



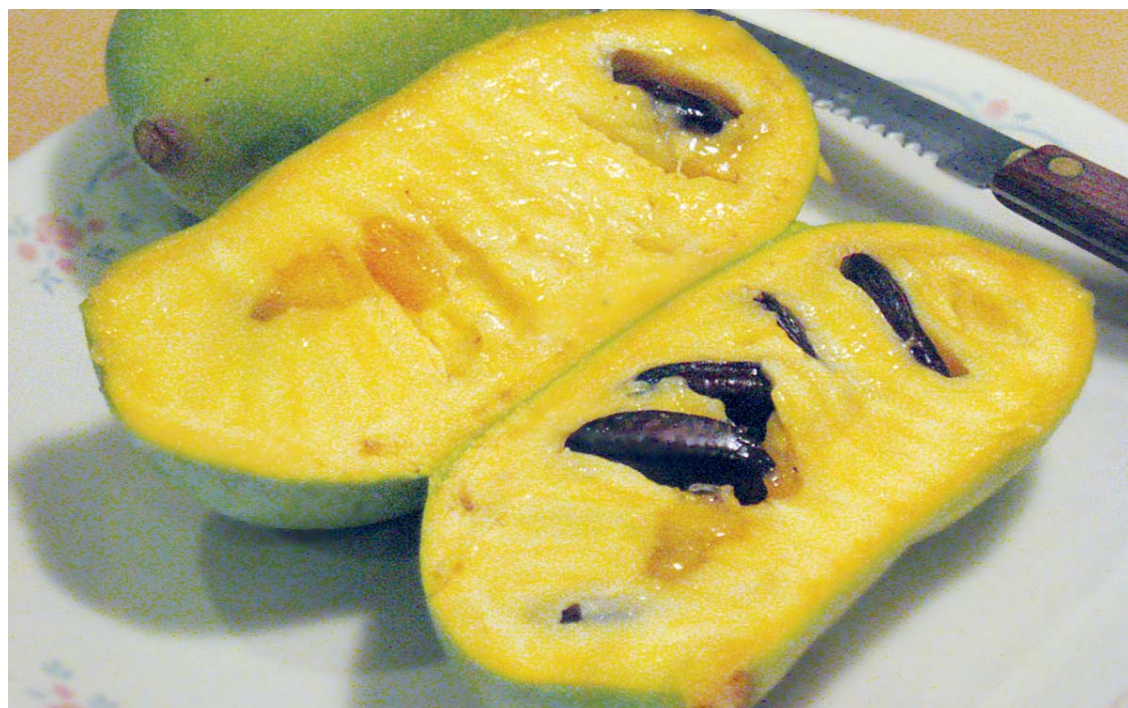
Pawpaw – A "Tropical" Fruit for Temperate Climates

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This publication is intended as an overview of pawpaw production, including overall culture, pests, harvest, postharvest handling, marketing, and research that seeks to advance the pawpaw's potential for commercial development.

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'Fayetteville' pawpaw. Photo: Robyn Metzger, NCAT

Introduction

The pawpaw (*Asimina triloba*) has great potential for commercial development. It has always been a delicious and nutritious native American fruit, but history, cultural prejudices, and difficulty in storing and shipping have relegated it to the obscure backwoods of American cuisine. However, several factors seem to be coming together to bring the pawpaw to the attention of the American public—at least, to the “foodie” segment of the public. These include recent improvements in available cultivars (with even better flavor and fewer seeds), production research at Kentucky State University, breeding

programs both private and public, international interest, a renewed interest in America's food system and diet, and a nascent effort by growers and aficionados to publicize the virtues of the pawpaw.

Though the pawpaw's only near relatives are tropical, and pawpaws look like mangos and taste like bananas, they are not tropical but are native to most of the eastern United States and even parts of Canada. The pawpaw grows best in areas with hot summers and cold winters (USDA Plant Hardiness Zones 5 to 8). It is hardy and relatively pest-free, and its tolerance to shade makes it suitable for intercropping with certain other trees. In addition, the pawpaw has genetic variability that can be used to improve the plant.

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A major research effort centered at Kentucky State University and involving a few other universities (including Cornell, Clemson, Purdue, Ohio State, Iowa State, and Oregon State) should contribute significantly to the commercial development of this crop (Pomper et al., 1999). These universities have established identical plots of pawpaws, which they hope will identify the best cultivars and best management techniques. They are breeding for the following desirable traits: yellow to orange flesh; fruit size 10 ounces or larger; seeds small and few; fruit of uniform shape and free of external blemishes; and mild, sweet flesh with no unpleasant aftertaste.

The KSU program has delivered results. In 2016, KSU-Benson™ joined Kentucky State's 2010 release, KSU-Atwood™, from their pawpaw breeding program. With a flavor combining those of banana, pineapple, and mango, KSU-Atwood shows promise as a commercially available cultivar (Pomper et al., 2011).

Culture

The pawpaw is native to most of the humid eastern United States. It is hardy to USDA Zone 5. Pawpaws thrive in moist, fertile, well-drained soils having a pH of 5.5 to 7.0. Although the pawpaw tolerates shade, it produces best in full sunlight, as long as it receives enough water and is protected from high winds. It is true that pawpaw trees grow readily in the forest, but fruiting is compromised in full, dense shade. Permaculture enthusiasts promote the idea of pawpaws under trees like black locust (*Robinia pseudo-acacia*), which cast sparse, dappled shade, but there is not yet research to evaluate this practice. Growers with commercial ambitions should probably choose to provide some shade during the first one or two growing seasons and later remove the shade apparatus when the tree seems well established (see photo on page 2).

Neal Peterson and the Peterson Pawpaws

There is probably no one person more responsible for the current renaissance in interest in pawpaws than Neal Peterson. He's been called "Johnny Pawpawseed," "Papa Pawpaw," and "The Mahatma Pawpaw," and according to Andrew Moore, author of *Pawpaw: In Search of America's Forgotten Fruit* (2015), "Neal knows more about [pawpaws] than just about anybody else who has ever lived."

Motivated by love of the native fruit and armed with a scientist's sensibilities and tools (he has master's degrees in plant genetics and agricultural economics), Peterson embarked on what was then the most comprehensive exploration and research into the pawpaw. And he did it almost entirely on a shoestring budget on his own. Only now, with Kentucky State University's pawpaw program, has anyone added significantly to Peterson's discoveries and work.

In 2003, after 20 years of exploration, breeding, and research, Peterson released six of the finest pawpaws the world has yet seen: Allegheny, Susquehanna, Shenandoah, Wabash, Potomac, and Rappahannock.

Peterson is still very actively involved in pawpaw research, and when I met him at the Fourth International Pawpaw Conference in Frankfort, Kentucky, in 2016, he was encouraging and advising high-tech nurseries, mostly from Europe, regarding tissue culture of pawpaws. This would allow for thousands, perhaps millions, of pawpaw trees to be made and spread around the world. You can read more about Peterson in *Pawpaw: In Search of America's Forgotten Fruit*.



KSU-Benson™, the newest release from Kentucky State University, was bred and chosen for a high flesh-to-seed ratio (as well as for flavor and high yield). Note its essentially round shape: in general, the rounder a pawpaw fruit is, the higher will be the flesh-to-seed ratio. Photo: Kirk Pomper, Kentucky State University



Young pawpaw under temporary shade provided by tomato cage and window screen. Photo: Guy K. Ames, NCAT

Pawpaw trees will grow from 12 to 25 feet tall and should be spaced from eight to 15 feet apart.

Although pawpaws flower in the spring, they bloom after apples, peaches, and pears, so are less likely than those fruits to lose a crop to late frosts. Nevertheless, it is possible to lose a crop to frost, so commercial plantings should probably avoid low-lying areas that can become “frost pockets.”

According to Dr. Kirk Pomper of Kentucky State University, weed control around trees, with straw or woodchip mulch, is important to increase tree survival rates. Pomper notes that voles that might be attracted to these mulches do not damage pawpaw trees as they would apple trees.

Planting: Seedlings vs. Grafted Trees

There are a number of cultivars that produce superior fruit. An unbiased description of most of these cultivars is available at Kentucky State University’s pawpaw website: www.pawpaw.kysu.edu/reports.htm. Grafted trees of these named cultivars can be relatively expensive—up to \$35 for a single potted tree; wholesale quantities would

presumably cost less per tree—so prospective growers might be tempted to plant ungrafted seedlings. Although seedlings are much cheaper than grafted trees, there is enough genetic variability in the pawpaw that commercial-scale growers will be taking a significant gamble if they plant ungrafted seedlings, and they will not know the outcome of their bet for around five to seven years because it can take that long for seedlings to begin bearing (grafted trees usually start bearing in three to four years).

If you live in an area where pawpaws grow wild, you might be tempted to transplant from the wild, but wild pawpaws have long taproots, which are very easily damaged. Often, pawpaw trees in wild patches are rootsuckers from a single original tree. With poorly developed root systems per individual shoot, these rootsuckers do not transplant well. Even nursery-grown pawpaws can be difficult to transplant. They have fleshy, brittle roots with very few fine root hairs, which inevitably get damaged when transplanting. Experimentation has shown that, to be successful, transplantation should be done in the spring, at the time when new growth commences or soon after. If many roots are lost, it may be desirable to prune the top to bring it into balance with the remaining roots.

Andrew Moore and his book, *Pawpaw: In Search of America’s Forgotten Fruit*

“Why would a fruit as delicious and nutritious as the pawpaw be all but forgotten in its native land?” asks Andrew Moore in his 2015 (Chelsea Green) book *Pawpaw: In Search of America’s Forgotten Fruit*. Moore in his answer to this question provides a rich but obscure history of this unusual fruit, a history that includes Native Americans, Lewis and Clark, white settlers, slaves, and earlier attempts to bring this fruit out of the shadows (dappled shade?) and into the culinary limelight it deserves.

Moore captures the reader with a core narrative about searching for the winners of the 1916 American Genetics Association’s contest to find the best pawpaws in America. Along the way there are side trips into the botany, the folklore, the uses, the festivals, the farmers, the pharmacology, and the rich, rich history of this most unusual of temperate-zone fruits. What could have been a “dry read” is anything but, as Moore manages to evoke suspense and mystery in this tasteful exploration.

Belying the subtitle, this book, which has received rave reviews in cooking and horticultural circles, may play a part in forever freeing the pawpaw from obscurity. “Stories deftly told, research deeply done, this book is an engaging ride through the haunts of a fruit many Easterners quietly—secretly, even—gorge themselves on each autumn. A ripe pawpaw is as illicit as Persephone’s pomegranate, and Moore captures that passion well.” So says Hank Shaw, James Beard Award winner, and so it is.



Many nurseries use extra deep pots to accommodate pawpaw's taproot. Photo: Guy K. Ames, NCAT



A chip-budded pawpaw will have a "dog leg" where the bud was inserted. In two to three years, this feature will disappear and it will be difficult to tell where the bud or graft union was. Photo: Guy K. Ames, NCAT

Propagation

Separate the seeds from the fruit and store the seeds in a plastic bag with moist (not wet) peat moss or some similar medium. Never allow the seed to dry out or freeze, as either will kill the seed. The bagged seed should be held under refrigeration for three to four months to satisfy the seed's need for a cold period. Sow seed the following spring into pots or field about an inch deep. Most pawpaw nurserymen employ deep pots to allow for important tap root development (see photo above).

Compared to apples and pears, "trueness to seed parent" is high for pawpaw; that is, seedling plants are somewhat likely to resemble their female parent. In other words, seed from high-quality fruit has a moderate chance (around 50%) of producing plants that also produce high-quality (but not necessarily identical) fruit. Nevertheless, only vegetative propagation will produce trees that can be relied upon to produce the highest-quality fruit.

Vegetative propagation for pawpaws is a matter of budding or grafting. Micropropagation by tissue culture to produce hundreds or thousands of clones at a time remains a desired, but stubbornly elusive, goal for pawpaw researchers, though progress is being made (Stanica, 2016). Budding

(chip only; "T" budding has proven ineffective) or grafting should be done using dormant scionwood and actively growing seedling rootstock. Dormant scionwood should be collected in mid- to late winter and held in plastic bags under refrigeration until the seedling rootstocks are showing growth and the ambient temperatures are consistently warm. Kentucky State University recommends early June for budding and grafting, the important variable here probably being temperature: it should be consistently warm to allow for adequate callus growth and subsequent knitting together of tissues from the rootstock and the scion/bud.

Pollination

The slightly foul-smelling pawpaw flowers are fly- and beetle-pollinated, and that may be one of the reasons that fruit set is so inconsistent in the wild. An old recommendation to hang road kill in your trees to attract fly pollinators (Black, 2009) might actually be helpful if you have only a few trees, but Sheri Crabtree at Kentucky State University says that hand pollination is probably more effective...and less objectionable. She also offered that at Kentucky State's relatively large research

Chris Chmiel, Integration Acres, and the Ohio Pawpaw Festival

"Welcome to the Pawpaw Capital of the World," reads the sign at the entrance to the Ohio Pawpaw Festival, an annual, three-day event near Athens, Ohio, which in 2015 admitted about 10,000 visitors. With pawpaw beer, a pawpaw eating contest, pawpaw desserts, "best pawpaw" contest, and pawpaw experts (along with the usual festival accoutrement like live music, vendors, and art), the Festival is the premier event in the world of pawpaws. It is also an important part of Chris Chmiel's business.

Chmiel, founder of the Festival, told me over breakfast in Frankfort, where we were both attending the Fourth International Pawpaw Conference, that he "kinda backed into" the pawpaw business. Before he got into pawpaws, he was grazing goats on his hilly 50 acres and making gourmet goat cheeses (which he still does). He noticed soon enough that there was one plant that the otherwise voracious goats would not eat: pawpaws. Soon enough, Chmiel realized that not only could he graze the goats among the pawpaw trees without fear of the trees being destroyed, but all the while the goats are providing weed control and fertility for the pawpaws. It's permaculture and agroforestry at its best, hence his farm's name: Integration Acres.

Chmiel is possibly the most profitable pawpaw grower in the country. He's certainly the leader in processing and selling frozen pawpaw pulp. To learn more about Chmiel and his integrated businesses, go to his website, www.integrationacres.com/.

orchards, pollination has not been a major issue, probably because the presence of so many trees is simply that much more attractive to pollinators (2016). More detail about hand pollination of pawpaw is available at a Virginia Cooperative Extension Web page (Bratsch, 2009).

Pests and Diseases

Pawpaws have very few pest problems. There are a few lepidopteran pests (caterpillars), the principal one being the pawpaw peduncle borer. The peduncle borer (*Talponia plummeriana*) burrows into the pawpaw flower and causes it to drop. Usually, however, so little damage is done that this is not considered a serious problem.

The asimina webworm, *Omphalocera munroei*, is a moth of the Pyralidae family. Larvae web, roll, and fold leaves as they feed. Feeding also can extend to twigs and stems, and occasionally a stem can be girdled from feeding. It can be found throughout the range of the pawpaw but seems to be a nuisance only sporadically, according to Sheri Crabtree of Kentucky State. Some growers in Arkansas, Kentucky, and Maryland have reported problems with the asimina webworm (Crabtree, 2016). The author has a consistent year-to-year problem with the webworm in his Arkansas planting, requiring manual removal of the webs and larvae and/or sprays of *Bacillus thuringiensis* or spinosad-containing pesticides.

Other reported pests include earwigs, slugs, San Jose scale, and tent caterpillars. To discourage earwigs and slugs, Ray Jones, a California pawpaw grower, ties a three-inch band of aluminum foil around each trunk and paints the middle two inches of the foil with Tanglefoot® (Pyle, 1992). San Jose scale can be controlled with dormant oils. Tent caterpillars can be physically removed from the tree by cutting out the "tent" or the branches holding the tent.

Phyllosticta and flyspeck or greasy blotch (*Zygothiala jamaicensis*) can be problems of pawpaw. This occurs only during periods of high humidity and frequent rainfall. Dense foliage and lack of proper ventilation contribute to this condition, so proper spacing and pruning can reduce it. *Phyllosticta* can infect the leaves and the surface of the fruit; it can also cause the fruit to crack when it expands, reducing quality and storability.



Asimina webworm larvae feeding on pawpaw leaves. Photo: Guy K. Ames, NCAT



Photo: Guy K. Ames, NCAT

There appears to be some variation in susceptibility among varieties, but nothing comprehensive has yet been published in this regard.

Harvest and Postharvest Handling

Pawpaws ripen very quickly and bruise easily, which limits shipping time. Though the fruit of some cultivars will exhibit a slight color shift from green to yellow, Dr. Pomper's research shows that skin color is a poor indicator of ripeness. Pomper claims that the best indicators are a slight softness when gently squeezed and the ease with which the fruit releases from its stem when gently pulled. Since one of the very best indicators of ripeness is that the fruit has fallen from the tree, and because the fruit is easily bruised, some growers have taken to piling a few feet of straw or hay under the trees to cushion the fall of those perfectly ripe fruit (Moore, 2015). Chris Chmiel of Integration Acres has planted ground ivy under his trees for the same reason (Moore, 2015).

Similarly, because of its tenderness and susceptibility to bruising, pickers will want to pick into something that will cushion and protect the fruit. Pawpaws in harvest totes or boxes should not be stacked more than two deep.

Fruits picked just before they are fully ripe, but

after they have begun to soften, will ripen indoors at room temperature or slowly in a refrigerator. Already-ripe fruit will last only two to four days at room temperature, but refrigerated fruit will last up to three weeks. Research is being conducted to determine the effectiveness of using modified-atmosphere shipping and ethylene-control sachets to extend shelf life (Galli, 2007).

Pawpaws are not suited for certain value-added products like jams and jellies. Heating pawpaws changes their flavor, so pawpaws would be best used in foods such as ice cream. Recipes using pawpaws are available from several sources, including the Kentucky State University website www.pawpaw.kysu.edu/Recipes.htm.

Iowa State scientists are researching mechanical pulp extraction and freezing techniques. Because cooking destroys important flavor components, and shelf-life of fresh pawpaws is so limited, such research could be crucial to the commercialization of the pawpaw (O'Malley, 2010).

Dennis Fulbright of Michigan State University has adapted an Italian machine for processing chestnuts to separate pawpaw seed from pulp (Moore, 2015). However, the fruit still has to be skinned by hand.

Marketing

Given the fragility and short shelf-life of the fruit, the uncertain status of processing pawpaw pulp, as well as the simple novelty of the fruit itself, the enterprising pawpaw marketer should have a good sales plan before hitting stores, restaurants, or farmers markets. Careful handling, of course, is a must because the fruit is so easily bruised. There are a few commercial-scale growers in Kentucky and Ohio leading the way, including Chris Chmiel, who successfully processes and sells thousands of pounds of frozen pulp every year (2016).

In general, the pawpaw direct-marketer would be well-advised to have some printed material (posters or hand-outs) to acquaint the consumer with the fruit and its uses. If you have a cultivar that tastes like banana or mango or custard, tout that in a very visible way because most consumers won't have any idea what a good pawpaw tastes like. Because it is so nutritious, nutrition information might be a good sales tool and can make good poster or blackboard text, as long as you don't overwhelm the reader with too much (shoppers are at stores or farmers markets to shop, not read; emphasize the high points: one of the highest

protein contents of any fruit; high in potassium, vitamin C, riboflavin). Consult www.pawpaw.kysu.edu/pawpaw/cooking.htm#Nutritional%20Information for more detailed nutrition information. Lastly, recipes for the buyer to take home can be another inducement for the consumer to make that first purchase of a new food. Go to www.pawpaw.kysu.edu/Recipes.htm for recipes.

The North American Pawpaw Growers Association (www.NAPGA.com/AboutUs.html) (spun off from the Ohio Pawpaw Growers Association) has many members around the country. This organization can also help individuals in pawpaw marketing efforts.

Plant Extracts as Anti-carcinogens and Insecticides

Dr. Jerry McLaughlin of Purdue University, now retired, found that pawpaw is a source of

phytochemicals called acetogenins with powerful anti-carcinogenic properties (Moore, 2015). An herbal extract made from pawpaw is on the market. For more information on pawpaw as an anti-carcinogen go to www.pawpawresearch.com/.

Dr. McLaughlin also isolated a botanical insecticide, asimicin, from pawpaw twigs and bark (Anon., 1999); however, without financial backing to shepherd it through the regulatory process, it is unlikely to be on the market anytime soon (Bratsch, 2009).

Summary

Pawpaws may be a viable enterprise for small-scale farmers who can develop a local clientele. However, the amount of time that must be invested before the first fruit crop (four years or longer) is a deterrent to many would-be producers. The ongoing university research should answer many questions regarding cultivars, culture, and processing/marketing.

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Further Resources

Online Resources

Kentucky State University's Pawpaw Project
147 Atwood Research Facility
Kentucky State University
Frankfort, KY 40601-2355
www.pawpaw.kysu.edu

Provides information on pawpaw research, guide to growing pawpaws, cultivars, suppliers, PawPaw Foundation, and links to other pawpaw websites.

Purdue University's facts sheet on pawpaws
www.hort.purdue.edu/newcrop/cropfactsheets/pawpaw.html
Includes production information and suppliers.

Virginia Cooperative Extension
http://pubs.ext.vt.edu/438/438-105/438-105.html

Ohio Pawpaw Growers' Association
www.ohiopawpaw.com/AboutUs.html

North American Pawpaw Growers' Association
http://napga.com

The North American Pawpaw Growers' Association is a spin-off from the Ohio Pawpaw Growers' Association and is meant to accommodate the increasing national and international interest in pawpaws. It also maintains a Facebook page.

Plant Sources

Note: These listings are provided for information only. NCAT does not endorse any particular supplier.

Blossom Nursery
Mark and Kathleen Blossom
216 CR 326
Eureka Springs, AR 72632
479-253-7895
BlossomNursery@gmail.com
www.blossomnursery.com

Seedlings, seed. Container and bareroot (quart or gallon, 8-inch to 18-inch).

England's Orchard and Nursery
2338 Highway 2004
McKee, KY 40447-9616
nuttrees@prtcnet.org
606-965-2228

Cultivars: Davis, Overleese, Rebecca's Gold, Halvin's Side-winder, Summer Delight, and others, including seedlings.

Forrest Keeling Nursery
88 Forrest Keeling Lane
Elsberry, MO 63343
www.fknursery.com
573-898-5571

Cultivars: Peterson pawpaws, Mango, NC-1, Overleese, PA-Golden, Sunflower, and more.

Hidden Springs Nursery
170 Hidden Springs Lane
Cookeville, TN 38501
931-2688-2592
hiddenspringsnursery.com

Cultivars: KSU Atwood, Mango, NC-1, Mitchell, Overleese, Wells, and more.

Nolin River Nut Tree Nursery
John & Lisa Brittain
797 Port Wooden Road
Upton, KY 42784
270-369-8551
john.brittain@windstream.net
www.nolinnursery.com

Cultivars: KSU-AtwoodTM, Allegheny, Potomac, Rappahannock, Shenandoah, Susquehanna, Wabash, Davis, Greenriver Belle, IXL, Mitchell, NC-1, Overleese, PA Golden, Prolific, SAA-Zimmerman, Sue, Sunflower, Taylor, Wells. Bareroot (1-foot to 6-foot)

One Green World
P.O. Box 881
Mulino, OR 97042
www.onegreenworld.com
Phone: 877-353-4028

Cultivars: KSU-AtwoodTM, Davis, Mango, Mitchell, NC-1, Overleese, PA Golden, Prolific, Sunflower, Sweet Alice, Taylor, Taytwo, Wells, Wilson, seedlings.

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