruit is yellow to red and oblong, similar to both the fruit of the flowering dogwood of Eastern North America and the tiny bunchberry plant in the northern forests. Cornelian cherries are the only dogwood species grown for fruit. Most Cornelian cherries are hardy through USDA Zone 4, and the tree does appear to be suitable for the southern third of Minnesota, with experimental plantings further north.

Cornelian cherries were primarily grown for their fruit in Eastern Europe from Austria to Turkey. Attempts to develop a market for the fruit in North America have largely stuttered. Cornelian cherries have two traits that make the trees difficult to grow profitably. The first is that there are few varieties available in the U.S. that were selected for fruit quality. The second is that the trees grow very slowly, and a grower may have to wait a decade for the first crop. Many Cornelian cherry trees on the market are seedlings and therefore have variable fruit quality and tree hardiness.

Cornelian cherries work perfectly in edible landscaping. The trees have a great form, along with tiny fragrant blossoms that open early in the spring. The fruits are even easy to harvest. Most people put a tarp under the tree when the fruit is ripe, shake the tree and then gather the fruit off the ground to be used in jellies, juice and wine.

Note from Thaddeus:

I once visited the farm of a woman who had planted several of what she thought were true cherry trees but were, in fact, Cornelian cherry trees. After pointing out to the disappointed woman that the slow growing trees in her yard were a species of dogwood, I began referring to the plant as "Cornelian cherry dogwood."

MULBERRIES

Mulberries are rarely grown for their fruit on this continent, largely because the primary species is the white or common mulberry (*Morus alba*), a species typically grown for its leaves as food for silkworms instead of for fruit. The name white mulberry refers to wood color rather than fruit color. Mulberries are small fruit that grow on large trees, making harvest both difficult and uneconomical. Mulberries are a sweet, low-acid fruit, lacking the “zing” of our most popular fruit. In spite of these problems, mulberries have a place in the edible landscape and home garden. With their sweet taste, mulberries are a perfect fruit for small children, and they ripen in June, when little other fruit is available. Mulberries are very attractive to numerous bird species.

White mulberries are common in the southern third of Minnesota, where they grow as weeds in shelterbelts. They will grow as far north as Brainerd and Fargo, but the trees are noticeably weaker than further south. Fruit color varies from a light lavender to black, and the flowers are small and hard to see. Almost all mulberry seedlings produce edible fruit, but the fruit is very small, sometimes little over a half inch long and quarter inch in diameter, and prohibitively expensive to harvest. There are a number of large fruited cultivars listed in various garden catalogs, but those cultivars have not been tested in Minnesota.

EDIBLE MOUNTAIN ASH AND SHIPOVA

The group we call mountain ashes are trees and shrubs belonging to the genus *Sorbus*, which is related to apples and pears. The most common mountain ashes planted in the U.S. produce orange, mealy berries that nonetheless are great for attracting birds. Several varieties and species have been selected for fruit, including *S. aria* or whitebeam, and the ‘Rabinia’ cultivar of *S. aucuparia*; however the fruit has mainly been a novelty. Edible mountain ashes have variable fruit quality but work well in edible landscaping.

The Shipova is a cross between the whitebeam (*Sorbus aria*) and a European pear cultivar, making it one of the few commercially available fruit varieties that is a cross between species of different genera. The fruit is about two inches in diameter, and forms in small clusters. The fruit lacks seeds, and the flowers do not need to be pollinated to set fruit. Like a pear, shipova ripens into a soft, sweet fruit, and it is resistant to most diseases. Shipova is rated to at least Zone 4, so it is worth trying in the southern third of Minnesota as an alternative to pears.

PAWPAW

The pawpaw is a fruit native to eastern North America, south and east of Minnesota. In the deciduous forests it is generally an understory shrub. The fruit belongs to the Annonaceae family that primarily grows in the tropics. The fruit is oblong, with large seeds embedded in sweet flesh, with a unique tropical flavor similar to cherimoya. The natural range of the pawpaw extends from southeast Wisconsin to Florida. Over the years, it was called “Michigan banana” or “Hoosier banana”, but

the pawpaw is not related at all to bananas. It is only distantly related to its namesake, the tropical papaya, which in some countries is called pawpaw.

Pawpaws were eaten and treasured by Native Americans and European settlers, but the species remained marginally domesticated until the second half of the 20th century. Like most wild species, fruit quality in wild pawpaws varied tremendously. Some plants produced exceptional

fruit while others were marginally edible.

At the end of the 20th century, there was a big push in states like Kentucky to develop commercial pawpaw production, primarily by selecting wild plants with good fruit quality and planting seeds from those plants. Asexual propagation is difficult with pawpaw, and all of the available varieties come from seeds. As a result, there are an increasing number of varieties with good fruit quality that are rated to be hardy to Zone 4 and should grow in southeastern Minnesota or in the urban heat island

of the Minneapolis/St. Paul metropolitan area. If testing pawpaws, look for varieties that come from wild plants at the northern end of their natural range such as 'Campbell' (Ontario), 'Pennsylvania Golden', or 'Davis' (Michigan).

Minnesota lacks the climate for large scale commercial pawpaw production, with the short growing season as much of a limiting factor as the cold winters. Brave growers who want an unusual landscape plant that produces unusual but delicious fruit may want to try pawpaws.

BUFFALO BERRIES

Buffalo berries (*Shepherdia argentea*) are native to the western Great Plains, including western North Dakota; and can survive drought, alkaline soils, and harsh climates. Like the closely related Russian olive, autumn olive, and seaberry, buffalo berry plants can fix nitrogen. The plant is a woody shrub that grows as tall as 12 feet with silver leaves. Buffalo berry plants produce small red or orange berries that have long been eaten by Native Americans or made into jellies by white settlers. Recently, scientists have discovered that buffalo berries are extremely high in lycopene, the same compound that gives tomatoes both red color and health benefits. As a result, buffalo berries are being touted as a new "super fruit."

Like most wild species of fruit, buffalo berries exhibit variation in fruit quality and most plants produce berries not suitable for the modern palate. In spite of receiving favorable reviews in the national press, buffalo berries are not ready for commercial production due to a combination of low yields and extraordinarily difficult picking. They are suitable for edible landscaping, and the silver leaves will stand out in a yard.

Southern Minnesotans interested in a high lycopene fruit may be better served by the autumn olive.

AUTUMN OLIVE AND GOUMI

Autumn olives (*Elaeagnus umbellata*) are small trees that produce bright red, edible stone fruit. Autumn olives are closely related to Russian olives (*E. angustifolia*), a tree with silver leaves native to semi-arid regions of Eurasia that has become invasive in the Intermountain West. In Minnesota, Russian olives have been planted as a landscape tree in some areas, but are not as invasive in Minnesota due to competition from other trees and higher disease pressure in our climate. Russian olives have small inconspicuous yellow flowers that produce an intense aroma that many people find pleasant while others find the aroma overwhelming. Autumn olives produce larger, white flowers that have both ornamental value and a pleasant aroma that is

not as strong as Russian olive. Russian olives have edible, dry, and unappetizing fruit. Autumn olives are juicy, with a nice red color and a good sugar/acid balance. The guomi, gumi, or cherry silverberry (*E. multiflora*) produces fruit similar to autumn olives, but on a shrub rather than a small tree, and the fruit has longer stems. The autumn olive is rated as being hardy to Zone 3, while the gumi is rated to Zone 4.

In 2000, autumn olives were found to have a high concentration of lycopene, a red pigment most commonly found in tomatoes. Lycopene is a carotenoid and has entirely different health benefits than the anthocyanins that are found in most types

of blue fruit. Lycopenes help prevent some cancers⁵³ and may help prevent heart disease. Autumn olives contain five times more lycopene than fresh tomatoes, making them an alternative source of lycopene for those who are allergic to tomatoes.

There are ten registered cultivars of autumn olive, including two that have yellow or golden berries. The cultivar 'Cardinal' is grown in Japan for its fruit, and is rated as a Zone 4 plant. Cultivars rated to Zone 3 include 'Garnet', 'Red Autumn' and 'Ruby'. The goumi cultivars 'Red Gem' and 'Sweet Scarlet' were selected in Russia and Ukraine and are rated for Zone 4.

In spite of claims that autumn olive is exceptionally hardy, it does not do well in northern Minnesota. By

contrast, autumn olives appear to thrive in southern and southwestern Minnesota. There is a feral grove of autumn olive at Hole in the Mountain County Park near the town of Lake Benson in Southwest Minnesota (Figure 48). The fruit on these feral trees are about the size of peas, with yields too low for commercial production. Like most seedlings, the taste of the fruit is variable, ranging from astringent to quite good. Autumn olives show a good potential for edible landscaping. The flowers have a more universally appealing smell than Russian olive and the fruit is juicy and sweet. Both autumn olive and goumi have green leaves with a silver tint that work well in landscapes. Goumi may not be hardy enough for most parts of Minnesota.



Figure 48. Wild autumn olive at Hole in the Mountain County Park, Lake Benson Minnesota.

⁵³ Giovannucci, E. 1999. Tomatoes, Tomato-Based Products, Lycopene, and Cancer: Review of the Epidemiologic Literature. *JNCI: Journal of the National Cancer Institute*. 91(4):317–331. <https://doi.org/10.1093/jnci/91.4.317>

COMMON BARBERRY AND MAHONIA

The common barberry (*Berberis vulgaris*) is perhaps the most unknown of all the emerging fruits.

Barberries are small, thorny shrubs that produce pretty yellow flowers and red, edible fruit. In Europe, barberry was grown both for fruit and medicine, and was so popular that European settlers brought seeds to North America in the 1600s. By the end of the 19th century, white settlers in Minnesota were growing barberries on their homesteads.

Common barberries are the alternate host for wheat stem rust. Wheat growers noticed the correlation between barberries and crop failures centuries before the fungus was identified. Farmers in New England had pushed legislation to ban barberries as early as the 18th century. After major rust outbreaks in 1915 and 16, Minnesota joined several other states in eradicating barberries. Eradication efforts continued until 1980. The barberry commonly seen in yards and garden centers in Minnesota is the Japanese barberry (*B. thunbergii*), but its fruit are not edible. The Japanese barberry is not a host for wheat rust and has never been outlawed.

The state of Minnesota forbids the common barberry (*B. vulgaris*) from being “transported, propagated or sold.” Wheat rust can survive without barberries,

but the fungus needs to grow in barberries in order to complete its sexual lifecycle. Current control strategies for wheat rust work best when the fungus cannot go through its sexual stage⁵⁴.

Barberries contain a series of medicinal compounds that have been used for centuries. Those who wish to grow barberries for their health benefits may want to try a close relative, *Mahonia repens* or *Mahonia aquifolium*, which are called by a number of names, including Oregon grape, grape holly, and creeping Mahonia. All *Mahonia* species produce blue berries in small clusters, but have evergreen leaves similar to holly. There are several species of *Mahonia* native to the western U.S. Creeping Mahonia (*M. repens*) is more of a groundcover, rarely growing taller than a foot, and grows in Zone 3 areas of Montana. Some cultivars of *M. aquifolium*, or the upright Oregon grape, are hardy to Zone 4. *M. aquifolium* is a small shrub that grows up to five feet tall in Zone 4 areas of northern Idaho and is frequently planted as a hardy alternative to holly trees. Both *Mahonia* species produce fragrant yellow flowers that closely resemble barberry flowers. *Mahonia* berries of both species are sour and pungent, and easier to pick than barberries. Most of the medicinal compounds in barberry are also present in *Mahonia*.

Note from Thaddeus:

According to some sources, creeping Mahonia is found in parts of Minnesota, but I have yet to find it in our forests. Because mahonia have evergreen leaves that resemble holly leaves, some people think they are related to holly trees. Mahonia are so closely related to barberries that many taxonomists have put Mahonia into the same genus as barberries. In some guidebooks, M. repens is called “creeping barberry.” I have never heard that name in spoken conversation.

⁵⁴ Minnesota Department of Agriculture. Prohibited – Control Noxious Weed Common Barberry – *Berberis vulgaris* L. <http://www.mda.state.mn.us/plants/pestmanagement/weedcontrol/noxiouslist/commonbarberry.aspx>

marketing of perennial fruits

INTRODUCTION

Regulations for the sale of fruit in the state of Minnesota vary depending on the level of processing and whether or not the product contains added ingredients. Fresh or frozen fruits that do not contain off-farm ingredients are “product of the farm” and can be sold by the grower without a license. Once an ingredient has been added, such as salt or pectin, the fruit no longer falls under the product

of the farm category; and therefore is subject to different regulations. If you want to produce a fruit product with added ingredients, you will either need to become licensed or to follow requirements for the Cottage Food Law exemption from licensing. This chapter provides an overview of regulations regarding the processing and marketing of fruits, examples of processed fruit products, and resources.

Sale of product of the farm does not require a license and is an approved source of produce for food businesses to purchase. Farmers and small-scale fruit growers can do processing of their own produce without a license if no off-farm ingredients are added. This means farmers and fruit growers could peel, slice, blanch, mash, and freeze fruits for sale to any buyer.

Although a license may not be required, any processing and cold storage facilities will need to be inspected by a Minnesota Department of Agriculture inspector, and Current Good Manufacturing Practices (CGMPs) must be followed. Processing of product of the farm cannot be done in a home kitchen. More information about regulations for sale of produce can be found in Minnesota Department of Agriculture’s publication *Serving or Selling Locally Grown Produce in Food Facilities*⁵⁵, and Minnesota Institute for Sustainable Agriculture’s *Selling Minnesota Produce* fact sheet.⁵⁶

Product of the Farm

Farm products that you grow or raise on land that you “occupy and cultivate.” Land that you “occupy and cultivate” includes land that you rent or lease, so long as you have control over the production on that land.

Constitution of the State of Minnesota, Article 13, Section 7, https://www.revisor.mn.gov/constitution/#article_13. Minnesota Statute 28A.15 Subd. 2, <https://www.revisor.leg.state.mn.us/statutes/?id=28A.15>

Information about CGMPs can be found in the FDA’s Guidance document for the FSMA Preventive Controls Rule⁵⁷ under the section entitled **XIII UPDATED AND CLARIFIED CURRENT GOOD MANUFACTURING PRACTICE (CGMP)** found on pages 27 – 38.

COTTAGE FOOD LAW

Minnesota’s Cottage Food Law exempts qualified sellers of home-kitchen baked or processed foods from the food handler license requirement. This is an option for fruit growers to make a fruit product with added ingredients in their home kitchen, and sell it to individual consumers (not food businesses). There is a sales cap of \$18,000 per year. Cottage Food items must qualify as Non-Potentially Hazardous (NPH) foods. NPH foods are foods that are not conducive to the growth of bacteria that may be

hazardous to human health. For more information on what foods do and do not fall under this category, please see the Minnesota Farmers’ Market Association Fact Sheet⁵⁸.

In order to qualify for the Cottage Food exemption, the producer must:

- Only sell food products that meet the definition of Non-Potentially Hazardous.

⁵⁵ Minnesota Department of Agriculture. *Serving or Selling Locally Grown Produce in Food Facilities*. State of Minnesota. July 2016. Web. 07 March 2017. https://www.mda.state.mn.us/food/safety/~/_media/Files/food/foodsafety/fs-produce.ashx

⁵⁶ Minnesota Institute for Sustainable Agriculture. *Selling Minnesota Produce*. Fact Sheet. Web. http://misadocuments.info/LFAC_local_produce_factsheet.pdf

⁵⁷ Food & Drug Administration. What You Need to Know About the FDA Regulation: Current Good Manufacturing Practice, Hazard Analysis, and Risk-Based Preventive Controls for Human Food (21 CFR Part 117): Guidance for Industry, Small Entity Compliance Guide. <http://www.fda.gov/downloads/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/UCM526507.pdf>

⁵⁸ Minnesota Farmers’ Market Association. *Minnesota Cottage Foods Law: Non-Potentially Hazardous Foods*. 2016. Web. <http://www.mfma.org/resources/Documents/MFMA%20Fact%20Sheet%20NPH%20Foods%20List%202016-03-15.pdf>

- Not exceed \$18,000 in sales per year per individual.
- Register with the Minnesota Department of Agriculture prior to selling cottage foods, and renew registration annually.⁵⁹
- Complete an MDA-approved food safety training prior to selling cottage foods (Materials written at 8th grade level).
- Sell the produce in face-to-face transactions with individual customers only; no sales to food businesses.
- Label product according to MDA requirements.

Cottage food producer food safety training can be taken online via the MDA website. In-person courses are offered by University of Minnesota Extension.⁶⁰

APPROVED RECIPES

Non-potentially hazardous (NPH) foods are foods that will not become hazardous to human health if left unrefrigerated. Examples might include dried fruit, baked cookies or breads, or canned fruit items with a final pH of 4.6 or less. Many recipes for these types of items clearly fall into the NPH category, but some types of baked or canned items are questionable. Any baked item with a custard or cream cheese filling is not allowed as Cottage Food, because it must be refrigerated for food safety. Very moist fruit breads or cakes may be able to support rapid bacterial growth and would therefore not be allowed as Cottage Food. Non-acidic fruits like saskatoon might have a final pH higher than 4.6 when canned, and would have to be either mixed with a high-acid fruit or acidified through addition of lemon juice or vinegar.

Recipes found on a state Extension website are considered tested recipes acceptable for Cottage Food use. However, because the fruits covered in this document are not in common use, there are few recipes for products containing them. The University of Minnesota Extension service website has recipes for chokecherry jelly, chokecherry syrup, gooseberry jam, and gooseberry jelly.⁶¹ The site is also a

resource for fruit freezing procedures.

Another source for approved recipes is the National Center for Home Food Preservation at the University of Georgia.⁶² Use the search bar to find information on canning, drying, freezing, and making jams/jellies with gooseberries, elderberries, currants, and chokecherries. Available for purchase through the website is the Extension book *So Easy to Preserve* which contains similar information as what is found on the website.

Recipes for other types of fruits can be adapted to the perennial fruits described in this book. Also, you may have family recipes handed down or find other heirloom recipes that use these perennial fruits. Normally if a recipe used by a Cottage Food operator is very similar to an approved recipe from Extension, it will be fine to use. Recipe alterations are a problem if they will cause the product to have a pH level higher than 4.6, or if the product will need to be refrigerated to maintain food safety. If in doubt, you can have your recipe reviewed. To have a recipe reviewed by MDA for approval, send it in an email it to mda.cottagefood@state.mn.us

⁵⁹ Minnesota Department of Agriculture Cottage Food Registration. <http://www.mda.state.mn.us/licensing/%20licensetypes/cottagefood.aspx>

⁶⁰ University of Minnesota Extension Food Safety. Cottage Food producer food safety training. <http://www.extension.umn.edu/food/food-safety/courses/cottage-foods/>

⁶¹ University of Minnesota Extension Food Safety. Preserving and Preparing: Fruits. Web. 08 March 2017. <http://www.extension.umn.edu/food/food-safety/preserving/fruits/>

⁶² National Center for Home Food Preservation. University of Georgia College of Family and Consumer Sciences, n.d. Web. 08 Mar. 2017. <http://nchfp.uga.edu/index.html>

A Family of “Individuals”

Under Minnesota’s Cottage Food Law, multiple family members can register and therefore increase the maximum income ceiling by \$18,000 annually per “individual.” This can include children; however, the children need to be mature enough to read and understand the materials presented in food safety training and to follow the food safety guidelines. The materials are written at an eighth grade level. Generally the MDA would consider a child of 12 or older, with at least eighth grade reading comprehension skills, to be mature enough to register as an “individual” and participate in home-based production and sales of non-potentially hazardous foods.

If any off-farm ingredients will be added to the product, including any produce from other farmers, and the enterprise does not qualify under the Cottage Food Law, a food handlers license is required. Licensing is required if the processed, multi-ingredient product will be sold to food businesses: sales to food businesses cannot be done under the Cottage Food exemption. The standards for food processing are not as strict as restaurant standards. A suitable kitchen might be found in a local church or township hall. To begin the inspection and licensing process, obtain contact information for your local inspection agent by calling the Minnesota Department of Agriculture at 651-201-6027.

PROCESSED PRODUCTS

Perennial fruits can be sold fresh when in season, but they can also be frozen, processed, or added to other products for year-round sales.

Vinegar drinks such as shrubs and switchels are an emerging market in Minnesota. Made from muddled fruit, vinegar, and sugar; shrubs and switchels are syrups used to flavor drinks and food. Ag Innovation News published an article entitled “Vinegar Drinks Making a Splash” which highlights some Minnesota shrub and switchel producers.⁶³ Locally grown, perennial fruits have great potential for use in these products.

Gourmet vinegars are another option worth consideration. Clover Valley Farms⁶⁴ in Duluth uses several of the fruits covered in this document in their fruit-infused vinegars.

Fruit tinctures are made by preserving fruit in alcohol with a minimum proof of 50 (25% alcohol). Fruit tinctures are easy to make, last for years if stored properly, and have a number of uses. Tinctures are becoming more popular as craft beverages gain in popularity. Producers and sellers of alcohol-containing tinctures would need both food handler licensing from the MDA, and permitting for alcohol sales from the Minnesota Department of Public Safety.⁶⁵

⁶³ Morrison, Liz. 2017. Vinegar Drinks Making a Splash: Tangy thirst quenchers get a modern twist. *Ag Innovation News*, Jan–Mar 2017, Vol. 26, No. 1. <http://www.aui.org/2017/01/10240/>

⁶⁴ Clover Valley Farms. <http://clovervalleyfarms.com/about-our-products/clover-valley-fruits/>

⁶⁵ Minnesota Department of Public Safety. “What Can I Sell in My Liquor Store?” <https://dps.mn.gov/divisions/age/alcohol/Pages/FAQ/faqGeneral.aspx>

landscaping perennial fruits

PLACEMENT OF PERENNIAL FRUITS ON THE LANDSCAPE FOR ECOSYSTEM SERVICES

INTRODUCTION

Woody perennials can provide ecosystem benefits. Soil and agricultural nutrients and chemicals cause water quality issues when surface runoff reaches water bodies, streams, and wellheads. Groundwater quality can also be compromised when nutrients and chemicals leaching through the soil profile reach groundwater; or in areas where the geology allows surface runoff to reach groundwater, such as karst sinkholes (see Agriculture and Water Quality sidebar, p. 101). When perennials are strategically placed on the agricultural landscape, sediment and nutrient loss from surface runoff can

be greatly reduced. Iowa State University Extension's publication *A Targeted Conservation Approach for Improving Environmental Quality* suggests that agroforestry niche crops such as perennial fruits can be integrated into cropping systems as a means to improve water, air, and soil quality while providing habitat for pollinators, wildlife, and predatory insects that serve as biological control of pests.⁶⁶

Some additional farm-level benefits that can be gained by the thoughtful placement of woody perennials include resilience in flood, living snow

⁶⁶ Schulte, Lisa A., et al. *A Targeted Conservation Approach for Improving Environmental Quality*. Iowa State University. 2008. Web. 06 March 2017. <https://www.nrem.iastate.edu/research/STRIPs/files/page/files/A%20Targeted%20Conservation%20Approach%20for%20Improving%20Environmental%20Quality.pdf>

fences, and mitigation of issues like wind stress to crops or livestock. Iowa organic farmer, Tom Frantzen, experienced first-hand the effectiveness of woody perennials in an agroforestry planting. During the flooding of his farm in 2008, the 66' wide shelterbelt surrounding his fields slowed down rushing floodwater, thereby allowing it to deposit sediment on the fields rather than carry topsoil and nutrients away.⁶⁷

When woody perennial fruit crops such as elderberries or currants are placed strategically to attain ecosystem benefits, there is an added bonus of a harvestable crop. The fruit crop can be used on-farm or sold in a niche market. There is income potential from value added products, fruit sales directly to consumers or to processing facilities. Several emerging fruit crops are gaining interest due to nutritional content and health benefit claims. Woody perennial fruits that sell in niche markets can be a great way to diversify the farm enterprise while addressing environmental concerns. The University

of Missouri Center for Agroforestry discusses the market opportunities for agroforestry species in their comprehensive *Training Manual for Applied Agroforestry Practices (chapter 5)*.⁶⁸

When considering perennial fruit crops for dual purposes of ecosystem benefits and a saleable crop, keep in mind that perennial fruits require intensive management in order to produce a harvestable, profitable crop. A typical conservation planting of perennials may be managed in the early years to control weeds and ensure establishment of the perennials, but little management after that other than mowing or spot spraying for weed control. Fruit crops, on the other hand, typically require ongoing management such as pruning, nutrient and pesticide application, protection from foraging animals including birds, and weed management to achieve a harvestable crop. Management of a perennial fruit planting for both ecosystem benefits and a harvestable crop will be quite different from management of a typical conservation planting.

PLANTING SITE FACTORS

When selecting a fruit crop for a site, match the species or cultivar to the conditions of the area where it will be grown. Fruit crops can be sensitive to site conditions just like most other horticultural

or agricultural crops, and attention to the plants' requirements can mean the difference between crop failure and success.

⁶⁷ Grimsbo Jewett, Jane. "Tom and Irene Frantzen." Green Lands Blue Waters. July 2015. Web. 07 March 2017. http://greenlandsbluewaters.net/Tom_and_Irene_Frantzen_2015_022317.pdf

⁶⁸ Gold, Michael, Cernusca, Mihaela, & Hall, Michelle, Eds. "Chapter 5: Upland & Riparian Forest Buffers." *Training Manual for Applied Agroforestry Practices*. 2015 Edition. Center for Agroforestry, University of Missouri. 2015. Web. 07 March 2017. http://www.centerforagroforestry.org/pubs/training/chap5_2015.pdf

Table 15. Soil and other conditions for emerging fruit crops.

Crop	Sunlight	Preferred soil type	Preferred soil pH	Unique Features
Red Currants	Full sun to partial shade	Silty to clay loam	6.0-7.0	Prefers cool soil
Black Currants	Full sun to partial shade	Sandy to clay loam	6.0 – 7.0	Prefers cool soil
Clove Currants	Full sun	Sandy loam to clay	6.0 – 7.5	Heat tolerant
Gooseberries	Full sun to partial shade	Sandy loam	6.0 – 7.5	Prefers cool soil
Aronia	Full sun	Sandy to clay loam	5.0-7.0	Tolerates acidic soil
Saskatoon*	Full sun	Silty and clay loam	6.5- 8.0	Tolerates high pH
Juneberry	Partial shade	Sandy to clay loam	5.5 -7.0	
Elderberries	Full sun	Silty loam to clay	6.0-7.5	Can survive poorly drained soil
Honeyberries	Full sun to partial shade	Sandy to clay loam	6.0 – 7.5	Frost tolerant flowers
Chokecherries	Full sun	Sandy to clay loam	6.5-8.0	
Nanking cherries	Full sun	Sandy loam to sand	6.5-7.5	Drought tolerant
Sand cherries	Full sun	Sandy loam to sand	6.5-7.5	Drought tolerant
Wild Plums	Full sun	Sandy loam	6.5-7.5	Spreads through root suckers
<i>Actinidia</i> (Hardy Kiwi)	Full sun- <i>A. arguta</i> Partial shade - <i>A. kolomitka</i>	Sandy to silt loam	5.0-6.5	Needs trellising
Goji Berries	Full sun	Sandy loam	6.0-7.5	
Seaberries	Full sun	Sandy to Clay loam	6.5-8.5	Nitrogen fixing
Buffalo Berries	Full sun	Clay loam	7.0-8.5	Tolerates alkaline soil
Autumn Olive	Full sun	Silty to clay loam	5.0-8.0	Nitrogen fixing

*Saskatoon refers to a specific genotype of *Amelanchier alnifolia* which has different site requirements than eastern juneberries.

Riparian buffers are a zone of vegetation along rivers and streams. Woody species have been recommended for use in sediment-slowing buffers as a means to improve water quality and wildlife habitat. In the publication *Riparian Buffers for Wildlife* from Penn State Extension⁶⁹, trees and shrubs are presented as important components of riparian buffers.

By slowing overland flow of water to rivers and streams, riparian buffers trap sediment and nutrients thereby improving water quality. In a statewide effort to enhance water quality, Minnesota's Buffer Law requires riparian buffers on all public waters and drainage systems.⁷⁰ The law requires at least 75% of

the vegetation within the buffer must be perennial. The law does not restrict harvest and sale of crops from those buffer areas so long as perennial vegetation is maintained. Planting woody perennial fruits in these buffer zones can satisfy part of the 75% perennial requirements and provide a harvestable, income-generating crop from these acres.

Additional benefits of installing buffers include groundwater recharge and improved fish habitat. One need not be motivated solely by a legal mandate to address runoff issues and provide an income-generating crop.⁷¹

Agriculture and Water Quality

Annual agricultural crops tend to allow runoff of soil, chemicals, and nutrients into adjacent water bodies. This is due in part to the smaller root systems of annual plants in comparison to perennial plants, and because annual cropping systems tend to leave the ground with no living roots or living cover on it, for several months out of the year.

The consequences are water quality issues. One striking example is the hypoxic zone in the Gulf of Mexico. Nicknamed the "Dead Zone," agricultural runoff along the Mississippi River leads to areas of the Gulf where fish and other aquatic organisms cannot live.

Another example is groundwater with high levels of nitrogen contamination in heavily row-cropped areas. Nitrogen can become a pollutant in local drinking water when there are no substantial root systems in place to take up the excess. High levels of nitrogen can be a health concern and as a result, treatment of water can be an expense for municipalities.

When the Minnesota Pollution Control Agency assessed Minnesota's waters, 40% of the waters were deemed impaired. This means that pollution by chemicals, bacteria, particulates, etc. were high enough to render the water quality unsuitable for "beneficial uses" such as swimming or drinking.

<http://www.gulfhypoxia.net/Overview/>

<http://www.health.state.mn.us/divs/eh/wells/waterquality/nitrate.html>

<https://www.pca.state.mn.us/water/minnesotas-impaired-waters-list>

⁶⁹ DeCecco, Jennifer A. and Brittingham, Margaret C. *Riparian Buffers for Wildlife*. PennState Extension. N.d. Web. 06 March 2017. <http://extension.psu.edu/natural-resources/wildlife/habitat-management/pa-wildlife-16-riparian-buffers-for-wildlife>

⁷⁰ State of Minnesota. 2015. Water Quality Buffer Initiative. Fact Sheet. State of Minnesota. Web. 07 March 2017. http://mn.gov/gov-stat/images/2015_buffers_fact_sheet.pdf

⁷¹ DeCecco, Jennifer A. and Brittingham, Margaret C. *ibid*

WINDBREAKS

A windbreak is a structure, natural or human-made, that slows wind velocity. The use of woody fruit species in a strategically placed windbreak can provide income with the added benefits of protecting row crops or livestock, preventing wind erosion, evenly dispersing snow across cropland, improving air quality, or improving energy efficiency in buildings. More information about strategic planting of perennials in windbreaks and shelterbelts can be found in the University of Minnesota Extension publication, *Discovering Profits in Unlikely Places: Agroforestry Opportunities for Added Income*.⁷²

Placement, density, and height are all important factors to consider when planning a windbreak. For example, windbreaks must be a minimum of 2.5 feet high to be effective. The area protected by the windbreak is proportional to the height of a windbreak. If a fruit species does not grow high enough to provide desired effects, consider taller species flanked by the shorter species. Detailed information on placement, density, and height can be found in chapter 6 of the University of Missouri Center for Agroforestry's *Training Manual for Applied Agroforestry Practices*.⁷³

ALLEY CROPPING

Another opportunity for integrating fruit crops is a practice referred to as alley cropping. Wide rows of crops are alternated with rows of woody perennials such as high-value lumber species or fruit trees. When arranged in this manner, woody perennial rows serve as windbreaks and create a protected

micro-climate for the shorter-term crop growing in the alleys. More details for how to integrate alley cropping on the landscape can be found in chapter 3 of the University of Missouri Center for Agroforestry's *Training Manual for Applied Agroforestry Practices*.⁷⁴

⁷² Josiah, Scott. 2000. *Discovering Profits in Unlikely Places: Agroforestry Opportunities for Added Income*. University of Minnesota Extension. Web. 14 June 2017. <http://www.extension.umn.edu/environment/agroforestry/discovering-profits-in-unlikely-places/>

⁷³ Gold, Michael, Cernusca, Mihaela, & Hall, Michelle, Eds. "Chapter 6: Windbreaks." *Training Manual for Applied Agroforestry Practices*. 2015 Edition. Center for Agroforestry, University of Missouri. 2015. Web. 07 March 2017. http://www.centerforagroforestry.org/pubs/training/chap6_2015.pdf

⁷⁴ Gold, Michael, Cernusca, Mihaela, & Hall, Michelle, Eds. "Chapter 3: Alley Cropping." *Training Manual for Applied Agroforestry Practices*. 2015 Edition. Center for Agroforestry, University of Missouri. 2015. Web. 07 March 2017. http://www.centerforagroforestry.org/pubs/training/chap3_2015.pdf

glossary

Abscission Layer – A layer of specialized cells that facilitate the separation of fruit from the plant or allow a deciduous tree to shed leaves.

Anthocyanin – A class of red, purple, and blue water soluble pigments found in plants. Anthocyanins are the main pigment in temperate fruit.

Antioxidant – Molecules found in some plant based foods that are believed to provide health benefits by halting an oxidation chain reaction that might cause damage to cells.

Astringency – A sensation in the mouth, caused by the constriction of mucus membranes, set off by tannins found in some fruits. The sensation can be described as dryness or choking.

Breed True – An organism that always passes a certain physically expressed trait to its offspring

is said to breed true. This phenomenon happens because the pairs of alleles responsible for the trait are the same in the parent and therefore there is no chance of variation.

Brix – A unit used for reporting dissolved solids in solution. In fruit, the figure usually corresponds to sugar content.

Cane – Long, woody stem of berry bushes that sprouts from a central crown. Canes rarely live more than 4-8 years.

Carotenoids – Common orange or red pigments found in plants and algae. Carotenoids are fat soluble and include the compounds that give the red color of tomatoes and the orange color of carrots.

Circumboreal – A region that exists in northern parallels around the globe just below the arctic.

Clone – A plant that is genetically identical to the parent plant, usually as a result of asexual propagation.

Crown – The totality of the above ground parts of a plant can be referred to as the crown, but typically the crown is the area where above ground parts meet the below ground parts. Frequently this is the area where new shoots originate.

Cultivar – a cultivated cultivar of a plant that has distinctive traits that can be passed onto the next generation by either seed propagation or asexual propagation.

Cyme – A cluster of flowers in which the flower on a terminal bud opens first and secondary flowers form on lateral stems.

Determinate – Determinate cultivars produce a full crop at once as opposed to indeterminate cultivars which will produce continually throughout the growing season.

Dioecious – A plant that does not have the male and female parts on the same plant but instead individual plants are either male or female.

Dormant – The state in which a plant or seed is alive but not actively growing.

Drupe – See “Stone Fruit”.

Ellagic Acid – A plant-based antioxidant common in strawberries and fruit of related species that is purported to provide health benefits. The U.S. Food and Drug Administration does not support these claims.

Gamma Linolenic Acid – A plant-derived Omega-6 fatty acid with a long history as a folk medicine.

Graft – When two different plants fuse together. For propagation, an upper part of a plant, called the scion, is attached to a rootstock, and two grow together. Grafting is only successful if scion and rootstock belong to the same species or closely related species.

Hardiness Zones – Standardized zones on a map that are based on average minimum temperatures within each zone. The zone designation can help growers determine whether a plant will survive winters in their growing zone.

Hybrid – A plant that is the result of the cross-breeding of two different species or varieties.

Indeterminate – A plant that continues to grow and produce flowers throughout the growing season, as opposed to a determinate cultivar which flowers and fruits at one time.

Interspecific - Between species. An interspecific hybrid is a hybrid between two species.

Invasive – A non-native species that is highly successful to the detriment of other, usually native, species. The loss of native species to non-native potentially leads to environmental degradation.

Leggy – Having long, floppy branches or stalks. This is usually a result of cultural conditions that cause a plant to grow excessively tall, frequently without the ability to support itself. Low light causing a plant to “reach” towards the light is a common cause.

Maceration – Fruit and seeds are mashed together to promote seed germination.

Macronutrients – Elements required by plants or animals in large amounts.

Micronutrients – Elements required by plants or animals in small amounts.

Native – Plants that developed and exist in a certain place over long periods of time. Also known as indigenous plants.

Nutraceutical – A nutrient derived from a plant or food that is purported to provide health benefits. The term “nutraceutical” is not defined by law in the United States.

Pectin – A naturally occurring carbohydrate found in firm fruit like apples that can be extracted to serve as a thickener when making jams or jellies.

Pemmican – A Native American food, now part of Canadian cuisine, made from pulverized, dried meat protein and dried fruit mixed with animal fat. Traditionally, pemmican stored well, was nutritious, and easy to transport. This made it a popular food for fur-traders and expeditions.

Phytonutrient – A natural chemical found in plant-based foods. There are more than 25,000 identified phytonutrients and many provide health benefits when consumed. Carotenoids and lycopene are examples of phytonutrients.

Pome Fruit – The fruit of apples, pears and their close relatives. The fleshy and edible part of a pome is formed where the ovaries, floral tube and calyx cup all fuse together.

Pustule – A raised spot or bump on a plant that is the result of a fungal infection.

Raceme – An indeterminate (see indeterminate in this glossary) flower produced on a single stalk. As the stalk grows, it produces new flowers so that the oldest flower is at the base and the newest, near the tip.

Release/Cultivar Release – A plant breeder propagates and sells a new cultivar to the public.

Rootstock – In plant propagation, the rootstock is the lower part of the plant onto which the upper part (the scion) is grafted.

Root Sucker/Suckering – A sprout that grows from a bud in the underground roots of the “mother” plant.

Scion – In plant propagation, the scion is a branch or bud of a parent plant that is grafted onto a rootstock.

Self-infertile – A mechanism in a flowering plant that prevents self-fertilization, also known as self-incompatibility.

Sepal – A part of a flower that sometimes remains on the ripened fruit, such as the small leaf-like structures on the bottom of an apple or pear. Before the fruit develops, the sepals enclose the petals of the flower.

Spore – Microscopic reproductive cells of fungi.

Stone Fruit – A fruit that contains a large “stone” or “pit” in which the seed is found. Stone fruit are also known by the botanical name, drupe. Cherries, apricots, and almonds are commonly known drupes.

Tissue Culture – A variety of techniques used to grow plant tissue in a growing medium to produce clones, which are genetically identical offspring.

Valeric Acid – A simple acid often used as a precursor to flavor compounds. Pure valeric acid has an unpleasant odor.

Cultivar – A group of plants within a species that have distinctive traits. The distinctive traits are passed onto the next generation even when propagated by seed.

Vegetative Propagation – The propagation of a plant using non-sexual methods such as tissue culture or cuttings. The offspring produced with vegetative propagation are genetically identical to the parent plant as opposed to sexually propagated offspring involving the use of cross-pollinated seed.

Vestigial hairs – Small hairs that likely evolved from more prominent hairs or thorns that may have served some earlier purpose.

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