

## CIDER APPLES

*Malus spp.*

### Introduction

Despite being one of the more challenging perennial crops to grow, growing interest in hard cider (hereafter referred to simply as cider) by both growers and consumers makes apples a key crop. There are numerous apple pests and diseases to contend with making it difficult to meet consumer expectations of size and appearance for apples destined for fresh eating. An alternative is to produce apples for processing into cider. Because the fruit need not be visually perfect, they can be grown with fewer inputs. However, even cider apples require careful and timely management, especially if using organic methods.

### Requirements:

**DRAINAGE:** Apple trees tolerate a range of soil types, with optimal growth in moderate to well-drained soils.

**PH:** 5.5–7.5

**LIGHT:** Full

**ZONES:** Variety dependent.

### Plant Selection:

**ROOTSTOCK:** Types include dwarfing, semi-dwarfing, and full-sized seedling rootstocks. Smaller trees bear fruit earlier and are easier to harvest and maintain, but have a shorter productive lifespan than larger trees. Larger trees are better able to handle drought and certain pests.

**VARIETIES:** Cider makers usually use a mix of varieties that have different levels of tannins, acidity, and sweetness. Select appropriate varieties to suit your growing conditions and goals.

### Spacing:

**IN-ROW SPACING (FEET):** Rootstock dependent.

**BETWEEN ROW SPACING (FEET):** Rootstock dependent.

### Timing:

**YEARS TO PARTIAL/FULL BEARING:** 4–6

**HARVEST SEASON:** July–Nov

**HARVEST HRS/ACRE:** 23 (hand), 2 (machine)



### Management

**PEST AND DISEASE:** While apples destined for the cider press can be less-than-perfect cosmetically, certain pests and diseases such as apple maggot and apple scab still need to be controlled. Apple maggots can be caught with sticky traps, while controlling scab may require raking and composting inoculum-carrying leaves or applying sprays like neem oil, compost tea, or approved fungicides such as Bordeaux mixture.

**POLLINATION:** Apples require cross-pollination with a compatible variety. Cultivating the understory of the orchard can increase native bee populations.

**PRUNING:** Apples require yearly pruning to stay productive, though some growers use techniques such as training branches to grow in a downward direction to decrease vigor and reduce the need to prune.

### Livestock Integration & Food Safety

Feed can be thrown under trees to encourage poultry to scratch and consume insect larvae. Hogs can be put in orchards after the main harvest to glean fallen fruit. This approach not only provides food for the animals (apple finished pork) but has shown to reduce pests such as plum curculio in the following year. Common sense precautions, as well as legal regulations, govern best practices to prevent livestock manure from contaminating fruit for human consumption. Harvesting fruit so that it doesn't touch the ground and careful timing of when livestock are among the trees are key food safety considerations.

## Harvest

In Europe, cider apples are shaken off the trees, then swept up with machinery. In the United States, cider apples are mostly still hand-picked due to food safety requirements. Harvest labor constitutes a major cost for producers, as some cider apple varieties have small fruits that can take up to four times as long to harvest. High-density, trellised orchards are increasing in number as they provide earlier yields and higher returns.

## Markets

Hard cider was the alcoholic beverage of choice in the United States until an influx of immigrants who preferred beer, along with the temperance movement, led to declines in the cider market. Profitability will likely depend upon having local cideries who are willing to pay well for specialty cider apples. Making cider (both sweet and alcoholic) on-farm is possible but requires careful consideration of the buildings and equipment you will need, as well as ensuring that you are complying with all applicable state and federal laws and regulations.

“ Today, cider production is the fastest growing sector of the apple industry.—Wilson, et al. 2018, *Planting Tree Crops* ”



## ECONOMICS CASE STUDY

Assessing the Economic Feasibility of Growing Specialized Apple Cultivars for Sale to Commercial Hard Cider Producers, Virginia Cooperative Extension.

**BASIC ASSUMPTIONS:** 5-foot by 15-foot row spacing, which equates to 581 trees per acre; price per bushel is \$15; and non-organic chemical application.

### ESTABLISHMENT COSTS

**FIRST YEAR ESTABLISHMENT COST:** \$14,421/acre.

### MAINTENANCE COSTS

**ANNUAL VARIABLE COSTS:** \$3,270/acre at maturity.

### YIELD AND PROFITS

**YIELD PER ACRE:** second through sixth year crop yields estimated at 25, 100, 250, 550, and 600 bushels per acre, respectively.

**PRICE PER BUSHEL:** \$12 to \$18 for difficult-to-find hard cider apple cultivars and \$8 to \$13 for multipurpose cultivars.

### REVENUE

**ANNUAL REVENUE:** \$11,625/acre at maturity.

**TOTAL REVENUE:** \$243,750/acre over 25 years.

**NOTES:** Planting year costs include trees, tree guards, stakes, labor to plant and train trees, fertilizer and pesticides (if non-organic). Before trees come into production, costs include labor for pruning, training, mowing, and pest control. When trees get larger and come into full production, some costs for pest management, pruning, and thinning will increase, while yields and income are also increasing. Consider cost of the labor it will take to harvest all that fruit.

### SOURCES AND ADDITIONAL INFORMATION

Wilson, M., Lovell, S.T., & Carter, T. (2018). *Planting Tree Crops: Designing and Installing Farm-Scale Edible Agroforestry*.

Farris, J., Peck, G., & Groover, G. E. (2013). *Assessing the economic feasibility of growing specialized apple cultivars for sale to commercial hard cider producers*.

<https://fruit.umn.edu/content/before-start-apple-orchard>



This material is based upon work that is supported by the Center for Integrated Agriculture Systems at the University of Wisconsin-Madison, and the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2016-38640-25381 through the North Central Region SARE program under project number NCR16-019. USDA is an equal opportunity employer and service provider. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

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## ARONIA

*Aronia melanocarpa*

### Introduction

This native, up-and-coming “super fruit” is extremely productive and relatively easy to grow. Clever marketers preferred to advertise the fruit as Aroniaberry, rather than the common moniker of “chokeberry,” so-called due to an unpleasant astringency when eaten fresh. Juiced, it adds color and healthy antioxidants to beverages and juice blends. It can be harvested by the same machine as Juneberries, currants, and haskap, making it a great candidate for mixed plantings.

### Requirements:

**DRAINAGE:** Well-drained soils preferred, but can tolerate a range of soil types and conditions

**PH:** 5.0–7.0

**LIGHT:** Full

**ZONES:** 3-9

### Plant Selection:

**PROPAGATION:** Can be propagated by seed, cuttings (softwood or semi-softwood), micropropagation, or division of root suckers.

**VARIETIES:** Cultivars grown for berry and juice production include ‘Viking’ and ‘Nero’. Varieties specifically for wildlife have little to no juice.

### Spacing:

**IN-ROW SPACING (FEET):** 3-4 ft

**BETWEEN ROW SPACING (FEET):** 12–14 ft

### Timing:

**YEARS TO PARTIAL/FULL BEARING:** : 3–5 years

**HARVEST SEASON:** August-September

**HARVEST HRS/ACRE:** Hand- 700hrs/acre;  
Machine- 65hrs/acre



### Management

**PEST AND DISEASE:** Aronia is relatively pest-free, but may need protection from deer or birds.

**POLLINATION:** Aronia is self-fruitful and does not require planting more than one variety for pollination.

**PRUNING:** Pruning recommendations vary. Annual pruning may be needed if machinery requires a smaller height, but plant productivity can be maintained by pruning every 4–5 years.

### Livestock Integration & Food Safety

Aronia is not commonly planted for livestock, though poultry may help control weeds or insects if pastured in the rows. Common sense precautions, as well as legal regulations, govern best practices to prevent livestock manure from contaminating fruit for human consumption. Harvesting fruit so that it doesn’t touch the ground and careful timing of when livestock are among the trees are key food safety considerations.

## Harvest

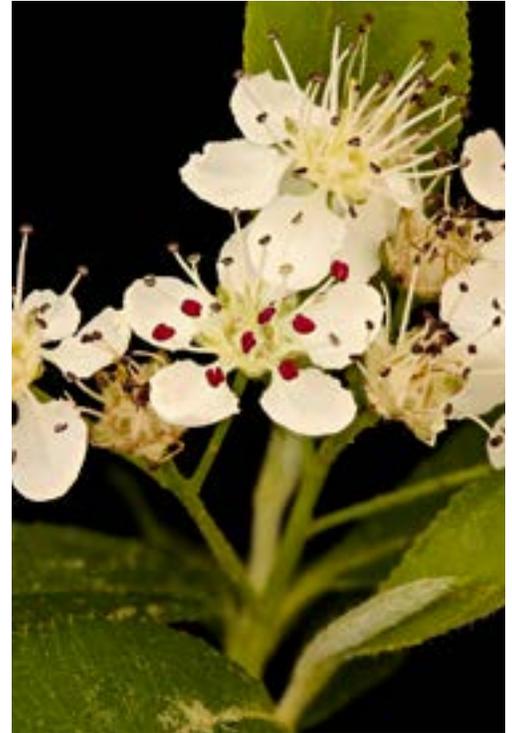
Yields vary from 4,000 to 18,000 pounds per acre or more. An average harvest of 8,000-10,000 pounds per acre (yielding 600-750 gallons of juice) can be expected with a space of 4ft by 12 ft at 900 plants an acre. Hand harvest of aronia is only viable for very small plantings and direct sales at retail prices. Several companies offer mechanical harvesters suitable for the fruit that can reduce harvest time significantly.

## Markets

Aronia has the greatest potential in larger markets that can handle the volume generated by machine harvest. Since fresh market sales are limited, aronia is usually frozen or processed into juice, wine, preserves, or nutraceuticals. Refrigeration will be required to store the berries until processing. Wholesale prices range from \$0.50-\$1.25 per pound.

“Aronia is recognized as a superfruit because of the high level of antioxidants it produces, higher than other well-known fruits like blueberries, pomegranates, and acai berries.”

—Agroforestry on the Farm: Aronia Berry at Winding Creek, Belmond Iowa



## ECONOMICS CASE STUDY

**BASIC ASSUMPTIONS:** 4-foot by 12-foot row spacing, which equates to 900 shrubs per acre; price per lb is \$1 (wholesale)

### ESTABLISHMENT COSTS

FIRST YEAR ESTABLISHMENT COST: \$9,000/acre

### MAINTENANCE COSTS

ANNUAL VARIABLE COSTS: Varies due to irrigation, soil, and weed management needs and labor costs.

### YIELD AND PROFITS

YIELD PER ACRE: 4,000-18,000 lbs an acre

PRICE PER LB: \$5-\$15lb, retail; \$0.50-\$1.25, wholesale

### REVENUE

ANNUAL REVENUE: \$12,000/acre (12,000lbs at \$1/lb)

TOTAL REVENUE: \$300,000/acre over 25 years

**NOTES:** Establishment year costs include seedlings, tree guards, stakes, and labor to plant. This estimate does not include cost of machine harvest, processing, transport, or marketing.

### SOURCES AND ADDITIONAL INFORMATION

Wilson, M., Lovell, S.T., & Carter, T. (2018). *Planting Tree Crops: Designing and Installing Farm-Scale Edible Agroforestry*.

Jensen, Jeff (2014). *Agroforestry on the Farm: Aronia Berry at Winding Creek, Belmond Iowa*. <https://dr.lib.iastate.edu/entities/publication/ac87694a-8aaa-4782-baf6-1ec609f607ce>

University of Maine Extension (n.d.). *Culture of Aronia for Fruit Production*. <https://extension.umaine.edu/agriculture/aronia/culture/>



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## BLACK CURRANT

*Ribes spp.*

### Introduction

Black currants are very attractive candidates for mixed agroforestry systems because they are one of the few fruits that produce well in partial shade, including under larger trees like chestnuts. Currants were once more widely grown in the United States, but at the outbreak of a disease called White Pine Blister Rust (WPBR) in the early 1920's, regulations were passed to protect the white pine timber industry by prohibiting cultivation of currants, which harbor this disease. Since then, cultivars have been developed that are resistant to WPBR. Black currants remain popular in Northern Europe, suggesting market development potential in North America.

### Requirements:

**DRAINAGE:** Currants are very adaptable, but do not tolerate standing water or heavy clay soils

**PH:** 5.5–6.5

**LIGHT:** Full sun to partial shade

**ZONES:** 3–8 (although some varieties hardy to 2)

### Plant Selection:

Pure *Ribes nigrum* are susceptible to WPBR, so crosses were made with *Ribes ussuriense* to impart resistance, but early varieties had poor fruit quality (e.g. 'Consort', 'Cornet', 'Crusader'). Newer varieties show resistance to WPBR while retaining good quality and high yields (e.g. 'Titania', 'Blackcomb', 'Cheakamus', 'Stikine'). Although the federal ban has been lifted, some states still have laws on the books that may or may not be enforced, so consult local regulations and select only resistant varieties.

Currants are easily propagated by layering or cuttings if not protected by patent.

### Spacing:

**IN-ROW SPACING (FEET):** 2–3 feet

**BETWEEN ROW SPACING (FEET):** 12–14 feet

### Timing

**YEARS TO PARTIAL/FULL BEARING:** 3–5 years

**HARVEST SEASON:** June–August

**HARVEST HRS/ACRE:** 770 (hand), 12–65 hours (mechanical)



### Management

**PEST AND DISEASE:** Powdery mildew is a problem for currants, so choosing resistant cultivars are important. Locations with good air circulation will help prevent mildew. With disease-resistant varieties, black currants are a good candidate for organic management.

**POLLINATION:** Black currants are self-fruitful, but larger and better crops will occur with cross-pollination.

**PRUNING:** Pruning is required, usually done by removing about a third of the oldest stems each year, leaving 10–12 stems per bush. In some commercial orchards, bushes are cut to the ground every third year on a rotation. Although this reduces yields, it also reduces pruning costs.

### Livestock Integration & Food Safety

There are few examples of livestock integration with black currants, as most animals enjoy eating the berries and ruminants will strip the leaves while plants are young. Common sense precautions, as well as legal regulations, govern best practices to prevent livestock manure from contaminating fruit for human consumption. Harvesting fruit so that it doesn't touch the ground and careful timing of when livestock are among the trees are key food safety considerations.

## Harvest

Ripe fruit keep well on bushes, allowing some flexibility in harvest. Black currants are well suited to machine harvest with straddle (over row) or side-harvesters pulled by a tractor. Side harvesters require a pass up each side of the row, while straddle harvesters can do a whole row per pass. Machine harvest is important for making currants financially viable, unless you can develop a strong pick-your-own operation.

## Markets

Although some varieties of black currant are suitable for fresh eating, most North American consumers are unfamiliar with the fruit. Therefore, the primary market is processed products such as wine, ice cream, syrups, jellies, pie fillings, dessert toppings, candies, and juice.

“ Black currants are among the most nutrient-dense fruits, with three times the vitamin C of oranges and twice the antioxidants of blueberries, along with high levels of calcium, iron, magnesium, and potassium. ”

—Wilson, et al. 2018, *Planting Tree Crops*



## ECONOMICS CASE STUDY

Potential for Ribes Cultivation in North America

**BASIC ASSUMPTIONS: 2,200 plants per acre using non-organic chemical application. Cost estimates are for currants grown for juice production**

### ESTABLISHMENT COSTS

FIRST YEAR ESTABLISHMENT COST: \$2,278.50/acre

### MAINTENANCE COSTS

ANNUAL VARIABLE COSTS: \$1,013.33/acre

### YIELD AND PROFITS

YIELD PER ACRE: 4,047 lbs

PRICE PER LB : \$1/lb (adjusted for US market; prices much higher for whole fruit)

### REVENUE

ANNUAL REVENUE: \$4,047/acre

TOTAL REVENUE: \$101,175/acre over 25 years.

### SOURCES AND ADDITIONAL INFORMATION

Wilson, M., Lovell, S.T., & Carter, T. (2018). *Planting Tree Crops: Designing and Installing Farm-Scale Edible Agroforestry*.

Dale, Adam (2000). *Potential for Ribes Cultivation in North America*. <https://journals.ashs.org/horttech/view/journals/horttech/10/3/article-p548.xml>



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## BLACK WALNUT

*Juglans nigra*

### Introduction

Black walnut is one of the most common trees used in temperate agroforestry because of the valuable timber, edible nuts, and beneficial traits to other crops. Ample sunlight reaches crops under black walnut trees because of their sparse canopies, as well as their late leaf out and early leaf drop. A deep root system allows black walnuts to reach water and nutrients without competing with shallow-rooted alley crops or forages. These trees excrete a chemical from the roots and fallen leaves called juglone that can cause growth problems in some crops. Although most crops are not affected, Juglone-sensitive crops such as tomatoes should not be interplanted. Most growers focus on either nut production or timber from black walnut due to different management requirements.

### Requirements:

**DRAINAGE:** Well drained

**PH:** 6.0-7.5

**LIGHT:** Full

**ZONES:** 4-9

### Plant Selection:

For timber production, inexpensive seedlings are used to keep establishment costs low. For nut production, use grafted cultivars selected for increased nut production and thin shells for easy cracking.

### Spacing:

**SPACING (FEET):** Nut Production: 30 x 30 (with thinning at age 30 & 50)

**TIMBER PRODUCTION:** 10 x 10

### Timing

**YEARS TO PARTIAL/FULL BEARING NUT**

**PRODUCTION:** 7-10+ years

**TIMBER PRODUCTION:** 30-60 years

**HARVEST SEASON:** September-October, with alternate bearing years

**HARVEST HRS/ACRE:** 13-32 (hand); 1-2 (mechanical)



### Management

**PEST AND DISEASE:** Anthracnose is a foliar fungal disease that can defoliate trees and cause a drop in nut production. It affects black walnuts after leaf expansion and can be controlled through fungicide application post pollination. Walnut caterpillar, fall webworm, and yellow-necked caterpillar can defoliate young trees. Tree protection (e.g., tubes) can protect young trees from deer and other mammal damage. Regular pest and disease scouting can prevent damage to orchards.

**POLLINATION:** Black walnuts can self-pollinate, but it is recommended that at least four varieties with overlapping flowering dates can be planted to increase nut set.

**PRUNING:** Tip pruning in late winter helps create strong trunks and helps promote greater leaf area. A second tip pruning in July (minus the central leader) channels energy to trunk growth. Do not prune lower lateral branches until they are one-inch diameter, then only remove the lowest 1 or 2 branches each year until the lowest branch is 8-10 ft from the ground.

### Livestock Integration & Food Safety

Black walnut is an excellent tree for silvopastures stocked with sheep or cattle, where trees can increase forage quality and animal comfort. Full-grown hogs can be trained to eat whole black walnuts, and laying hens can feed on shelled nuts. Common sense precautions, as well as legal regulations, govern best practices to prevent livestock manure from contaminating fruit for human consumption. Harvesting fruit so that it doesn't touch the ground and careful timing of when livestock are among the trees are key food safety considerations.

## Harvest

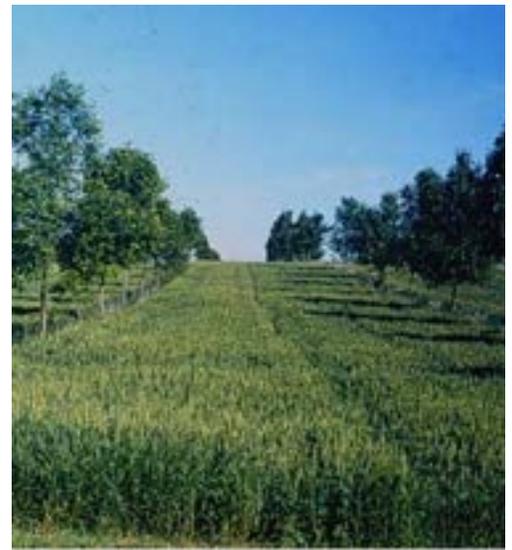
Nuts are harvested after falling to the ground naturally or after being shaken by a machine. They can be collected by hand, with a human powered nut collector (a tool that rolls on the ground and picks up nuts through a globe-shaped wire cage), or modified pecan or English walnut tractor-pulled machine harvesters. Prompt removal of the green hulls will prevent dark stains on the nut from hull pigments. After hulling, the nuts are washed and air dried.

## Markets

Economic analysis of orchards grown solely for nut production show it is a challenge to make money unless you process and direct-market nuts. Processing the nuts on-farm and selling the nut meats at retail prices can increase the value, but hulling, cracking, and sorting black walnuts requires specialized equipment that may not be feasible for the average producer. For some growers, black walnut's cousin heartnut (*Juglans ailantifolia* var. *cordiformis*) is more profitable and marketable thanks to its interesting shape and ability to crack with ease.

“ The most profitable uses of black walnuts are for silvopastures and alley cropping, which can provide early cash flow while timber is maturing. ”

— Wilson, et al. 2018, *Planting Tree Crops*



## ECONOMICS CASE STUDY

University of Missouri Center for Agroforestry Black Walnut Financial Model

**BASIC ASSUMPTIONS:** 30 ft by 30 ft row spacing, which equates to 48 trees per acre; both nut and timber production; nut harvest by hand.

### ESTABLISHMENT COSTS

FIRST YEAR ESTABLISHMENT COST: \$735.70/acre

### MAINTENANCE COSTS

ANNUAL VARIABLE COSTS: \$436.00/acre

### YIELD AND PROFITS

YIELD PER ACRE: 1,500 lbs every other year between year 13 & 68

PRICE PER LB: \$0.125

### REVENUE

ANNUAL REVENUE: \$187.50/acre between year 13 & 68

TOTAL REVENUE: \$19,301 (\$10,312 over 55 year for nut production; \$8988 after timber harvest in year 68)

### SOURCES AND ADDITIONAL INFORMATION

Wilson, M., Lovell, S.T., & Carter, T. (2018). *Planting Tree Crops: Designing and Installing Farm-Scale Edible Agroforestry*. <https://www.savannainstitute.org/planting-tree-crops/>

University of Missouri Center for Agroforestry (2009). *Growing Black Walnut for Nut Production*. <https://extension.missouri.edu/publications/af1011>



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## CHINESE CHESTNUTS

*Castanea mollissima*

### Introduction

Chestnuts play a star role on the perennial crop stage. Low pest pressures, dependable high yields, strong markets, and ease of maintenance make for an attractive tree crop. The American chestnut (*Castanea dentata*) was once a major timber species in the eastern U.S. and a valuable source of food for both people and livestock. Unfortunately, the imported chestnut blight has all but wiped them out. The blight-resistant Chinese chestnut (*Castanea mollissima*) is now the primary species grown east of the Rockies, though some commercial hybrids utilize Japanese (*C. crenata*) and European (*C. sativa*) chestnut genetics.

### Requirements:

**DRAINAGE:** Well-drained soils

**PH:** 5.5–6.5

**LIGHT:** Full

**ZONES:** 6a–8

### Plant Selection:

**GRAFTED:** Predictable harvest timing and known nut quality, but expensive.

**SEEDLING OR STRATIFIED SEED:** Can be less susceptible than grafted trees to a number of problems: blight, low vigor, and delayed graft union failure in colder areas. Seedlings and stratified seed can be planted and then grafted later, if desired.

### Spacing:

**IN ROW & BETWEEN ROW SPACING (FEET):** 20 x 20 or 30 x 30, thinning periodically as trees grow.

### Timing:

**YEARS TO PARTIAL/FULL BEARING:** 12–15

**HARVEST SEASON:** Sept–Oct

**HARVEST HRS/ACRE:** 70 (hand); 5–43 (mechanical)



### Management

**PEST AND DISEASE:** Although Chinese chestnuts suffer from relatively few pests and diseases, some growers occasionally spray to control leafhoppers, European red/two-spotted spider mites, or yellow necked caterpillars.

**POLLINATION:** Chinese chestnuts require at least one other cultivar for cross-pollination.

**THINNING:** Final spacing for Chinese chestnuts is usually around 40 by 40 feet, or 27 trees per acre. Since it takes many years to reach this size, some growers plant at a higher density (20 x 20 feet, or 108 trees per acre) and thin when the trees become crowded. In this way, yields are higher early on in the life of the orchard, and selective thinning can remove under performing trees.

### Livestock Integration & Food Safety

Hogs can run through the orchard after the main harvest to pick up any leftovers and poultry may be integrated into the rotation to help gobble up chestnut weevil.

Common sense precautions, as well as legal regulations, govern best practices to prevent livestock manure from contaminating nuts for human consumption. A hot water bath is commonly done to chestnuts in weevil-infested areas, and adding a sanitizer to this step may be advisable if food safety is a concern.

## Harvest

Researchers in Michigan determined that under 2 acres of chestnuts can easily be harvested by hand. More than 8 acres favors an imported commercial harvester. Most chestnut orchards, even relatively large ones, rely on human labor to collect nuts. This can be done by opening up the orchard for you-pick, hiring seasonal workers, or by working with groups to put on fund-raisers. Tools such as Nut Wizards can be made available to customers. Customers with a cultural familiarity with chestnuts (primarily from Eastern Europe and Asia) are often willing to travel to an orchard to harvest nuts in a you-pick market. In areas with chestnut weevil, you will have to do a hot-water bath of the chestnuts, perhaps complicating you-pick. Chestnuts must be harvested at least every two days to keep the chestnuts from drying out and to ensure that chestnut weevil larvae do not re-infest the orchard.

## Markets

The market for chestnuts appears to be strong, with domestic production currently making up only a tiny fraction of the chestnuts consumed in the U.S. Prices paid range from \$1.50 per pound wholesale up to \$5.00 or more per pound retail. Chestnuts are primarily sold fresh in-shell but can also be frozen or dried and ground into flour. Cooperatives exist for marketing chestnuts:

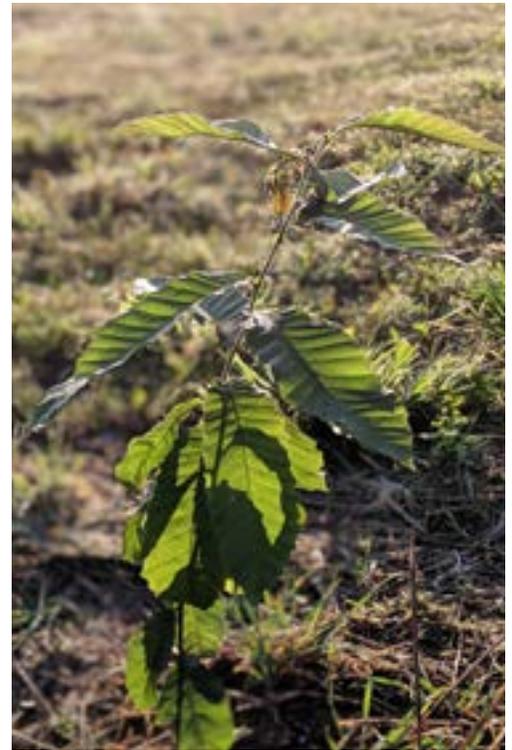
**PRAIRIE GROVE CHESTNUT GROWERS** (Columbus Junction, Iowa)

**ROUTE 9 COOPERATIVE** (Carrollton, Ohio)

**CHESTNUT GROWERS, INC.** (across Michigan)

“Chestnuts are extolled as the ‘corn’ of the tree world because they serve as starch sources and demand for chestnuts currently far exceeds the supply.”

— Wilson, et al. 2018, *Planting Tree Crops*



## ECONOMICS CASE STUDY

Commercial Chestnut Cost of Production, Michigan State University

**BASIC ASSUMPTIONS:** Grafted, European x Asian chestnuts at commercial scale greater than 10 acres

### ESTABLISHMENT COSTS

FIRST YEAR ESTABLISHMENT COST: 0-5 years: \$7,783.72 per acre

### MAINTENANCE COSTS

> 5 years: \$2,819.92 per acre

### YIELD AND PROFITS

YIELD PER ACRE: 3,500 pounds

PRICE: \$0.81 per pound (break even price)

### REVENUE

ANNUAL REVENUE: \$2,935 per acre

### SOURCES AND ADDITIONAL INFORMATION

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## HAZELNUT

*Corylus avellana* (European), *Corylus americana* (American).

### Introduction

Hazelnuts are a promising low-input perennial source of food, oil, and livestock feed. Researchers and farmers have been developing hazelnut plant material and cropping systems for the Eastern United States over the last several decades. The main environmental challenges in these regions are cold winters and Eastern Filbert Blight (EFB), a fungal disease that affects the European hazelnut (*Corylus avellana*) but not the American hazelnut (*C. americana*). For this reason, American hazelnut selections have been used as a source of disease resistance, as well as cold tolerance, in hybrid crosses with commercial European varieties. Improved hybrid hazelnut cultivars have recently become available, and are currently being compared to seedling populations in joint performance trials.

### Requirements:

**DRAINAGE:** Moderate to well drained

**PH:** 5.5–7.5

**LIGHT:** Full (partial shade tolerated)

**ZONES:** 3–9

### Plant Selection:

European hazelnuts with documented resistance to EFB have so far not performed well in the Midwest due to cold winters, prompting the cultivation of either bush-form or tree-form American x European hybrids. Cultivars that have successfully undergone micropropagation are now being released by Rutgers University as well as the Upper Midwest Hazelnut Development Initiative.

### Spacing:

**IN-ROW SPACING (FEET):** 16–20 (European); 3–5 (hybrid)

**BETWEEN ROW SPACING (FEET):** 18–20 (European); 10–15 (hybrid)

### Timing:

**YEARS TO PARTIAL/FULL BEARING:** 4–5 partial, 11–12 full (European); 3–6 partial, 8 full (hybrid)

**HARVEST SEASON:** August–October depending on zone

**HARVEST HRS/ACRE:** 211



### Management

**PEST AND DISEASE:** Other than EFB, big bud mite is another potential concern, but certain varieties show resistance. This pest is not considered a major problem, though spraying is recommended if more than 5% to 10% of buds are affected. Measures might need to be taken to protect nuts from squirrels, mice, chipmunks, and birds like jays and crows.

**POLLINATION:** Hazelnuts are self-incompatible, and therefore selection of pollinizers is variety specific. For this reason, care must be taken to designing orchard layouts that involve interplanting of compatible varieties or seedling populations.

**PRUNING:** Prune to 1–3 trunks (more trunks lead to earlier nut production). After the first or second year, pruning is needed to remove broken branches, those too near the ground, or ones that crowd other branches. Nuts are only produced on new wood, so removing branches may be reducing yield.

### Livestock Integration & Food Safety

Livestock integration into hazelnut systems is uncommon, but hogs and turkeys (who are large enough to eat nuts whole) will eat dropped nuts. Chickens thrive under mature hazelnut canopies, and the plants benefit from the fertilization. Common-sense precautions, as well as legal regulations, govern best practices to prevent livestock manure from contaminating fruit for human consumption. Harvesting fruit so that it doesn't touch the ground and careful timing of when livestock are among the trees are key food safety considerations.

## Harvest

**HYBRIDS:** In seedling orchards, plant yields vary greatly (0.03–2.58 lbs per plant), and as a result many growers plant at a high density and thin out underperformers. Even when planting clonal varieties, such “double-density” plantings can result in faster canopy closure and higher yields early on. Most varieties ripen in-husk on the shrub. For this reason, commercial harvesters that sweep nuts off the ground are not suitable. Hybrid hazelnuts can be harvested by hand (at a rate of up to 13 lbs in-shell per hour) but on a larger-scale, mechanical harvesting using modified over-the-row blueberry or olive harvesters is critical.

**EUROPEAN:** Mature orchards can produce 1,000–3,000 lbs of dry nuts per acre in the Pacific Northwest which fall from their husks when ripe. West coast farms maintain bare soil under plantings and use mechanical harvest equipment to harvest several acres per hour.

## Markets

After harvest, nut need to be husked, washed, sanitized, and dried before sale to consumers. Most hazelnuts grown in the Midwest are direct marketed through small grower-owned businesses, such as the American Hazelnut Company. Most nuts are processed into value-added products like chocolate candies, cooking oils, and baking ingredients.

“ In the future, large confectionary companies may be willing to buy Midwestern hazelnuts if the quantity and quality are adequate. ”

## ECONOMICS CASE STUDY

A Production and Economic Model for Hedgerow Hazelnut Production in the Midwestern United States

**BASIC ASSUMPTIONS:** 4ft by 12ft plant spacing, which equates to 908 plants per acre; non-organic production; all costs include trees, tree guards, stakes, labor to plant and train trees, fertilizer and pesticides, land rent and labor.

### ESTABLISHMENT COSTS

ESTABLISHMENT YEARS (1-5) COST: \$8,400/acre.

### MAINTENANCE COSTS

ANNUAL VARIABLE COSTS: (AFTER YEAR 5): \$1,106.67/acre/per year

### YIELD AND PROFITS

YIELD PER ACRE: 1,700–2,200

PRICE PER LB: \$2/lb in-shell

### REVENUE

ANNUAL REVENUE: \$3,800/acre at maturity.

TOTAL REVENUE: \$95,000/acre over 25 years.



### SOURCES AND ADDITIONAL INFORMATION

Wilson, M., Lovell, S.T., & Carter, T. (2018). *Planting Tree Crops: Designing and Installing Farm-Scale Edible Agroforestry*

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The Savanna Institute is a 501(c)(3) nonprofit organization working to catalyze the development and adoption of resilient, scalable agroforestry in the Midwest US. We work in collaboration with farmers and scientists to develop perennial food and fodder crops within multifunctional systems grounded in ecology and inspired by the savanna biome. The Savanna Institute strategically enacts this mission via research, education, and outreach.

## SASKATOON, SERVICEBERRY, JUNEBERRY

*Amelanchier spp.*

### Introduction

The *Amelanchier* family includes dozens of species that are native to North America. The most commonly grown for fruit is *Amelanchier alnifolia*, usually referred to as Saskatoon berry or Juneberry. The nutritious fruits are about the size of a blueberry but with more variation in color and a different, but agreeable taste. Saskatoons are another highly nutritious, machine-harvestable berry that can fit well into diversified systems.

### Requirements:

**DRAINAGE:** Moderate to well drained soil

**PH:** 6.0–8.0

**LIGHT:** Full

**ZONES:** 2–5

### Plant Selection:

'Pembina', 'Smokey', 'Parkhill', 'Honeywood', 'Regent' varieties tested in the Midwest.

### Spacing:

**IN-ROW SPACING (FEET):** 3–5 ft

**BETWEEN ROW SPACING (FEET):** 12–16ft for hand harvest; 17–20ft for mechanical harvest

### Timing

**YEARS TO PARTIAL/FULL BEARING:** 3 years

**HARVEST SEASON:** JUNE-AUGUST

**HARVEST HRS/ACRE:** 300–480 (hand), 12–65 hours (mechanical)



### Management

**PEST AND DISEASE:** True Saskatoons (*Amelanchier alnifolia*) may have problems with leaf spot and adapting to early spring warming periods outside of the northern US and Canada, where other species such as Allegheny serviceberry (*Amelanchier laevis*) and hybrids grow better, although they tend to be larger trees, which may make harvest difficult.

**POLLINATION:** Self-pollinating

**PRUNING:** During the first three years only dead, damaged, or diseased stems should be trimmed. Starting year four, prune for good light and air movement. All fruiting wood should be replaced every 3–4 years as the best production is on 2–4 year wood.

## Harvest

Saskatoons can be harvested by hand or machine. Individuals can produce between 4 to 10 lbs per bush depending on variety. Harvest occurs over a two-and-a-half week period. Due to uneven ripeness, machine harvest is usually done twice, four to six days apart. Fresh fruit does not keep long and must be refrigerated immediately after harvest. Fruit must be sorted before sale, either on-farm or at the processing facility. Freezing is the most common processing method for commercial Saskatoon production.

## Markets

Saskatoons have been cultivated in the Canadian prairies for more than a hundred years, but few US consumers are familiar with them. Integration with more well-known fruits in a you-pick operation is one way to increase consumer awareness. They have broad commercial potential and have high nutritive and antioxidant values.

“The timing of fruiting is an opportunity for filling the seasonal gap between strawberries and blueberries.”

—Wilson, et al. 2018, *Planting Tree Crops*



## ECONOMICS CASE STUDY

Juneberries: University of Kentucky Center for Crop Diversification Crop Profile

**BASIC ASSUMPTIONS:** 900 plants per acre at 5ft x 20ft; mechanical harvest

### ESTABLISHMENT COSTS

FIRST YEAR ESTABLISHMENT COST: \$10,500/acre.

### MAINTENANCE COSTS

ANNUAL VARIABLE COSTS: \$5,000/acre at maturity.

### YIELD AND PROFITS

YIELD PER ACRE: 6,000 lbs

PRICE PER LB: \$2.50

### REVENUE

ANNUAL REVENUE: \$15,000/acre at maturity.

TOTAL REVENUE: \$375,000/acre over 25 years.

**NOTES:** Planting year costs include trees, tree guards, stakes, labor to plant and train trees, fertilizer and pesticides (if non-organic). Before trees come into production, costs include labor for pruning, training, mowing, and pest control. When trees get larger and come into full production, some costs for pest management pruning and thinning will increase, while yields and income are also increasing. Consider cost of the labor it will take to harvest all that fruit.

### SOURCES AND ADDITIONAL INFORMATION

Wilson, M., Lovell, S.T., & Carter, T. (2018). *Planting Tree Crops: Designing and Installing Farm-Scale Edible Agroforestry*.

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Alberta Agriculture and Rural Development (2013). *Saskatoon Berry Production Manual*. <https://open.alberta.ca/publications/9780773261013>



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## ASIAN PEAR

*Pyrus pyrifolia*

### Introduction

Asian Pears, also known as apple pears, have a high value in the marketplace, especially with consumers familiar with its crisp, juicy texture, and sweet flavor. They have fewer issues with diseases and insects than apples or European pears, but integrated pest management is often needed for commercial production. The fruit bruises easily, so hand harvest and careful storage are necessary.

**PROS:** Tolerant of heavier soils than apples, fewer pests, good consumer demand, can be dried.

**CONS:** Blooms early, hand harvest only, requires pruning and thinning.

### Requirements:

**DRAINAGE:** Poor to well-drained

**PH:** 5.5–7.0

**LIGHT:** Full

**ZONES:** 4–9

### Plant Selection:

**ROOTSTOCK:** Standard or semi-dwarfing. *Pyrus betulifolia* (BET) seedling rootstocks increase fruit size in Asian pears. Rootstocks that dwarf European pears do not have the same effect on Asian pears.

**VARIETIES:** ‘Korean Giant’ and ‘Olympic’ are fire-blight resistant and ripen later in the season.

### Spacing:

**VARIABLE** based on variety and rootstock. At least 15’ between trees and rows.

### Timing:

**YEARS TO PARTIAL/FULL BEARING:** 2–3 partial, 7 full

**HARVEST SEASON:** August–October

**HARVEST HRS/ACRE:** 40 hrs



### Management & Harvest

Pears are susceptible to fire blight, but choosing resistant cultivars can significantly cut risk. Stink bugs are also a significant issue. Integrated Pest Management (IPM) systems, which rely on regular observation and data collection, can help keep plantings safe from significant damage. Fruit must be thinned to increase fruit size and sugar content.

Asian pears ripen on the tree and are harvested after changing color from green to more golden and sweetness intensifies.



## ELDERBERRY

*Sambucus canadensis*

### Introduction

Elderberries are tough native plants that are easy to propagate and grow. The flowers support pollinators, and the fruits are high in healthy antioxidants and flavonoids. The main markets are for juice, preserves, syrup, wine, and medicinal products. The small berries are borne on clusters that do not lend themselves to machine harvest, and fruit must be frozen before processing. Unlike most other shrubs, elderberries can be coppiced to the ground annually, which reduces yields slightly but saves pruning labor and makes for more even ripening and larger fruit clusters. Birds can consume the entire crop if not controlled. Spotted Wing Drosophila is a newer pest that may require management for a marketable crop.

**PROS:** Native, tolerant of poor sites, easy to propagate, good for pollinators, health benefits, easy pruning, well-suited to mixing with other fruits, frost tolerant

**CONS:** Hand harvest, birds, spotted wing drosophila, frost tolerant

### Requirements:

**DRAINAGE:** Moderate to well drained soil

**PH:** 5.5–6.5

**LIGHT:** Full to partial

**ZONES:** 3–9

### Plant Selection:

North American cultivars developed from wild plants perform much better in the US than their European counterparts. Midwest developed selections with proven commercial success include 'Bob Gordon' and 'Wyldwood'.

### Spacing:

4ft between plants, 10–12 ft between rows

### Timing:

**YEARS TO PARTIAL/FULL BEARING:** 2 partial; 3 full

**HARVEST SEASON:** June–July for flowers; July–September for fruit

**HARVEST HRS/ACRE:** 163–650



### Management & Harvest

Elderberries can be propagated through hardwood and softwood cuttings, root cuttings, or from seed. Dormant plants are planted in early spring with flowers removed during the establishment year to encourage root growth. After establishment, pruning is encouraged, by either coppicing to the ground or standard means, but is not necessary. Plants need 1–2 inches a week of water for good fruit development and are wind pollinated. While mostly pest and disease resistant, the Spotted Wing Drosophila has become a major concern for commercial growers. Elderberry flowers and fruit are harvested by hand. Yields range from 2–4 tons per acre. Elderberry and flowers are highly perishable and must be refrigerated immediately after harvest.



## HONEYBERRY, HASKAP

*Lonicera caerulea*

### Introduction

These members of the honeysuckle family are native to the cold northern regions of North America, Europe, and Asia. The oval-shaped fruits vary in flavor and are suitable for fresh eatings or for making into wine, ice cream, or other products. Commercial plantings exist in Russia and Japan, and farmers are experimenting with them in Canada and the United States. Recent breeding work has made this cold-loving plant more adaptable to warmer regions. It has the potential to be harvested mechanically and would fit well into processing streams for currants, aronia, and saskatoon. However, marketing efforts will be required to increase consumer awareness and variety trials and breeding work must continue before widespread planting can be recommended for most regions of the US.

**PROS:** Fresh eating or processing, high nutrient value, machine harvestable, few pests and diseases, fits well with other fruits

**CONS:** Few variety trials in the US, lack of consumer familiarity, best suited to colder zones (though breeding has made more varieties available)

### Requirements:

**DRAINAGE:** poorly to well-drained

**PH:** 5–7

**LIGHT:** Full

**ZONES:** 2–7

### Plant Selection:

North American cultivars include 'Borealis' and 'Tundra'. Russian cultivars available in the US include 'Berry Blue,' 'Blue Moon,' and 'Blue Bird'. Breeding and plant selection continues to make cultivars more tolerant to warmer growing zones.

### Spacing:

3–4 ft between plants, 12–14 ft between rows

### Timing

**YEARS TO PARTIAL/FULL BEARING:** 3–4

**HARVEST SEASON:** June–August

**HARVEST HRS/ACRE:** 65hrs, machine



### Management & Harvest

Honeyberry has low maintenance requirements. Light pruning in late winter encourages growth but no more than 25% of branches should be removed. Wind can damage plants during winter, so windbreak protection is recommended. While this crop has few disease and pest pressures, powdery mildew can be an issue; new Canadian selections are bred for resistance. Honeyberries can keep on the plant once ripe for several weeks under the right conditions and can be machine harvested with the same equipment used for black currants and similar fruit.



## NORTHERN PECAN

*Carya illinoensis*

### Introduction

Pecans are native, and the most important economic nut crop, throughout much of the eastern US. For northern growers, adapted varieties are required to fill nuts and avoid winter injury. Pecans are alternate bearing, producing heavy crops in some years and light crops in others. The nuts fall from the trees when ripe and can be picked by machines. Wild stands of native pecans are managed for nut production, but may require 80 or more acres to justify harvest equipment. Cattle are often grazed in pecan stands. Pecans suffer from a variety of pests and diseases depending upon the area where they are grown. Most commercial production requires pest management, as well as fertilizer inputs for good nut production.

**PROS:** Native, high quality nut, grows in wetter areas than most nuts, mechanical harvest and processing, minimal pruning, known to consumers

**CONS:** Alternate bearing, low yields for northern cultivars, pests and diseases require intervention

### Requirements:

**DRAINAGE:** Moderate to well drained

**PH:** 6–7.5

**LIGHT:** Full sun

**ZONES:** 6–9

### Plant Selection:

Pecan plantings can be established by grafting onto seedlings planted 2–3 years prior, or planting grafted trees.

### Spacing:

At least 30' between trees and rows.

### Timing

**YEARS TO PARTIAL/FULL BEARING:** 5-7 (grafted), 20–25 full

**HARVEST SEASON:** September-November

**HARVEST HRS/ACRE:** 2–6.5, mechanical



### Management & Harvest

Pecan scab, pecan weevil, stink bugs, twig girdlers, and pecan phylloxera all pose a threat to Northern pecans. Integrated Pest Management, which rely on regular observations and data collection, can help keep plantings safe from significant damage. Do not fertilize during the first year to protect from winter damage. Pecans are wind pollinated. Most northern pecans are grown in managed wild stands.

When mature, pecans drop from their husks to the ground. They can be collected by hand, with a human powered tool, or by machine. After harvest, unshelled pecans must be cured.





## PAWPAW

*Asimina triloba*

### Introduction

Pawpaws are a native understory tree with a flavor somewhat like a banana or mango. In their native range (zones 5-8), pawpaws suffer from few pests or diseases. Pawpaws can produce fruit in partial shade, which makes them suitable for planting under larger trees or at the shady edges of fields, though they will yield more fruit in full sun.

**PROS:** Native, good companion trees, frozen pulp may be marketed along the same lines as persimmon pulp or other fruits, few pests, no pruning, not palatable to deer

**CONS:** Hand harvest, fruits have a short shelf life, young trees require sun protection, short-lived tree

### Requirements:

**DRAINAGE:** Moderate to well drained

**PH:** 5.5–7.0

**LIGHT:** Partial shade to full sun

**ZONES:** 5–8

### Plant Selection:

Pawpaws are usually grown from seed or grafted with known cultivars. Seedlings are not identical to their parent tree, so fruit quality can be unpredictable. Trees grafted with named cultivars have more consistent fruit quality under the right growing conditions. Cultivars should be chosen from locations that have similar growing conditions to the location they will be planted. Container-grown pawpaws have a higher survival rate than field-dug trees due to their sensitive root systems.

### Spacing:

8–15 ft between trees and rows

### Timing

**YEARS TO PARTIAL/FULL BEARING:** 3 partial, 5–8 full

**HARVEST SEASON:** September–October

**HARVEST HRS/ACRE:** 250



### Management & Harvest

Young trees must be protected from sun damage until they are established, usually for the first 1–2 years. Poor pollination can be an issue; pawpaws are pollinated by various species of beetles and flies and require pollen from a pawpaw that is genetically different to be fertilized. Hand pollinating may be required. While pest pressure is low, pawpaw peduncle borer and zebra swallowtail butterfly can cause damage. Although pawpaws are one of the only trees not to be browsed by deer, bucks may rub their trunks. Pawpaws fruit in clusters and harvest must be done by hand due to the delicate nature of the fruit. Pawpaws are fully ripe once they drop to the ground, but many growers harvest just before fruit drop for higher fruit quality and to prevent contamination.

