



UNIVERSITY OF MISSOURI CENTER FOR AGROFORESTRY

# GROWING AND MARKETING PAWPAW IN MISSOURI

By Patrick Byers, Zhen Cai, Michael Gold, Kiruba Krishnaswamy, Chung-Ho Lin, Sarah Lovell, Andrew Thomas, and Michele Warmund

## Introduction

The North American Pawpaw (*Asimina triloba*) is a relatively common but little-known tree native to Missouri and much of the midwestern and eastern United States. The tree is often found in large patches growing along streams and as an understory tree in rich, relatively moist forest soils.

The pawpaw tree is small and attractive with long, droopy, dark green glossy leaves. The striking, deep purple or maroon flowers appear in early spring, sometimes persisting well into May. The fruit varies in size, shape, flavor, and color, but is generally oblong-shaped, 2 to 5 inches long and 1 to 3 inches wide. When fully ripe, pawpaw fruit is sweet, with a bright yellow or orange custard-like and sometimes juicy flesh. They have a unique tropical flavor that is often compared with banana, mango, peach, melon, and pineapple. Some wild fruits, however, can occasionally have an "off" or unpleasant flavor, especially if they are under- or over-ripe. Ripe fruits are very fragile and have a short shelf life, making them difficult to market in good condition. Pawpaw is well suited for intensive, small- to medium-scale orchard production. Improved pawpaw cultivars produce large, high-quality fruit with excellent flavor and aroma, beautiful custard-like flesh, and few seeds.



Pawpaw trees (above), blossoms and fruit



Check out more pawpaw resources on the "[Mizzou Agroforestry](#)" YouTube channel!



## Applications in Agroforestry

Pawpaw has a great deal of potential for inclusion in agroforestry production systems, which are defined as “the designed integration of trees and shrubs with crops or livestock.” As a valuable species native to the eastern U.S., pawpaw can serve in the role as the main crop or as a supporting tree species, providing a wide range of environmental benefits that add to the conservation value of the overall system. When the focus is on optimizing the fruit production potential, either in an orchard or combined in an agroforestry system (e.g., alley cropping), improved cultivars should be planted in an appropriate spacing in full sunlight, with irrigation and protection from wildlife damage.

One agroforestry practice that is particularly well-suited for pawpaw production is alley cropping, the planting of rows of trees (i.e., pawpaw or pawpaw mixed with other trees or shrubs) with a companion crop grown in the alleyways between rows. If irrigation is available to avoid competition for water, a berry shrub such as aronia could be planted between trees within the tree row. A wide range of crop options are available for inclusion in the alleyway such as vegetables, low-growing fruits, or cut flowers to provide cash-flow for the farmer before the pawpaw trees become fully productive. Alternatively, pawpaw can be the secondary crop, inter-planted in a polyculture alley cropping system designed to optimize production of, for example, a tree nut crop. Many of the tree nut crops take a number of years to become productive, plus additional years to reach the full production level and mature canopy diameter. With the nut trees planted on the final optimal spacing (e.g., 60 feet for pecan, 40 feet for Chinese chestnut), one to two pawpaw trees could be planted between each. The pawpaw will become productive earlier than the nut trees, but at some point, the shade from the overstory nut trees would result in a decline in the pawpaw fruit production.

With this type of polyculture, consideration should be given to the successional transition through the life span of different species.

In addition to alley cropping, pawpaw can be integrated into riparian forest buffers to add to the conservation value and contribute a secondary production function. In those systems, the higher tree cost for improved cultivars may or may not be justified, depending on the design and maintenance program. Since pawpaw grows naturally in river floodplains, the tree makes an excellent component of a riparian buffer that includes a wide variety of species. Pawpaw thrives in the understory of larger trees, though fruit production would be limited in the shaded environment. The colonies they form by root suckers can help to stabilize the soil, reducing erosion in the sensitive riparian zone.

## Site Selection

Pawpaw is adapted to USDA Hardiness zones 5b to 8, and is grown across Missouri. Begin the site preparation process for a pawpaw orchard well in advance of the expected planting date. Order grafted nursery trees at least 6 months before the planting date. Plan the orchard layout with two or more cultivars to accommodate cross-pollination of trees. While pawpaw will grow on a range of soils, those soils that are moderately fertile and with adequate surface and internal water drainage are best for commercial production. To increase success when planting on soils with drainage issues, form the planting rows into “berms” (raised ridges) prior to planting. A typical berm for pawpaw is 4 feet wide and 18 inches high. Pre-plant soil testing is recommended to evaluate the soil pH and nutrient levels. Adjust pH level to 5.5 to 6.5, phosphorus level to 90 lbs/acre, and potassium level to 250 lbs/acre. A nematode test will reveal the presence or absence of these troublesome pests. Always select sites that are elevated relative to surrounding land to reduce the risk of blossom



damage from spring frost (i.e., low lying areas known as “frost pockets”). Pawpaw requires full sun for optimum fruit production. Control perennial weeds such as bermudagrass, johnsongrass, and perennial woody weeds before planting pawpaw. Establish a non-competitive ground cover in the middles between rows to conserve soil and facilitate operations in the orchard.



*Pawpaw is easily propagated using grafting techniques such as chip budding.*

## Propagation and Rootstocks

Grafted trees are recommended for commercial and home pawpaw plantings. Ungrafted seedling pawpaw trees often have delayed and reduced productivity and produce inferior fruit when compared to grafted trees of improved pawpaw cultivars.

Commercial pawpaw orchards are typically established using trees grafted to named, improved cultivars that are purchased from a nursery (see list). On a small scale, pawpaw is easily propagated through a variety of grafting techniques.

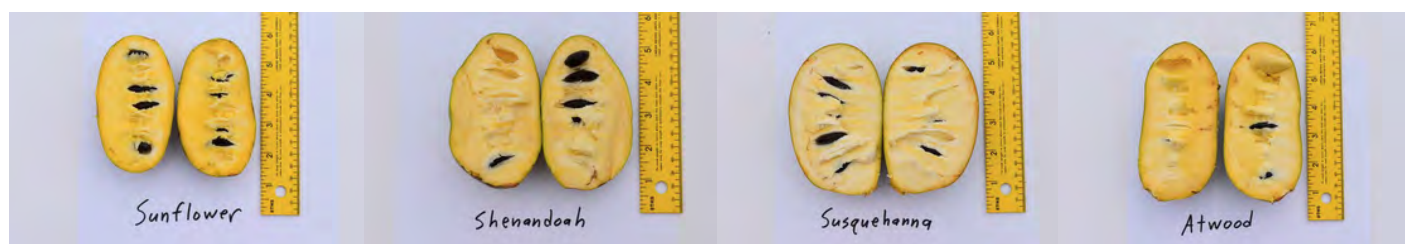
Pawpaw rootstock is typically grown from seeds collected at large, because improved pawpaw rootstocks have not been developed. Pawpaw seeds are somewhat challenging to germinate; the most important factor is not to let the seeds dry out.

Seeds also need a period of at least 3 months of moist cold storage (stratification) at 40°F to break dormancy. Establish rootstocks from seed in pots, as pawpaw does not transplant easily as a bareroot tree. Pawpaw is difficult to propagate from cuttings. Severing suckers from large trees or digging up and moving established pawpaw trees is often unsuccessful.

## Planting Establishment

Pawpaw orchards are commonly established using one year old grafted trees. Survival of bare root trees is erratic; container-grown trees are recommended. Grafted trees are planted in the spring in March to mid-April. Space tree rows 15 to 20 feet apart, with trees spaced 6 to 10 feet apart in the planting row. Research and grower experience suggests that first year seedlings and grafted nursery trees less than 24 inches in height benefit from shading during the establishment year; consider using a tree tube or temporary shelter over the trees. Grafted nursery trees typically begin producing fruit 3 to 4 years after establishment, and full production is reached in year 5-7. The productive life of a pawpaw orchard in Missouri is poorly understood; the experience of several pawpaw growers suggests that trees may not have a long lifespan.

Mulch is not recommended for pawpaw orchards because it attracts voles and mice.



*Fruit characteristics of improved pawpaw cultivars.*



## Pawpaw Cultivars for Missouri

Numerous improved pawpaw cultivars exist, and new cultivars continue to be released from the Neal Peterson and Kentucky State University programs.

### Standard & Heirloom Cultivars

<b>Mango</b>	Selected from the from wild in Georgia, 1970; moderately productive in MO; good quality.
<b>NC-1</b>	Hybrid of Davis × Overleese selected in Canada in 1976; early- to mid-season ripening; productive and excellent in MO.
<b>Overleese</b>	Selected from the wild in Indiana in 1950; one of the oldest pawpaw cultivar selections; inconsistent fruit production in MO and sometimes difficult to grow.
<b>PA-Golden</b>	Seedling from NY; first pawpaw to ripen; fruit generally small and poor quality in MO trials.
<b>Prolific</b>	Selected in Michigan in the 1980's. Inconsistent yield in MO trials.
<b>Sunflower</b>	Selected from the wild in Kansas in 1970; smaller fruits but consistently very productive and excellent flavor; one of the best in MO.
<b>Sweet Alice</b>	Selected from the wild in West Virginia in 1934; inconsistent fruit production in MO trials.
<b>Wells</b>	Selected from the wild in Indiana in 1990; has performed poorly in MO trials and is not generally recommended.

### Neal Peterson Cultivars

<b>Allegheny</b>	Horizontal branching; large symmetrical fruit; not extensively trialed in MO.
<b>Potomac</b>	Upright tree with large fleshy fruits; not extensively trialed in MO.
<b>Rappahannock</b>	Large symmetrical fruits with exceptional flavor; not widely trialed in MO but somewhat inferior to other cultivars.
<b>Shenandoah</b>	Mid-season ripening; excellent flavor, beautiful fruit, and very productive. Highly recommended cultivar after Susquehanna.
<b>Susquehanna</b>	Late ripening, very large flavorful fruits with few seeds. Highly recommended for MO planting.
<b>Tallahatchie</b>	A new release; mid- to late-season; excellent flavor; not yet trialed in MO.
<b>Wabash</b>	Medium-sized fruit with firm flesh; very promising in MO trials.



## Kentucky State University Cultivars

<b>Atwood</b>	Precocious heavy producer of very large and flavorful fruits. Extremely promising in early MO trials, rivaling Susquehanna.
<b>Benson</b>	Strong producer; disease resistant; not yet trialed in MO.
<b>Chappell</b>	A new cultivar; large mid-season fruit; fewer seeds; vigorous; not yet trialed in MO.

## Pruning

A key consideration for maximizing pawpaw productivity and fruit quality is the interception of sunlight within the canopy of the pawpaw tree. While several training systems are suitable for pawpaw, consider a central leader structure for pawpaw to achieve this goal. Train young trees to a single leader, and distribute scaffold branches around the trunk during the first 3 to 4 years following orchard establishment. Allow spacing among the branches to promote sunlight interception and air movement, and consider limb spreading to develop a strong tree structure. With mature pawpaw trees, remove branches that rub on other branches, branches in dense areas of the canopy, and broken or injured branches. Most pawpaw pruning is done during the dormant season.

## Soil Fertility Management

Research is underway into understanding pawpaw soil fertility management. At present, consider using general recommendations for fruit trees as a starting point for pre-plant soil levels of phosphorus, potassium, calcium, and magnesium. Modify these levels if needed before planting the orchard. Assuming that periodic soil tests reveal sufficient levels of these nutrients, the primary nutrient needed on an annual basis with established pawpaw orchards is nitrogen. A general recommendation for a producing pawpaw orchard is 100 lbs/acre of actual nitrogen per year.

Consider one of the following approaches to fertilizing the pawpaw orchard: apply the entire recommended amount as growth begins in the spring, or apply half as growth begins in the spring and the other half one month later.



*Young pawpaw orchard, showing in-row and between-row spacing.*

## Irrigation

Pawpaw trees are not drought tolerant and require 1 to 2 inches of water per week for optimum growth and fruit development. Early in the season, sufficient water is needed to support vegetative growth and flowering. Pawpaw ripens in the heat of summer and early fall, and adequate water must be available at that time to produce high quality, marketable fruit. Drip or trickle irrigation is commonly used to irrigate trees. Drip irrigation systems using 0.5-inch plastic lines with inline emitters spaced at 24 to 36 inches apart are typical. A well-designed drip-irrigation system is operated as needed, except during wet periods.



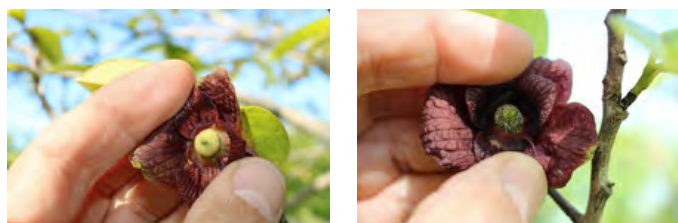


## Pollination and Crop Management

Flowers emerge from buds before leaves are apparent on trees in the spring. At first, flowers are green in color but turn dark maroon as they mature, eventually becoming about two inches in diameter. When fully open, the flowers have a fetid aroma, which may attract pollinating carrion flies and beetles. The flowers are also protogynous, whereby the female portion of the flower is receptive before the pollen is shed. Thus, most pawpaw cultivars require cross-pollination to produce fruit. Although some cultivars, such as 'Sunflower' may be self-fertile, this type of cultivar will produce more fruit when cross-pollinated. For successful cross-pollination, the pollinizer must be a different cultivar than the main cultivar and have an over-lapping bloom period. In large-scale plantings, trees are placed in rows, with a pollinizer placed between every three to four trees of the main cultivar.



*Pawpaw blossom and carrion fly pollinator*



*Receptive female flower parts (left) and male flower parts*

Although insects are natural pollinators for pawpaw, they may not always be dependable. For this reason, hand pollination may be used to ensure fruit set. To hand pollinate, a small artist's paintbrush can be used to transfer fresh pollen, which is yellow, from the pollinizer tree to the receptive stigma (female part) of a different cultivar. A receptive stigma will have green, glossy pistils.

Pawpaw commonly sets fruit clusters that contain up to 5-7 fruit. For largest fruit at harvest, consider thinning fruit clusters to 1-2 fruit in May once fruit set is apparent.

## Pest Management

Pawpaw trees are relatively pest-free for the first few years after planting. However, as trees mature and bear fruit, they are more likely to be affected by pests, especially in large plantings. Pests found at specific plantings are often influenced by site characteristics, including environmental conditions and nearby vegetation that may harbor insects and disease organisms.

One of the frequent diseases found on leaves and fruit is leaf spot, which is a fungal disease caused by a complex of fungi, including *Mycocentrospora asiminae*, *Rhopaloconidium asiminae*, and *Phyllosticta asiminae*. When foliage or fruit remains wet from rainfall or dew for a prolonged period of time, infection can occur. Symptoms of this disease first appear as tan spots with brown borders, but later form dark brown to black lesions. Symptoms are similar on the fruit, but lesions can eventually crack open. When the flesh is exposed from cracking, it quickly becomes infected with other disease organisms and insects, resulting in unmarketable fruit.

Additional pawpaw resources available at:  
<https://centerforagroforestry.org/pawpaw>



*Pawpaw leaf spot*

A disease commonly found on the fruit surface is sooty blotch and fly speck, which is caused by several fungi including *Colletogloeum* spp., *Dissoconium aciculare*, *Peltaster* spp., *Stomiopeltis* spp., and *Zygothiala jamaicensis*. Although sooty blotch and fly speck appear as surface blemishes on the skin of the fruit, the flesh can also be damaged. Symptoms of sooty blotch are black blotches (resembling soot) with poorly-defined borders. Flyspeck is visible as very small black dots in groups. Both of these diseases are superficial and are sometimes removed by vigorous rubbing or peeling the skin of the fruit. Like leaf spot, sooty blotch and fly speck infection occurs during extended periods of warm temperatures, high humidity, and rainfall.

The pawpaw peduncle borer (*Talponia plummeriana*) is a common pest on trees. The larval stage of this moth feeds on stems, roots, flowers, and flower parts. The first generation of adult moths emerges from twigs in April and May, often when trees are blooming. The adults are brown, speckled with darker wing tips and are small (about  $\frac{1}{4}$  inch long). As these insects emerge in spring, their pupal cases are visible on twigs. After mating, the female deposits eggs on anthers (male part of the flower) where larvae later hatch. Larvae initially feed on the anthers, then move through the floral tissue, and eventually bore into stems where they continue to consume tissue until they pupate and emerge from the twigs. Their feeding causes the flowers to wither and eventually drop.

Because these borers also feed on fruit tissues, there are likely multiple generations of this insect during a growing season. When there are serious outbreaks of this pest, major crop loss occurs.

Larvae of the Asimina webworm moth (*Omphalocera munroei*) larvae are another voracious moth pest. The black and orange striped larvae (caterpillars) are up to 2 inches long and feed on the vegetative parts of trees. Groups of these larvae generally begin feeding on the upper portions of the pawpaw tree canopy. Chewed leaves and webbing are visible around congregations of larvae in July. As they continue feeding, larvae tie mature leaves together, forming a protective shelter, and the infested foliage dies. In severe infestations, the larvae can damage the fruit rind, rendering the fruits unmarketable. Later, the female moths lay as many as 45 flat, yellowish eggs on the underside of mature leaves. To control this pest, infested parts of the tree can be pruned and removed from the site.



*Foliar feeding and webbing characteristic of the Asimina web-worm moth.*

Larvae of the pawpaw leafroller (*Choristoneura parallela*) also tie leaves together and feed inside this shelter. This insect is also known as the spotted fireworm or the parallel-banded leafroller moth on other fruit and nut crops. Small larvae are yellowish with brown heads, but subsequently turn olive green with white spots.



Also, a single hair is usually visible on each white spot. At the latter stage, larvae are about  $\frac{3}{4}$  inch long. Appropriately named, the adult moth is bell-shaped with alternating orangish-brown to brown-colored parallel bands and is up to 1 inch long. As with the *Asimina* webworm, leaves and twigs infested with this leafroller can be pruned and destroyed by burning the tissue.

Japanese beetles (*Popillia japonica*) can also be problematic on pawpaw trees. These beetles overwinter underground below the frost line as a grub. As soil temperatures warm, pupation occurs, and adults emerge in mid- to late-June in Missouri. Adults feed on the foliage of many plant species, including pawpaw. During the four to six week feeding period, pawpaw leaves become skeletonized. Adults lay eggs in the soil, where they hatch in mid to late summer, and larvae move back into the soil in the fall. Mass trapping can be used to lure adult Japanese beetles away from the plantings. More detailed information on mass trapping and other control methods can be found at: [https://ipm.missouri.edu/IPCM/2018/1/mass\\_trapping\\_japanese\\_beetles/](https://ipm.missouri.edu/IPCM/2018/1/mass_trapping_japanese_beetles/).

The stinging rose caterpillar (*Parasa indetermina*) is another pest that occurs on a broad range of fruit and nut hosts, including pawpaw. Caterpillars feed in late summer, causing irregular-shaped holes in the leaves. It is easily identified by its seven pairs of long, bristly yellow spines, as well as other smaller clumps of spines. Each caterpillar also has a black stripe on its upper side and orange, black and white striping on its sides. As they feed, caterpillars are generally found on the underside of leaves. Later, each caterpillar spins a brown type of cocoon where they overwinter. Moths emerge in mid-summer, mate, and females subsequently lay eggs. Moths are up 0.8 inch long, and are green with brown-bordered wing tips and two side brown patches near the head.

As its name implies, this is a stinging caterpillar, causing painful swelling when touched. Thus, rubber gloves are recommended when removing these pests by hand. They can be drowned in a solution of dish detergent and water or burned.

Pawpaw trees are hosts for the zebra swallowtail butterfly (*Eurytides marcellus*) where larvae feed on young leaves. On newly-planted trees or seedlings, larvae can devour much of the foliage, but they rarely cause severe damage on older trees. These larvae are green or black ringed with narrow green, white, blue, or yellow bands and are up to 2 inches long. The head region of larvae is the widest, tapering along length of the body. Adults are visible from late March to October in Missouri. There are several broods of these black and white striped butterflies, with those in the spring smaller with shorter "tails." Those found later in the summer and fall have forewings with a span of up to 3.5 inches wide. Females deposit single eggs on the underside of young leaves.



*Zebra swallowtail larva (left) and adult*

Larvae of the pawpaw sphinx moth (*Dolba hyloeus*) can cause minor damage on trees by feeding on leaves. These green caterpillars have six pairs of oblique white stripes on the sides of the abdomen. They are also known as hornworms due to the green or purple horn on their rear end. Because this hornworm often raises its thorax with the head tilted downward, it resembles a sphinx statue. Fully-grown caterpillars pupate and overwinter underground. Adult moths are found throughout the growing season. They are dark gray to black with white blotching on the wings and have a 2.0 to 2.7 inches wide wing span.



The granulate ambrosia beetle (*Xylosandrus crassiusculus*) causes damage by boring tunnels into the branches and trunks of pawpaw trees less than 3 inches in diameter. These insects can attack healthy or stressed trees. Heavy infestations can cause tree wilting, dieback, and eventually tree mortality. Symptoms of infestation are small (1/16 inch diameter) holes in the wood or toothpick-like projections of frass and plant tissue. Female beetles are reddish brown and about 2.1 to 2.9 mm long. After mating, female beetles excavate galleries inside trees, introduce *Ambrosiella* and *Fusarium* fungi into the wood, and rear their young. Control of granulate ambrosia beetle is difficult, but trapping may be used. For more information on trapping these insects, see: <https://www.in.gov/dnr/entomolo/files/ep-GranulateAmbrosiaBeetleFactsheet.pdf>.

The brown marmorated stink bug (*Halyomorpha halys*) may soon become an important pest of pawpaw fruit. Feeding on the skin of some tree fruits results in corky spots in the flesh or disfigured fruits. Adults are 0.5 to 0.7 inch long, brown-colored with a triangular shield and alternating light and dark bands on the margin of the abdomen. Border sprays on adjacent crops or forested areas around pawpaw trees may be used to suppress marmorated stink bugs.

Another potential pest of pawpaw fruit is the spotted wing drosophila (*Drosophila suzukii*). This insect is a small fruit fly (0.08 to 0.1 inch long) that causes major crop loss of soft-fleshed fruit. Female flies insert their serrated ovipositor into the fruit flesh to deposit their eggs under the skin. Sour rot and fungal diseases can also be introduced during egg-laying. After eggs hatch, larvae infest the fruit and the flesh deteriorates. To reduce spotted wing drosophila, harvest fruit frequently and remove any over-ripe fruit from the site. Also, avoid standing water in the planting.

Small mammals, including raccoons, opossums, and foxes will eat pawpaw fruit.

These pests can be removed from the site by trapping. Fortunately, deer, goats, and rabbits do not usually eat pawpaw leaves or twigs.



Weed management focuses beneath the trees, the row middles, and the edge between the two.

## Weed Management

Weed management practices in pawpaw are similar to those of other tree fruit. A critical aspect of site preparation is the elimination of perennial weeds such as bermudagrass, johnsongrass, and woody shrubs and trees in advance of planting. Weed management in established orchards focuses on three zones. The zone under the trees, generally a 3 to 4 foot-wide band down the row centered on the trees, is often managed free of weeds. This is accomplished through the use of preemergent and postemergent labeled herbicides, weed barrier fabrics, mulch, or shallow tillage. The pawpaw root system is shallow; use caution with tillage to avoid damage to roots and possible rootstock suckering. Maintain the zone between the rows in an annual or perennial cover crop.

Common cover crops include tall fescue, orchardgrass, grass/legume mixtures, and naturally present species. Manage this zone with mowing as needed. The edge between the row middles and the area under the trees is frequently maintained with a postemergent herbicide application, or frequent mowing and/or tillage.



Several herbicide products containing paraquat and glyphosate are presently labeled for pawpaw; consult labels for up-to-date information on herbicide use on pawpaw. When using postemergent herbicides, remove all rootstock suckers to reduce the risk of unintended tree injury.

## Pawpaw Harvest, Storage and Use

Pawpaw fruit harvest in Missouri takes place in late August through September, and occasionally into early October. Harvested ripe fruit is highly perishable with a shelf life of less than 5 days after harvest. Pawpaw skin is delicate during the ripening phase and is prone to bruises and mechanical damage leading to black spots. Refrigerate fruit at 32-40°F as soon as possible after harvest to avoid browning of pulp and fermentation. Pawpaw fruit may be frozen for long-term storage for a few months before processing.

Pawpaw is eaten as fresh fruit or processed into value-added products. The flesh purees easily and freezes nicely. The pulp comprises 67-90% of the total fruit weight, with the rest being seeds and skin. The pawpaw offers multiple opportunities for commercial value-added products. Pawpaw may be blended into ice cream, included in baked products, and fermented to produce beer and wine. The fruit has a creamy flesh and the unique flavor of the fruit resembles a blend of various tropical flavors, including banana, pineapple, and mango, and varies by cultivar.

Sources report that generally, the fruit contains more vitamins and minerals than apples, peaches and grapes. It also contains antioxidants and other beneficial components.

At present, 56 bioactive compounds have been identified in pawpaw fruit. Limited research data is available on the impact of pawpaw processing, frozen storage, and repeated freezing and thawing cycles on these bioactive compounds.



*Ripe pawpaw fruit*

## Pawpaw Marketing

Pawpaw is a high-value specialty niche crop that can be sold and consumed fresh. The emerging pawpaw market appears to be profitable and has potential to grow. Since 2016 the Center for Agroforestry, University of Missouri, has conducted surveys to identify pawpaw market trends.

Pawpaw producers in the supply chain in the United States are primarily tree growers, fruit growers and pickers, value-added producers, distributors, retailers, and wholesalers. A majority of the producers are small-scale and part-time with annual gross sales income from pawpaw of less than \$5,000. Approximately 15% of the producers operate pawpaw businesses as full-time occupations.

Various barriers have impeded development of the pawpaw market. It can be difficult, for example, to obtain the knowledge and skills needed to grow, process, and market pawpaw successfully. High-quality grafted trees can be difficult to find at times as the supply is not stable, and fresh pawpaw fruit has a relatively short shelf life.

For additional information, check out the *Pawpaw Financial Decision Support Tool*: <https://centerforagroforestry.org/landowners/resources/marketing-economics/>





Two additional barriers are consumers' overall lack of familiarity with pawpaw and food safety regulations that make producing and selling pawpaw products more complicated. For example, to apply for the Farm Winery License in New York State, a winery must use 75% New York state-grown fruit (e.g., pawpaws and grapes) for alcohol production. However, supplies of fresh pawpaw in New York are extremely limited and unstable.

**Table 1. Reported prices for products in the pawpaw industry based on a pawpaw producer survey.**

Product	Price
<b>Fresh pawpaw fruit</b>	\$2 to \$15 per pound
<b>Frozen pulp</b>	\$8 per pound
<b>Pawpaw jam</b>	\$8 per pound
<b>Seeds</b>	\$0.2 to \$0.5 per seed
<b>Tree seedlings</b>	\$8 to \$35 per tree
<b>Grafted trees</b>	\$25 to \$50 per tree

Pawpaw producers are optimistic about the market supply and demand in the future. A majority of our survey respondents (60%) believe that the pawpaw supply will increase in the next five years. All our respondents believed that pawpaw demand would increase in the next five years.

Current prices for pawpaw-related products, including fresh pawpaw, frozen pulp, jams, seeds, seedlings, and grafted cultivars are provided in Table 1. Though there are many potential substitutes for fresh pawpaw (e.g., peaches, pineapples, pears, and mangos), pawpaw is differentiated by a unique flavor and texture, and the fact that this is a native fruit.

In terms of consumer demand, farmers market shoppers are most likely to be familiar with pawpaw. According to our survey results, more than half of the respondents at farmers markets and 22% of respondents to the national survey had heard about pawpaw.

Consumer demand for fresh pawpaw is likely to increase in the future since a majority of the respondents indicated that they liked eating fresh pawpaw and would purchase them in the future. Producers would benefit from finding ways to sell their products at local outlets such as farmers markets. Labeling organic and pesticide-free production processes also can potentially increase consumer demand for fresh pawpaw.

## Pawpaw Economics and Budgeting

The economic costs and returns from pawpaw production are variable. Costs associated with establishing a pawpaw orchard may include site preparation, planting stock, irrigation system installation, fertilization and planting. Pawpaw orchard management costs include fertilization, pruning, weed control, deer control, insect management, and irrigation. The cost of harvesting pawpaws depends on the yield. Economic income is generated by pawpaw sales.

Table 2 presents an example of the costs of a one-acre pawpaw orchard in Missouri. The hourly wage rate used in the calculation is \$15.00. Tree spacing used in the analysis is 10 feet between trees within rows and rows 15 feet apart, with approximately 280 trees per acre.



*Pawpaw fruit display at a farmers market.*





Table 2. Estimated Establishment, Management and Harvest Costs of a Pawpaw Orchard in Missouri.

	Cost per acre	Cost per tree
<b>Establishment Costs</b>		
Site preparation (herbicide only)	\$120.00	\$0.43
Planting stock (grafted trees)	\$7,000.00	\$25.00
Irrigation (drip irrigation)	\$1,500.00	\$5.36
Fertilization	\$100.00	\$0.36
Planting cost (use auger)	\$1,036.00	\$3.70
<b>Subtotal</b>	<b>\$9,756.00</b>	
<b>Management Costs</b>		
Fertilization	\$600.00	\$2.14
Pruning (manual)	\$100.00	\$0.36
Mowing and herbicide	\$250.00	\$0.89
Insecticide and fungicide	\$600.00	\$1.43
Deer control (cages)	\$560.00	\$2.00
Irrigation (drip irrigation)	\$300.00	\$1.07
<b>Subtotal</b>	<b>\$2,410.00</b>	
<b>Harvest Technique</b>		<b>Cost per pound</b>
Hand harvest	\$1,122	\$0.15
<b>Subtotal</b>	<b>\$1,122</b>	

The primary costs associated with site preparation are herbicide and labor costs. In terms of planting stock, there are numerous varieties of pawpaws, and the example does not specify a variety. Planting stock costs include labor and planting grafted trees. The price for 1-gallon potted tree is \$25. The cost of establishing a drip irrigation system is estimated to be \$1,500 dollars per acre. In sum, the total cost of establishing a pawpaw orchard is around \$9,756 per acre.

In terms of management costs, the example assumes that (1) fertilizer is applied twice per year, (2) manual pruning occurs once per year, (3) applications of insecticide and fungicide occur twice per year, (4) applications of herbicide occur three times per year, (5) tree tubes are used for protection from direct sun during establishment, and (6) irrigation as needed.

The total hand harvest cost is calculated based on fifth-year pawpaw tree yields and varies with yields. Hand harvesting costs include labor and fruit harvest bins. We assumed that a mature tree produces 30 pounds of pawpaw fruit with a potential 10% fruit loss due to windfall. The total orchard management cost per year is estimated to be \$2,410 per acre. The total harvest cost per acre is \$1,122.

These estimated pawpaw costs are for a representative Missouri pawpaw orchard. Costs can vary widely depending on the pawpaw orchard owner's management decisions. For instance, the cost of purchasing ungrafted trees and hiring skilled labor to do the grafting differs from the cost of purchasing grafted trees from a nursery. This example only provides references for costs associated with establishing and managing a one-acre pawpaw orchard in Missouri.



## Nursery Sources for Pawpaw Cultivars and Seedlings

(NOTE: list not comprehensive)

### Forrest Keeling Nursery

<https://fknursery.com/>

### Stark Brothers

<https://www.starkbros.com/>

### Nash Nurseries

<https://nashnurseries.com/pawpaws.html>

### One Green World Nursery

<https://onegreenworld.com/product-category/fruited-trees-shrubs/pawpaw/>

### Peterson Pawpaws

<https://www.petersonpawpaws.com/>

### George O. White State Forest Nursery,

Missouri Department of Conservation  
(seedlings only)

<https://mdc.mo.gov/trees-plants/tree-seedlings/order-seedlings>

## Pawpaw Resources

Cai, Z., Gold, M. and Brannan, R. (2019) An Exploratory Analysis of US Consumer Preferences for North American Pawpaw. *Agroforestry Systems*. 93:1673–1685.  
<https://doi.org/10.1007/s10457-018-0296-5>

Pawpaw. 2021., Kentucky State University.  
<https://www.kysu.edu/academics/college-acs/school-of-ace/pawpaw/index.php>

Bordelon, B. (2001). Growing Pawpaws. Purdue University Cooperative Extension Service publication HO-220-W.  
<https://ag.purdue.edu/hla/pubs/HO/HO-220.pdf>

Kaiser, C. and Ernst, M. (2018). Pawpaw. University of Kentucky Center for Crop Diversification publication CCD-CP-14.  
<https://www.uky.edu/ccd/sites/www.uky.edu.cc/files/pawpaw.pdf>

Ames, G.K. (2010). Pawpaw – A "Tropical" Fruit for Temperate Climates. National Center for Appropriate Technology publication IP373.  
<https://attra.ncat.org/wp-content/uploads/2019/05/pawpaw.pdf>.

Pomper, K. et al. (2020). Pawpaw Cultivars and Grafted Tree Sources.  
<https://www.kysu.edu/academics/college-acs/school-of-ace/pawpaw/2009-pawpaw-cultivars-and-grafted-tree-sources.php>



## Follow UMCA on social media:



Twitter: [@MUAgroforestry](https://twitter.com/MUAgroforestry)



Facebook: [The Center for Agroforestry](https://www.facebook.com/TheCenterforAgroforestry)



YouTube: [Mizzou Agroforestry](https://www.youtube.com/channel/UCMizzouAgroforestry)



Instagram: [@MUAgroforestry](https://www.instagram.com/MUAgroforestry)



LinkedIn: [University of Missouri Center for Agroforestry](https://www.linkedin.com/company/UniversityofMissouriCenterforAgroforestry)



## Pawpaw: Cultivating the Elusive Fruit

with Pat Byers, MU Extension, and Lauren Cartwright, Missouri NRCS.

*Listen wherever you get your podcasts.*



**Authors:**

- **Patrick Byers**, M.S., Horticulture Field Specialist, University of Missouri Extension;
- **Zhen Cai**, Ph.D., Assistant Research Professor, Center for Agroforestry, University of Missouri;
- **Michael Gold**, Ph.D., Research Professor, Center for Agroforestry, University of Missouri;
- **Kiruba Krishnaswamy**, Ph.D., Assistant Professor, Department of Bio-medical, Biological and Chemical Engineering and Division of Food, Nutrition and Exercise Sciences (joint appointment), University of Missouri;
- **Chung-Ho Lin**, Ph.D., Associate Research Professor, Center for Agroforestry, University of Missouri;
- **Sarah Lovell**, Ph.D., Director, Center for Agroforestry, University of Missouri;
- **Andrew Thomas**, M.S., Assistant Research Professor, Southwest Research Center, University of Missouri;
- **Michele Warmund**, Ph.D., Professor of Horticulture, Division of Plant Sciences, University of Missouri.



**Center for Agroforestry**  
University of Missouri



**Produced by the  
University of Missouri Center for Agroforestry  
Outreach and Education Unit**

**New 03/22**

*This work is supported by the University of Missouri Center for Agroforestry and the USDA-ARS Dale Bumpers Small Farm Research Center, Agreement number 58-6020-0-007 from the USDA Agricultural Research Service.*

