

Specialty Crop Profile: Pawpaw

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Introduction

Pawpaw (*Asimina* spp.) is a native fruit crop that is in the beginning phases of domestication in this country. As it is adapted to a commercial orchard setting, many issues related to genetic refinement, production and culture, handling, use, and marketing are being addressed by various research and educational programs. The primary effort is coordinated by Kentucky State University where an intense program was initiated in the 1980s. This publication provides basic background information about pawpaw, its potential, and the issues related to its development as a niche specialty crop in Virginia and throughout the Eastern U.S.

The pawpaw is the largest edible tree fruit native to the United States. It is the only temperate member of a new- and old-world tropical plant family (*Annonaceae*, Custard Apple family) that includes cherimoya and sweetsop. There are nine species of *Asimina*. The common pawpaw, *Asimina triloba*, has the greatest potential for commercialization. It is widely adapted with a native range from Florida to Michigan and as far west as Nebraska. It is a common species in Virginia, found near waterways and low, moist draws in the mountain drainage areas. Though technically a tree fruit, it can stretch the accepted definition for “small fruit” by plant size due to its natural bush-like and suckering habit. In most situations it is easily trained into a single-trunk small tree, pyramidal in form, which can reach 15 to 20 feet in height (Figure 1).

Historically, pawpaw was a well-known and much utilized fruit in the eastern U.S. It was an important food crop for both Native Americans and early settlers. Today it is a local specialty, gathered in the wild by enthusiasts and grown by hobbyists in backyard orchards.



Figure 1. Pawpaws in orchard setting, note pyramidal form.
(Photo by A. Bratsch)

Over the years, wild selections have been collected and named, and many of these cultivars (cultivated varieties) are now available through commercial nurseries as asexually propagated (grafted) stock.

In its ideal native habitat, pawpaw is characteristically found in the deeper, rich soils of river-bottom woodlands, growing in the shade as an understory tree. Because of root suckering, it usually forms clumps or thickets. Its leaves are long, drooping, dark green, and turn a brilliant yellow in the fall (Figure 2). The fruit (a true berry) may weigh up to a pound, is oblong to cylindrical in shape, one to six inches long, and one to three inches in diameter. Fruit is borne alone (Figure 3a), or in multi-fruit clusters (Figure 3b), which can resemble a “hand” of bananas, hence its common names: poor-man’s banana and Indiana banana. It has a strong floral and fruity aroma and its flesh is creamy textured, usually bright yellow to orange in color (Figure 4). Typical of its tropical family, the flavor of pawpaw is best described as richly complex, a mixture of papaya, banana, mango, and pineapple. Flavor can vary greatly

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Figure 2. The bright yellow fall foliage color of pawpaw makes it desirable as an ornamental species.
(Photo by Neal Peterson)



Figure 3a. Large, single-set pawpaw fruit.
(Photo by Neal Peterson)



Figure 3b. Pawpaw exhibiting typical clustered fruit set.
(Photo by Desmond Layne, courtesy Kirk Pomper, KSU website, <http://www.pawpaw.kysu.edu/photogal/Fruit2.htm>)



Figure 4. Internal fruit color of pawpaw.
(Photo by A. Bratsch)

among selections, with sweetness and minimal after-taste characteristics defining a high-quality cultivar.

Crop Prospects

Pawpaws are not yet a commercial crop in the U.S. Strong interest has been shown in the potential for development, and several institutions are working toward that goal. The national repository for pawpaw germplasm is located at Kentucky State University, Frankfort, Ky. KSU is a leader in pawpaw research, focusing on aspects of production, breeding, and post-harvest handling. The university also coordinates a multi-state, regional cultivar trial, with 12 other universities in the East and Midwest participating. They regularly conduct outreach meetings to teach growers about the crop (Figure 5). The New Crops Center at Purdue University is also involved with research and has initiated work into the pharmaceutical/pesticidal potential of the pawpaw. The Pawpaw Foundation, also based at KSU, is a nonprofit organization dedicated to research and promotion of pawpaws as commercial fruit.



Figure 5. Kirk Pomper (center, white cap), Pawpaw Program Leader, leading educational meeting held at Kentucky State University.
(Photo by A. Bratsch)

Crop Advantages

The crop is well adapted to the Eastern U.S. climate and soil conditions. Pawpaw is adapted to humid temperate zone growing conditions. It is hardy to the USDA growing zone 5 (-20°F or -29°C), and needs at least 400 hours in annual chilling requirements (time exposed to 35° to 45°F during winter months, depending on the cultivar). This is a low chill requirement compared to other tree fruit species (apples 800 to 1,700 hours), and once met, the trees will begin to flower early in the spring. A long, warm season is required to mature fruit (2,600 degree days; ~160 frost-free days). From 30 to 35 inches of rainfall is needed annually, with the majority falling in the spring and summer. Contrary to popular belief, pawpaw performs best in full-sun exposure. However, sunlight protection is needed in the first year in the field, as young tree shoots are sensitive to sunlight. In an orchard setting, this is accomplished by using commercially available tree shelters (see planting and establishment).

The pawpaw is a unique/unusual fruit crop with high nutritional value and potential for both fresh and processed market uses. As a food source, pawpaw exceeds apple, peach, and grapes in vitamin, mineral, amino acid, and food energy values. The current and primary market for fruit is as a fresh product in farmers markets and other direct sales outlets. Though large-scale commercial processing markets do not yet exist, the fruit's intense flavor and aroma have significant potential in blended fruit drinks, baby food, ice cream, and as a substitute for banana in various baking recipes. In Kentucky, various entrepreneurs are utilizing pawpaw as a local cuisine item for restaurants and in frozen custard and ice cream products.

There are valuable natural compounds in the plant, which have both anti-carcinogenic and pesticidal properties. Aromatic compounds in the fruit have potential for use in cosmetics and home products. Research has shown that pawpaws have a diversity of natural compounds in fruit, leaves, bark, and twigs. One class of compounds known as annooaceous acetogenins occurs in leaves and twigs and has reported anti-tumor properties. Currently, Purdue University has patented an extraction procedure and the development of an herbal formulation is underway by a private company. Commercial drug manufacturers, however, have shown limited interest in the compounds. An alkaloid, asimicin, is found in the seeds, leaves, and bark of pawpaw and is reported to have pesticidal proper-

ties. Pawpaws are resistant to insect and disease pressure. This may be due to asimicin and other natural defense compounds. With proper management, organic production of pawpaw is feasible. Aromatic constituents isolated from fruit may hold potential for marketing as well.

Nursery trade development for orchard and edible landscape plantings is on the increase. Currently in the U.S. there are over 40 nurseries selling pawpaw trees, and in the past several years, at a brisk pace. Named cultivars are offered as grafted trees along with non-grafted seedlings. Grafted trees are expensive and retail for \$18.00 to \$25.00 each. As a landscape tree, the pawpaw has attractive form, size, and fall color, as well as potential fruit production. It also attracts the zebra swallowtail butterfly (*Eurytides marcellus*), whose larvae feed exclusively on pawpaw, but do minimal damage (Figures 6a,b).



Figure 6a. Zebra swallowtail butterfly adult on pawpaw. (Photo courtesy of Mark Blossom, Blossom Nursery, <http://www.blossomnursery.com/index.html>)



Figure 6b. Zebra swallowtail larva, which does minimal foliage damage to pawpaw. (Photo courtesy of Mark Blossom, Blossom Nursery, <http://www.blossomnursery.com/index.html>)

Crop Disadvantages

Pawpaws, once ripe, are very perishable, soft, and bruise easily, presenting problems for marketing. Though they can be picked at a less than ripe, but mature stage, best flavor intensity and sweetness is achieved when fruit is allowed to tree-ripen, but not over-ripen. Pawpaw fruit are climacteric, which means there is a rapid increase in respiration and ethylene production during final fruit ripening, causing fruit to quickly become over-ripe. This may preclude storage with other fruits sensitive to high levels of ethylene. When completely ripe, pawpaws will last for about two days at room temperature, or about a week under refrigeration (40° to 45°F degrees). Fruit harvested immature will not ripen, even if treated with ethephon, a common fruit ripening material that releases ethylene gas. However, if the fruits are picked before fully ripe, but mature, they can be refrigerated for two to three weeks, and will subsequently ripen at room temperature over several days. As the fruit ripens, it quickly develops handling bruises, blotches, streaks, and freckles, much like an over-ripe banana, which can reduce its fresh-market appeal. Some fresh marketers have used bubble wrap in boxes to minimize damage during transport (Figure 7). Research is needed in postharvest handling of fruit.



Figure 7. Pawpaw fruit bruise easily and should be handled gently and packed with care; note use of bubble wrap to protect fruit in box.

(Photo by A. Bratsch)

Fruit set is poor in nature because of various pollination issues. However it has been shown that with proper pollination under cultivated conditions, yields can be exceptional. The flowers occur on one-year-old wood and are protogynous, meaning that the female stigmatic surface is receptive before male pollen is mature. Even if released on time, the pollen is often self-incompatible. Thus the flowers require cross-pollination from a genetically different plant. Means

of pollination is also an issue, and natural pollinators are neither efficient nor dependable. The reddish, meat colored flowers and their fetid, musky aroma belie the type of pollinating insects visiting pawpaw (beetles, carrion, and bottle flies). Recent chemical analysis indicates that the aroma is better described as “yeasty” versus fetid; either way, flowers have an unpleasant odor. Increases in pollination have been observed by introduction of carrion to the orchard. This, however, is an unusual orchard practice, and may be difficult for growers to adopt.

Fruiting characteristics can be highly variable between cultivars. Important factors of fruiting variability include time and concentration of maturity, fruit size, seed number, and seed size (Figure 8). Flavor components and sweetness are also variable. Breeding and selecting for quality and uniformity are part of bringing any new crop to market, and work has only begun with pawpaws.



Figure 8. Small seed size in the cultivar Rappahannock.

(Photo courtesy of Neal Peterson, Peterson Pawpaws, <http://www.petersonpawpaws.com/Rappahannock.php>)

A “Catch 22” situation is in place with regards to commercialization of the fruit for fresh and processed markets. For wholesale marketers and processors, a guarantee of fruit availability is needed before any major products or fresh-market line is developed. From the growers’ perspective, a market must be in place before planting. Most new orchards average one to five acres in size (Figure 9). It is hoped that as recently planted orchards come into bearing, the market situation will begin to change. Initially, cooperative marketing of fruit by limited acreage growers may help to address demand quantity issues. Research is also needed in crop processing and the best means of product commercialization.



Figure 9. New pawpaw orchard in northern Virginia. Four-year-old planting is shown. (Photo by A. Bratsch)

Commercialization of biomass production for drug or pesticide uses is expensive and may be an unrealistic expectation. Corporate investment for research and development of a new drug or pesticide product is expensive due to government approval requirements, and the market potential is a driving factor in decisions to develop a product.

Allergenic responses have been observed. While many people enjoy the taste of pawpaw, some individuals can become sick after eating the fruit. Skin rash, nausea, vomiting, or diarrhea can develop. In other cases, individuals may be allergic to the leaves or the fruit skin. Many tissues of this tree, especially bark, leaves, and seeds, contain a variety of alkaloids such as the aforementioned acetogenins, as well as phenolic acids, proanthocyanidins, tannins, and various flavinoids. Though these compounds represent potential commercialized products as anticarcinogens and botanical pesticides, they also can cause allergic reactions.

Little is known about the culture, physiology, and genetics of this crop. Current research in these areas is underway. However, prospective growers must realize that much information is simply not available and production practices are based, to a great extent, on assumption and extrapolation from other crops. Because this is a new crop, little if any chemical pest management materials are registered.

Growing Practices

Site, Soils, and Preparation

Though pawpaws are capable of fruiting in the shade, a full-sun location and standard orchard setting will result in best production. Rows should be oriented north/south. Trees should be planted on higher ground,

avoiding bottomland sites prone to flood and frost. As noted, pawpaws flower early and, like other orchard crops, may be susceptible to late spring frost and suffer flower damage. Elevation will provide some measure of frost protection and sloped sites allow for faster surface-water drainage. Windbreaks may alleviate leaf damage in very windy, exposed sites.

The best soil types are well drained and deep without a clay pan. Soils that are heavy tend to water log or have a high water table in the winter and should be avoided. Prior to planting, and depending on soil test, adjust phosphorus (P) and potassium (K) levels to 75 and 300 pounds per acre, respectively, and lime to bring soil pH to 6.0 to 6.8. The planting site should be moldboard plowed or chiseled to incorporate amendments and worked level and smooth. A common practice in peach production is the formation of a raised planting row four to six feet across and three to six inches high. For pawpaws planted in heavier soils, raised beds may also be advantageous to promote internal soil drainage.

Propagation and Cultivar Selection

Pawpaw trees can be acquired by collecting young trees from the wild, propagating by seed, or purchasing from established nurseries as bare-root or container-grown trees. Any seedling tree taken from the wild is an “unknown” in its fruit-bearing qualities, and all seedlings, regardless of parent tree, will express variability. Grafted trees, using scion wood from a named parent, is the only means to ensure a true clone and provide known performance. Softwood and hardwood cuttings have been shown to be unsatisfactory methods of propagation.

Collecting trees from the wild is usually unsuccessful for several reasons. Pawpaws tend to send up root suckers from a “mother tree.” While root suckers are true clones and identical to the mother plant, they tend to be poorly rooted, and rarely survive transplanting. Transplanting a seedling will be more successful than a root-suckered tree. However, distinguishing a new seedling from a root-suckered shoot can be difficult. Look for trees growing alone where seeds may have dropped and dig only smaller specimens. Trees should be dug in the spring when buds are beginning to swell. As pawpaws in general have weak, brittle taproots, it is important to leave soil on the roots and use ball and burlap to limit root damage. Bare-root wild seedlings usually have poor establishment percentages. Trim tops by 25 percent to compensate for root loss.

Seed propagation is slow but not difficult, provided certain conditions are met. Collect seeds from soft ripe fruit. Macerate the fruit and float the pulp off in water. Seeds can be dipped in a 10 to 20 percent bleach solution to reduce bacteria and fungi problems; be sure to rinse seeds well after dipping. **Pawpaw seeds should never be allowed to dry out** or their germination ability will be lost. Once cleaned, store seeds in a zipper-top bag with slightly moist sphagnum peat moss. Seeds have a dormant, immature embryo, and require stratification (time and cold) under refrigerated conditions (32° to 40°F) for 80 to 120 days before they will germinate. Refrigerated, moist seeds can be stored for up to a year or more. Following stratification, seeds should be sown in a well-aerated soil mix, with an optimum temperature of 75° to 85°F. Use tree pot containers 14 to 18 inches deep that will allow room for taproot formation (Figure 10). Seeds will germinate in two to three weeks, form a taproot, and then send up a shoot in two months. Freshly extracted seeds can be sown directly outdoors in seedbeds in the fall; expect germination to occur the following year in July or August. Field-grown seedlings should be dug or transferred to a pot or permanent site in the spring as plants come out of dormancy. All propagation and growing areas should be provided 70 percent to 80 percent shade cover.



Figure 10. To accommodate the taproot and encourage branching, these pawpaw seedlings are growing in deep “root trainer” pots. (Photo by Kirk Pomper, KSU, <http://www.pawpaw.kysu.edu/photogal/Propagation6.htm>)

For grafting, seedling trees are usually used as a “root-stock” with a named cultivar grafted to it. This is the most economical method of propagation of a known cultivar. Some cultivars may be protected by plant patent rights. Pawpaws have been successfully grafted or budded using whip and tongue grafts and chip budding. Avoid T-budding, which has been unsuccessful.

Nurseries sell both bare root and containerized stock. In general, container-grown trees have given better field results for novice growers, while bare-root trees if handled correctly, can be just as successful. Numerous cultivars can now be commonly found in the nursery trade: ‘Sunflower,’ ‘Taylor,’ ‘Taytwo,’ ‘Mary Foos Johnson,’ ‘Overleese,’ ‘Mitchell,’ ‘Davis,’ and ‘Reberras Gold’ are some examples. More recently, several cultivars have been developed for the Mid-Atlantic region: ‘Susquehanna,’ ‘Rappahannock,’ and ‘Shenandoah’ (see nursery source list). Each cultivar has its particular characteristics, and as noted, two or more cultivars are needed for cross-pollination. Grafted trees are usually two years old, and will be more expensive than seedling trees.

Table 1. Partial list of nursery sources.

Hidden Springs Nursery
Rt. 14, Box 159
Cookeville, TN 38501
(615) 268-9889

Corwin Davis (grafted trees)
20865 Junction Road
Bellevue, MI 49021
(616) 781-7402

One Green World
28696 S. Cramer Road
Mollala, OR 97038
(877) 353-4028
<http://www.onegreenworld.com/index.html>

Sherwood’s Greenhouses
PO Box 6
Shipley, LA 71073
(318) 377-3659

Burgess Seed and Plants, and Four Season Nursery
905 Four Seasons Road
Bloomington, IL
(309) 663-9551
<http://www.eburgess.com/>

Peterson Pawpaws (‘Susquehanna,’ ‘Rappahannock,’ ‘Shenandoah’)
PO Box 1011
Harpers Ferry, WV 25425
<http://www.petersonpawpaws.com/index.php>

Blossom Nursery
216 CR 326
Eureka Springs, AR
<http://www.blossomnursery.com/index.html>

Planting and Establishment

The ideal planting time for dormant stock is early spring. Between-row spacing should be 18 to 25 feet (depending on equipment access needs) with trees set at an in-row spacing of eight to 10 feet. Plant trees at the depth they were grown at the nursery. For containerized stock, take care not to damage the root ball as it is removed from the pot. Trees will often be sparsely rooted and the roots easily broken. For bare-root stock, trim any excessively long roots, and spread out the root system in the planting hole. Carefully backfill the planting holes, taking care to fill air gaps. Limited reports have suggested that adding soil (inoculation) from a native pawpaw site to the planting hole may provide some benefit to establishment and growth. In many tree species, mycorrhizal fungi create a symbiotic relationship between tree and fungus which aids tree growth. This relationship has been documented for pawpaws. However, the species of fungi is common to most soils, and only in chemically treated, fumigated soils, or long-term agricultural soils would result in a response site inoculation.

New trees should be well watered and fertilized with a liquid soluble fertilizer mix such as 20-20-20. Follow with additional applications at four-week intervals through June. Repeat this fertilizer application the second year. Trees should not be allowed to dry out during the first two years of establishment. Mulching with various organic materials may help maintain soil moisture status. Care should be taken in the winter months to address vole and mouse control under the mulch.

Plastic tree tube shelters (4 to 6 inches in diameter) that are used in reforestation and vineyard plantings work well for protecting the new seedlings from sunlight the first year (Figure 11). A wooden or metal stake should be driven next to the tube to secure it in place. Tubes should be removed by mid-August to allow tissue hardening for winter. Tubes left on trees too long may result in significant winter damage. Tree tube shelters are reusable and available through various horticulture supply stores.

If using grafted trees, monitor bud breaks, and remove any shoots originating below the graft union. Otherwise little corrective pruning is recommended as long as a distinct central leader is forming.

Information on the care of established trees in an orchard setting is limited and based on educated assumptions. Fruit are borne on the previous year's wood.



Figure 11. Tree shelters provide protection from direct sunlight during the first year. (Photo by A. Bratsch)

Like peaches, proper pruning and adequate fertility are needed to keep trees vigorous and producing many annual shoots. Currently, a central leader tree is recommended, with topping at about 15 feet to control height. Suckering (shoot development) from the roots or tree base may occur with some cultivar and rootstock combinations and these should be pruned (Figure 12). The canopy may require thinning to maintain good air movement and light penetration. Annual nitrogen (N) fertilizer requirements for bearing trees are at best an estimate. However, sparse root structure and high foliage densities would indicate that moderate rates of at least 40 to 60+ pounds of N per acre may be needed, with a split timing of the total rate between early spring and after fruit set. Should no crop set, the second application may not be needed. Site fertility, tree age, crop loads, and vigor will affect nitrogen application rates, and much research work needs to be done to characterize proper crop nutrition.



Figure 12. Suckers (shoots), which originate from the rootstock, developing near the base of an older pawpaw tree. (Photo by A. Bratsch)

Pollination and Fruit Set

Grafted trees may develop flowers as soon as the third season. Depending on vigor of the trees, a few fruit may be left on in years three and four. As noted, pollination may be difficult to achieve due to self-incompatibility and lack of pollinators. Various flies and beetles are attracted to the smell of the flowers and they are likely the primary pollinators. Honeybees do not prefer the flowers. Though carrion placement may attract fly and beetle pollinators to the area, simple hand pollination with an artist's paintbrush works well in small orchard situations to ensure fruit set (Figure 13a, b). Use the brush to transfer pollen grains from the anthers of one cultivar to the receptive stigma of another cultivar. Pollen is ripe when the anthers are brown, loose, and crumbly and the pollen comes off on the brush as a yellow dust. Stigmas are ripe when the tips of the pistils are green and glossy and the anther ball in the same flower is still hard and green. Using this method,



Figure 13a. Pawpaw flowers at maturity, note bright green stigma in center of flower, delayed development of the flower to the right, and the stage of leaf development. (Photo courtesy of Mark Blossom, Blossom Nursery, <http://www.blossomnursery.com/index.html>)



Figure 13b. Hand pollination of pawpaw flowers using artist's paintbrush to distribute pollen. (Photo by Neal Peterson)

fruit set can be heavy and care should be taken not to over-load and stress the tree. Excessive fruit may need to be thinned by hand. Fruit that develop in direct sunlight may become sunburned (Figure 14), and should be thinned first.



Figure 14. Typical sunburn damage on pawpaw fruit. (Photo by Ray Jones, provided courtesy of Neal Peterson)

Pest Concerns

Pawpaws have few noted pest concerns. The peduncle borer (*Talponia plummeriana*) is a caterpillar pest that can bore into the pawpaw flower and cause it to drop (Figure 15). Though this damage is minor, in certain years the borer can destroy many flowers. Its presence should be monitored. Earwigs, slugs, San Jose scale, leaf rollers, and tent caterpillars have also been reported as occasional pests. Deer are not known to readily eat twigs or foliage, but bucks will use young trees to rub velvet from antlers in the fall. Other potential mammalian problems include squirrels, raccoons, opossums, and foxes which prefer the ripe fruit and as with other fruit trees, voles and mice may cause bark or tunneling damage, particularly when mulch is used around the trees for weed control.



Figure 15. Peduncle borer damage of pawpaw flowers. (Photo by Colleen Anderson, provided courtesy of Neal Peterson)

The primary diseases reported on pawpaws are fly speck (*Zygothiala jamaicensis*) and sooty blotch (*Peltaster fructicola*), which usually occur together (Figure 16). This disease complex usually develops during periods of high humidity. Dense foliage and lack of air movement contribute to the problem and proper spacing and pruning should help reduce incidence.

Currently, with limited or no registered chemical options for pest control in pawpaw, cultural methods and “organic” pest control products are the primary option for both insect and disease management.



Figure 16. Fly speck and sooty blotch on pawpaw fruit.
(Photo by Peter Chrisbacher, provided courtesy of Neal Peterson)

Harvest and Postharvest Management

Depending on the cultivar, fruit can begin to mature in early August and up to the first frost. The concentration of ripening fruit will depend on the cultivar. Harvest can spread out over the course of a month or a few days. Ripe pawpaws develop a strong aroma that is both fruity and floral. When ripe, the fruit exhibits subtle visual clues, turning a lighter shade of green, and maybe showing some yellowing. The fruit will also begin to soften, similar to peach or avocado. In later stages, the fruit will yellow and develop brown blotches and streaks, eventually turning black, like an overripe banana.

If allowed to stay on the tree, the fruit will reach a peak of ripeness and then decline rapidly in quality. For best storage and postharvest longevity, fruit should be harvested as the skin color begins the initial change even though flavor and sugar development may not be at a peak. As noted, fully ripe pawpaws can be stored about a week in normal refrigeration (40° to 45°F). If the fruits were picked mature, but before fully ripe, they

can be refrigerated for two to three weeks. Like a pear or peach, when removed from refrigeration, the fruit can be brought out to room temperature and allowed to ripen fully over a period of several days.

For fresh eating, the best method of pulp extraction is to cut the fruit in half and use a spoon to scoop out the flesh. The seeds can be easily separated and removed. For cooking, the best recipes are those that require little or no heat. The flavor compounds are very volatile and heating will destroy the characteristic flavor. For flavoring ice cream, the fruit should be ripe and used fresh, chopped finely, and blended into vanilla ice cream.

Additional References

Pawpaw, *Asimina triloba* (L.), in fall, Michelle McClanan and Douglas G. Pfeiffer, Department of Entomology, Virginia Tech, and the Mid-Atlantic Regional Fruit Loop, Extension Research and Teaching in Fruit Crops, IPM Page, http://www.ento.vt.edu/Fruitfiles/PawPaw/PAW_000C.html

Pawpaw Information Web Site, Frankfort, Kentucky, Kentucky State University (the primary source for current information regarding pawpaw research, culture and marketing), <http://www.pawpaw.kysu.edu/>

Asimina triloba (L.) Dunal, Annonaceae, Pawpaw Purdue University Center for New Crops & Plants Products (series of historical articles on pawpaws), http://www.hort.purdue.edu/newcrop/nexus/Asimina_triloba_nex.html

Asimina Genetic Resources, Pawpaw, USDA ARS National Clonal Repository (pawpaw information summary), <http://www.ars-grin.gov/cor/minor/asiinfo.html>

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