UF IFAS Extension UNIVERSITY of FLORIDA

HS982
https://doi.org/10.32473/edis-hs229-2004

The Pecan Tree[1]

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Historical Information

The name “pecan” comes from the Algonquin natives. In their language pecan means “all nuts requiring a stone to crack.” Currently there are hundreds of varieties that are known by Native American given names from tribes such as Cheyenne, Choctaw, and Kiowa. Native Americans used the pecan as a food source for thousands of years before the arrival of Spanish and European explorers. Native Americans and fur traders disseminated the nuts from the Mississippi Valley eastward. Pecans soon became an important trade item. The first recorded shipment to England was documented in 1761, but the history of pecans can be traced back even further to the 16th century. This article provides a general overview on the pecan history, propagation, cultivars and production practices to county and state Extension faculty, tree nut growers, homeowners and students who are interested in growing pecan in Florida, particularly northern Florida.

Pecans have been cultivated for a relatively short period of time. Plant growth and development resemble a forest tree species rather than a domesticated crop. Pecan nuts were derived from seedling pecan trees until about 150 years ago. The cultivar 'Centennial' was grafted in Louisiana in 1846 (Sparks 1992). Grafted cultivars represented a significant proportion of pecans grown in the United States by the early 1900s. Over the last century, individual pecan trees with exceptional characteristics were selected, named, and propagated. During the last several decades, pecan breeding programs were also established to produce new cultivars. Today, there are more than 500 pecan cultivars, each with unique traits. Currently the United States produces about 80% to 90% of the world’s pecans and an annual crop of almost 300 million pounds. The annual value of pecans in the United States is reported to be from 400 to 800 million dollars.

Distribution

The pecan, *Carya illinoensis* (Wagenh.) K. Koch, is a deciduous tree native to North America. It belongs to the same family (Juglandaceae) as English walnut, black walnut, and hickory. The pecan tree is native to the Mississippi floodplain, which has deep, fertile, well-drained soils. Noncultivated pecan trees sometimes exist nearly as a pure stand.

Pecans also exist in the river bottomlands of Texas and northern Mexico. The climate of the native range of pecan is characterized by long, hot summers and moderately cool winters. Currently, the southeastern United States produces most of the pecan crop. Georgia produces about 50% of the total production within the United States. Florida produces from 5 to 10 million pounds of pecans annually. The value of the US pecan industry has increased greatly because of increased demand from China and other emerging nations.

There is also substantial production in the midwestern and southwestern United States. The acreage in the southwestern United States has been increasing at a rapid rate. Regions having an arid/semiarid growing season and well supplied with irrigation are optimum for commercial pecan production because of a reduction in the incidence of leaf fungal diseases, primarily pecan scab. Other regions of production include Australia, Brazil, Israel, Mexico, and South Africa.

In Florida, pecan trees can be found in all regions between Pensacola and Miami, although many of the pecans grown in the state are not well managed. Most of the total acreage (8,500 acres) is located in north Florida. Tree growth may be satisfactory in the southern half of the state; however, nut production is usually low because the winters are not cold enough and the higher rainfall increases disease pressure. Most of the production statewide is not well managed in respect to irrigation, soil fertility, weed, insect, and disease

control. Thus, the quantity and quality of the pecan crop is reduced.

Botany

Pecan trees are very large and capable of reaching 70 or more feet in height and 6 feet in trunk diameter. Pecan leaves are alternate and odd pinnate. Pecan leaves consist of between 9 and 15 leaflets. Flowers are unisexual (i.e., male and female flowers are separate). The male (staminate) flowers are called catkins and are arranged in groups of 2 to 8 by a common peduncle (Figure 1). The female (pistillate) flower is a star-shaped terminal raceme (Figure 2). Staminate or male flowers appear to arise from the previous season's wood but are actually produced on short current season's growth. Pistillate flowers are also produced on current year's growth. Pistillate flowers arise from the most apical buds on each shoot (one or two), while staminate flowers arise from most primary and secondary buds, except the terminal buds. Primary, secondary, and tertiary buds in each node have the potential to produce staminate and pistillate flowers along the length of 1-year-old shoots. Nuts typically occur in clusters of 2 to 6 nuts (Figure 3). For a given cultivar, staminate pollen shedding and stigma receptivity is usually largely asynchronous. Cross-pollination of pecans is usually required for maximum productivity. The fruit is a stone or nut enclosed in a thick, green husk that splits into 4 parts at maturity. The husk supplies photosynthate and protects the developing nut (Figure 4). The inside of the nut (kernel) is usually liquid until September, when it solidifies.

Figure 1. Staminate (male) flowers ready to release pollen. Male flowers are also known as catkins.
Credit:

Figure 2. Pistillate (female) flowers that have just been pollinated.
Credit:

Figure 3. Pecan fruit prior to dehiscence (or shuck split).
Credit:

Figure 4. A pecan that is nearly mature with the shuck peeled away.
Credit:

The period of juvenility (the duration of time in the life cycle of a plant that is limited to vegetative growth) can be especially long (10 to 12 years). Precocity can vary

from 4 to 12 years depending on pecan cultivar and cultural practices. Juvenility in the native stand is likely an adaptive feature to allow trees to establish themselves in a competitive position in the canopy. From a pecan production perspective, an excessive period of juvenility increases the time to achieve a positive economic return. The desirability for a rapid return on investments after orchard establishment has prompted pecan breeders to use precocity as an important selection criterion in their program. Unfortunately, a high degree of precocity has been correlated with poor nut fill (low percentage kernel), particularly with older trees (Sparks 1992).

Site Selection and Soil Preparation

A large amount of land should be allocated for pecan production. It is best to plant pecans in a field that has been cleared of forest trees for at least 10 to 20 years to minimize the effect of root pathogens associated with decaying tree roots. Hilltops are the best locations for growing pecans. Soil porosity is normally good and the increased air movement facilitates the drying of morning dew, which tends to reduce the incidence of leaf diseases. Bottomland sites are acceptable provided that there is good air and water drainage. North-south or east-west row orientation is satisfactory.

An ideal soil is one that is in pasture or one that has been used for agronomic crops for a number of years. A soil pH between 5.5 and 6.5 is satisfactory. If soil pH is less than 5.0, lime can applied at 1 to 2 tons per acre. Pecans grow well in a wide range of soil types, including the red clays of extreme north Florida and the sandy soils of south-central Florida. Best growth occurs in a sandy loam or a loamy sand with a clay subsoil. The soil should be at least 5 feet deep for optimum root penetration because the roots of mature pecan trees in a deep, well-drained soil may be more than 10 feet deep. Most of the feeder roots will be located in the upper 12 inches of soil. Adequate but not excessive soil moisture is important for pecan trees. Thus, shallow soils or sandy soils may require more frequent irrigation because they hold less water.

Soil pH can often fall below 5.5 with continued nitrogen fertilization. On average, 1 pound of dolomite can be applied per 100 square feet (or 2 tons/acre) to raise the soil pH 1 unit. Elemental sulfur can be applied at 1 to 2 pounds per 100 square feet to reduce soil pH by 1 pH unit. Dolomite or elemental sulfur should be applied in the fall and can be thoroughly incorporated by very shallow disking to increase soil penetration.

A weed-free in-row strip is often maintained to facilitate tree growth, fertilization efficiency and harvesting operations. For very young orchards a 6-foot in-row strip is sufficient, whereas with older bearing orchards a 10- to 12-foot in-row strip is preferable. For bearing orchards it is advisable to maintain grass or other cover crops between the rows. Keep grass closely mowed during late summer and fall to facilitate harvesting operations. This will facilitate harvesting the nuts on the ground. For a small number of trees, nuts can be picked up manually. For larger orchards, vacuuming the fallen nuts with specialized equipment is preferable.

Mechanical (disking) and/or chemical (herbicide) applications can be used to remove weeds from the orchard. Disking is sometimes practiced on land with orchards that are not sloped. If grass is to be maintained in the orchard, an application of glyphosate (RoundUp® or generic equivalent) at 6 oz per acre will stunt the grasses sufficiently so that frequent mowing is not required.

In pecan orchards containing trees that are just a few years old or those planted at a low density, there is an opportunity to intercrop with small grains (rye or oats) or some other crop, because only a small fraction of the sunlight is intercepted by the tree. Young pecan trees are sometimes intercropped with corn, beans, and other vegetables. In the southeastern United States, peach trees have sometimes been intercropped in pecan orchards. Alternatively, or in combination with a small grain, legumes such as crimson clover or vetch can be planted during the early winter to increase the nitrogen status in the soil and for cattle grazing. Prevent cattle damage to very young trees. Most of the damage will be in the form of tree rubbing (bark damage) and limb damage. Growers are advised not to graze cattle in bearing orchards due to possible contamination of nuts on the ground.

Tree Spacing

Tree size control is one of the greatest impediments to pecan production. Yield per tree and per acre is reduced when trees are overcrowded. Thirty- to forty-year-old trees need to be spaced 60 to 80 feet apart. However, newly planted trees at this spacing create a very inefficient use of land and equipment. Pecan trees need

to cross-pollinate, so they must be close enough to share pollen but far enough apart to not hinder each other's growth. There are no dwarfing rootstocks for pecan, and satisfactory cultivars that have a dwarfing growth habit are not available. 'Cheyenne' is a cultivar known for a compact growth habit but is no longer recommended in the southeastern United States. Planting trees at close spacing and retaining them at these spacings beyond about 15 years is not feasible (Figure 5) because pecan nuts are only produced where the sunlight is intercepted by the tree foliage, which in this case is at the top of the canopy. Some growers plant pecans from 50 to 70 feet apart and use the land between small trees to intercrop an agronomic crop as indicated above.

Figure 5. A mature pecan orchard that has become overcrowded.
Credit:

Another choice for spacing is to initially plant trees at a relatively close spacing and to thin trees as they become crowded. Initial spacing may vary from 30 to 40 feet with the most common being 40 feet. After trees become crowded, they can be thinned on a diagonal with the new spacing changed from 40 to 56 feet between trees. This is difficult for some growers because it entails removing alternate trees in each row and in each adjacent row. It may also entail renovating some portion of the established irrigation system. One may delay alternate tree removal by a few years if alternate trees are pruned; however, one must realize that these alternately pruned trees will sustain a reduction in yield commensurate with the amount of pruning.

Tree Planting

Trees should be planted during the dormant season (from late November to February) to allow root growth before the spring. Transplant bare-root trees as soon as possible after they are dug in the nursery. Bare-root trees from the nursery are recommended. The root system should be at least 2½ feet in length. Tree height should be at least 6 feet. Many pecan trees die as a result of drying out in the hours or days before they are planted. Heel in trees from the nursery with moist soil if they are not to be transplanted within a couple of days after delivery. It is best to plant trees on cloudy days or during days with high humidity. Bare-root trees that feel dry should be soaked in buckets of water long before planting.

Pecan trees require a large hole for proper transplanting. Holes 2 feet in diameter and 2 ½ feet deep are satisfactory. The best way to dig holes of this size is by using a PTO-driven auger. Plant trees at the depth to which they were planted in the nursery. The taproot should extend vertically down to the center of the hole. If container-grown trees are purchased from the nursery, it is likely that the taproot will circle the inside bottom of the container. Use your own judgment when deciding whether to cut or to retain and straighten the taproot at planting. Remove broken roots and all potentially decaying organic matter from the planting hole. Tamp the soil around the tree thoroughly. Add 10 gallons of water to the planting hole. Creating a shallow basin around the tree aids in the retention of water. Water at least once every week unless rainfall is sufficient until the irrigation system is established. Remove ⅓ to ½ of the plant top after planting (however, do not cut the tree shorter than 4 to 5 feet tall) to maintain a proper shoot-to-root ratio. A tall tree facilitates herbicide application. Whitewash (diluted white latex paint) can prevent sun scalding and bark splitting of young trees.

If trees are planted in a region with grazing livestock or in areas with heavy deer pressure, it will be necessary to protect trees with fences. The biggest problem arises from animals rubbing against and damaging the trees. The fences should be 6 to 9 feet high and sturdy enough to prevent the animals from getting through the fence.

Propagation in the Nursery

Nurseries select pecan seed for rootstock based on the price, the percentage of kernel, and the uniformity of the kernel. Common pecan cultivars for rootstocks are 'Elliott', 'Curtis', and 'Moore'. In addition, seedlings are used for propagation purposes. There is no dwarfing rootstock for pecans, which eventually makes tree

overcrowding a problem in orchards planted at a moderate or high density.

A common practice to enhance germination percentage is to stratify seeds by mixing them with moist peat moss, sawdust, or sand, and then storing them at about 35°F for 8 to 20 weeks. Nurseries usually begin stratifying seeds at the beginning of January. Nuts are ready for planting when they begin to germinate, as evidenced by nut splitting. Nurseries plant seedlings 6 inches apart in rows that are about 3 feet apart (Figure 6). This is much more preferable than planting nuts in containers because container-grown pecans do not form a taproot that is as well developed as bare-root trees.

Figure 6. Propagation of pecan seedlings in the nursery.
Credit:

Ring Budding or Patch Budding Nursery Trees

Annular ring budding and patch budding are the two methods of budding pecan trees. Seedling pecans are usually budded in the nursery after 1 or 2 years of growth when stem diameter approaches ½ inch. Trees are budded in June, July, or August when the buds are mature. If trees are budded in the spring, the sap should be flowing, and buds should be from stored wood or from one-year-old wood. The bark of buds and that of stocks generally unite (as evidenced by callusing) in 3 or 4 weeks, at which time the wrap may be removed. The wraps can be left on until winter when stocks are cut back to just above the scion. Remove seedling shoots that grow along with the scion. Scions may require staking for several months to give them support.Ring budding involves removal of a ring of bark from the stock and replacing it with a ring of bark containing a bud. The stick of budwood from which you take the replacement ring should be the same diameter as the stock so that the bark ring will fit closely (Figure 7).

Make sure to orient the ring with the bud facing upward. Cover all wounds, but not the buds, with grafting tape. The old stem is retained until the shoot emanating from the new bud can support itself.

Patch budding is a similar process. The main difference is that a square or rectangular patch of bark is removed from the stock, and an identical patch with a bud in the center is removed from the stick of budwood. This method allows you to use sticks of the budwood smaller than the stock. The patch is wrapped to cover all regions of the graft except the buds. Budding must be performed quickly so as not to allow the scion to dry out.

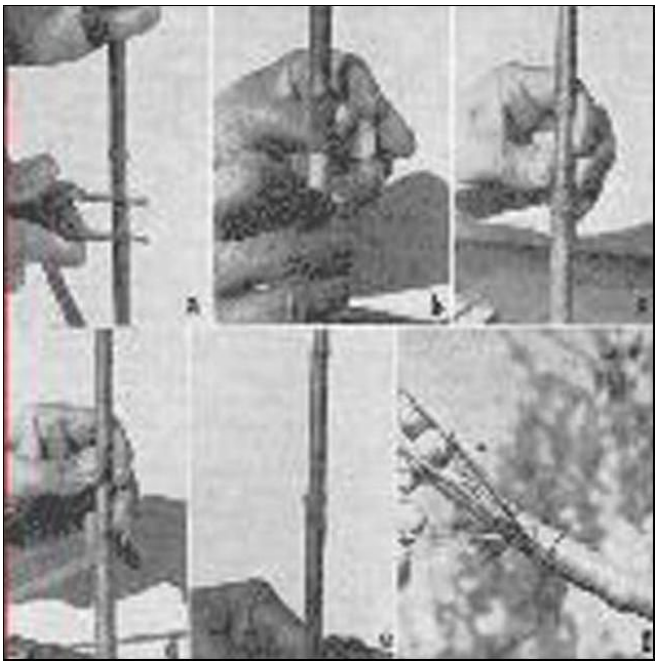

Figure 7. Patch budding pecans. (A) Make 2 parallel cuts extending halfway around the stock with a double-blade knife. Make a single vertical cut at one side connecting the parallel cuts. Make similar parallel cuts above and below the desired bud on the budstick. Then make 2 vertical cuts above and below the desired bud on the budstick. Then make 2 more vertical cuts so that the bark patch with the bud can be removed from the budstick. (B) Raise the flap of bark on the stock. (C) Fit the bud snugly against the one-cut side of the stock and tear off the flap of bark on the other side so that it slightly overlaps the bud patch. (D) Wrap the patch with a rubber budding strip or budding tape. (E) Wrapping completed. (F) Growth of patch bud.
Credit:

Grafting and Budding Small Trees

Some seedlings may be large enough to graft after the first year. Seedlings too small to bud during the second summer can be grafted during the following winter. The whip and tongue graft (Figure 8) is often used.

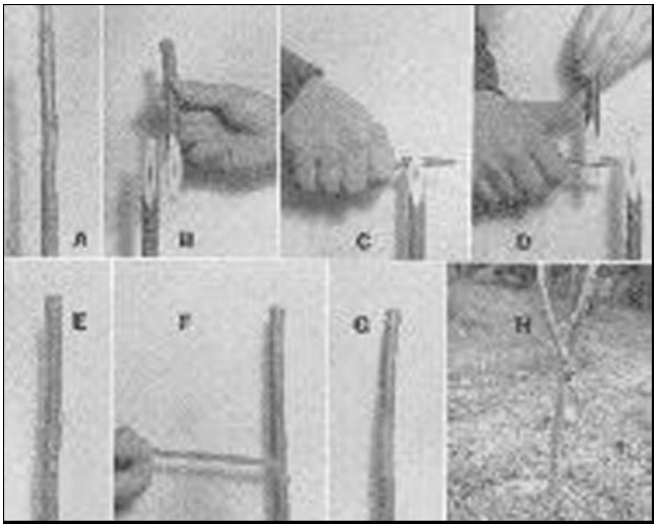

Figure 8. Whip grafting pecans. (A) Select a scion that closely corresponds to the size of the stock to be grafted. Cut the scion 4 to 6 inches in length. Scions should have 2 or 3 well-developed buds. (B) Make a diagonal cut 1 ½ to 2 inches in length at the base of the scion. Make a diagonal cut the same length on the stock. All cuts should be straight and smooth. (C) Make a cleft cut down the stock. The cut should be about ¾ inches in length and one-third of the distance down from the tip of the diagonal cut. (D) Make the same type of cleft cut in the scion. (E) Place scion on stock, interlocking the cleft cuts and matching the cambium layers of stock and scion on one side of the graft. (G) Wrapping secures the scion and stock together and prevents their drying out. (H) Whip grafted tree. Credit:

January and February are the best months for grafting. In the spring, there may be numerous shoots from the stock, and these will have to be removed, leaving only the scion. Most of the trees should be well developed by fall and ready for digging when dormant in the winter. New budding of mature trees involves cutting the tree back to several short branches during the dormant season. Retain branches 4 to 6 inches in diameter to ensure proper growth until new buds are established. Trees with a 6-inch or smaller diameter can be pruned to a single stub 4 or 5 feet above the ground. Using buds from mature trees may reduce the period of juvenility. Budding should take place during July or August when shoots become large enough in diameter.

It is advisable to make several buds per tree, and at least one or two per scaffold limb. Several different pecan cultivars can be budded on a single tree, if desired, to aid in pollination. The method of budding is described in the above section on Nursery Propagation (Figure 7). Most of the buds do not form scions until the following year. The shoot just above the bud should be removed before growth starts and the grafting wrap can be removed. The grafting wrap can be removed earlier if the tie binds the bud so tightly that it creates a constriction. The following year, remove competing shoots from the tree; however, a few shoots can be left for protection until the new scion can support itself. Part of the original branches that were left on the trees can be removed if the scions grow well. A small crop can be produced after as little as 2 to 4 years, and a considerable crop can be produced after 5 to 7 years.

Propagation of Mature Trees

Cleft Grafting

Cleft grafting is a technique whereby the top of the rootstock of the plant is cleaved and the scion base is inserted. This is done around the time that the plant is in a dormant state. The process is as follows. First, you will cleave the rootstock by six inches and then take the prospective scion's base that has been cut to six inches and insert it. After that you will apply wax or soil to seal the unions against drying, the unions being the points of the graft. Then finally you will continue to follow up with aftercare for the plant, making sure that all is well and that it grafts successfully.

Inlay Bark Graft

Inlay bark graft is a procedure that has been refined from the old standard bark graft. It is an improved grafted system developed by Texas A&M University. In this method you make parallel cuts throughout the stock bark. The cuts should be made into a scion inlay pattern. You will then take aluminum foil covered with polyethylene film and wrap the graft. This ensures that it keeps a high humidity around the graft. The ideal time for scion wood for inlay bark grafts should be cut in late February from 1- or 2-year-old shoots in 12-inch lengths. It then should be stored at 32°F to 40°F in moist sawdust or sphagnum moss (Figure 9). Place grafts in 2- to 4-inch-diameter limbs at the time of pollen shedding. Scions are usually cut 5 or 6 inches long with a sloping cut about 1 ¾ inches long at the basal end. Place the scion against the limb and make outline cuts through the bark of the stock. Remove the bark and fit the scion tightly into the groove. Use two small nails, ¾ inches long, to nail through the grafts to hold them firmly in place. Coat all the cut surfaces with grafting wax. Alternatively, the graft and the stock may be covered with highly reflective aluminum foil, which greatly reduces the temperature around the graft, with a slit to let the scions protrude. Pull a plastic bag down over the stock to cover the foil and tie it in place to maintain high humidity. Undesirable shoots may need to be removed

over a 2-year period. One scion should be cut back about halfway the following winter if both scions on a limb grow.

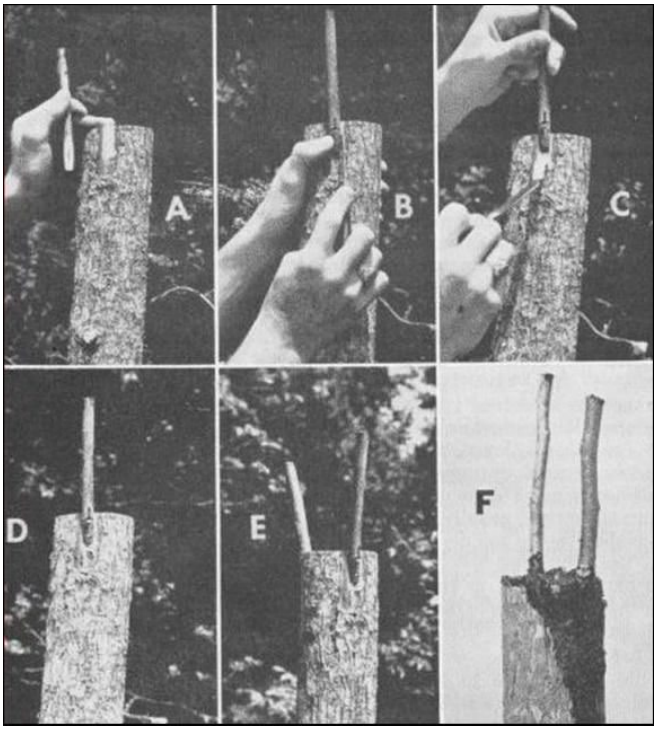

Figure 9. Inlay bark graft method. (A) Pare down the rough, scaly portion of the bark to provide a smooth surface for making the outline of the scion. (B) Lay the beveled side of the scion against the pared place on the stock. With the point of a knife, cut through the bark of the stock along each side and across the bottom of the scion. (C) Remove the patch of the bark from the stock and place the scion in the space. (D) Nail the scion in place. (E) In the same manner, place another scion on the opposite side of the stock. (F) Cover all cut surfaces with grafting wax or a tree-healing compound. Credit:

Cultivar Selection

Of all the pecan cultivars that have been named over the last 100+ years, very few are adapted to the southeastern United States. Ideally, a pecan cultivar should be precocious and consistently prolific, have high kernel quality, and be resistant to pecan scab and other leaf diseases. The major reason for the elimination of the great majority of cultivars from contention in the southeastern United States is their susceptibility to pecan scab. Pecan scab is a fungal disease that affects developing shoots, leaves, and nuts. Often, 4 to 15 fungicide applications yearly are required to control this disease. A listing of recommended cultivars, conditionally recommended cultivars, and those recommended for trial will follow. For more information on the performance of pecan cultivars in Florida, refer to EDIS publication HS106, *Pecan Cultivars for North Florida*. Excellent summaries of the best pecan cultivars in Georgia (Wells and Conner 2015) and Alabama (Goff 2015) are also available online. A summary of the characteristics of the most promising cultivars is presented in Table 1.

Active pecan research and Extension programs exist in Georgia and Alabama, and new information concerning cultivar performance has become available over the last 20 years. Some new and some rediscovered pecan cultivars have shown good yields, high nut quality, and scab resistance, but many of these have not been adequately tested in Florida. Many older cultivars that were once resistant to pecan scab, such as 'Cape Fear' and 'Stuart', now require an intensive spray program to consistently produce a good crop. The pecan scab organism has evolved over time to be especially pathogenic on many older pecan cultivars.

Each particular state has the cultivars recommended for their respective areas. Below is information explaining why they were chosen for these areas and also depictions of some of the most known cultivars in these groups.

Florida

'Elliott', 'Excel', 'Lakota', and 'Sumner' are recommended (Table 1). They all have very good to excellent resistance to pecan scab.

'Amling', 'Avalon', 'Eclipse', 'McMillan', and 'Zinner' have excellent scab resistance and are recommended on a trial basis because they have not been adequately tested in Florida.

'Caddo', 'Cape Fear', 'Desirable', 'Forkert', 'Kiowa', and 'Pawnee' are conditionally recommended because they produce high-quality nuts but require an intensive fungicide program. 'Stuart' is conditionally recommended because many older trees are productive, but newly planted trees can take 10 years to produce a crop.

Georgia

The recommended cultivars are 'Elliott', 'Excel', and 'Lakota' for their excellent scab resistance, 'Kanza', 'Sumner', and 'Zinner' (good scab resistance), and 'Caddo', 'Forkert', and 'Oconee' (average scab resistance).

'Amling', 'Avalon', 'Byrd', 'Excel', 'Lakota', 'McMillan',

and 'Zinner' are recommended for trial, and 'Cape Fear', 'Creek', 'Kiowa', and 'Stuart' are conditionally recommended only with an intensive fungicide spray program.

Figure 10. 'Kiowa' is known for producing very large and high-quality nuts. However, it is still subject to alternate bearing. This is a commonly recommended cultivar for the southeast area of the United States, with great resistance to pecan scab.
Credit: K. Leaks, UF/IFAS

Figure 11. Native to North Carolina, 'Cape Fear' is a strong early-bearing cultivar known for its well-filled nuts. The nuts are flavorful and resemble 'Stuart' in size and shape.
Credit: K. Leaks, UF/IFAS

Figure 12. The 'Stuart' variety is a great low-maintenance tree when compared to the other varieties. They are also late-season pollinators. Its drawback is that it takes 8–10 years to reach bearing age.
Credit: K. Leaks, UF/IFAS

Figure 13. Predominately planted in Georgia and Florida, 'Elliot' is a cultivar with great resistance to scab and teardrop-shaped nuts of great quality. However, the young trees are slow to production, and it is very susceptible to late spring freezes.
Credit: K. Leaks, UF/IFAS

Alabama

The recommended cultivars are 'Apalachee', 'Baby B', 'Caddo', 'Excel', 'Gafford', 'Giftpack', 'Headquarters', 'Lakota', 'McMillan', and 'Zinner', which all have good to excellent scab resistance.

'Adams 5', 'Amlin', 'Byrd', 'Creek', 'Desirable', 'Elliott', 'Forkert', 'Kanza', 'Mandan', 'Sumner', 'Surprize', and 'Syrup Mill' are conditionally recommended.

Figure 14. 'Sumner' is an excellent variety to grow from home or in an orchard. It has high-quality yield and a nice, visual appeal. The nut has an elongated shape with a very thin shell.
Credit: K. Leaks, UF/IFAS

Figure 15. Just like its name, 'Desirable' is one of the best pecan varieties. It is one of the largest and best-looking pecans out of all the cultivars. The shell is relatively soft and well filled.
Credit: K. Leaks, UF/IFAS

Figure 16. 'Forkert' is a variety that is not precocious but has an outstanding nut quality. It has a bumpy thin shell but smooth kernels, looks great, and shells out well.
Credit: K. Leaks, UF/IFAS

Pollination

Pecan trees are wind pollinated. Pecan trees have monoecious flowers, meaning they have separate male and female flowers (Figure 1). The staminate (male) flowers or catkins appear as fluffy, multilobed, fingerlike projections. Catkins appear to arise on last year's wood but are actually born on short current-season's growth. The pistillate (female) flowers resemble a small star and are born on current year's growth (Figure 2). Staminate and pistillate flowers on a given cultivar often do not mature at the same time. The degree of overlap between pollen shedding and pistillate receptivity varies with cultivar. Thus, to ensure the possibility of high yields, two or more cultivars should be planted together for cross-pollination. When a given cultivar sheds pollen before stigma receptivity, it is known as protandrous, whereas if stigma receptivity occurs prior to pollen shedding, it is known as protogynous. Ideally, growers should plant protandrous and protogynous cultivars together (Table 1). Conner (2015) has compiled the most complete database of pollination compatibility. In certain regions of the southeastern United States (such as Albany, GA) sometimes there is enough pollen in the air to obviate the need for planting pollinizer cultivars in close proximity.

Tree Training and Pruning

A newly planted tree should have between ½ and ⅓ of the top removed to bring roots and shoots into balance. Tree training is performed early in the life of the tree to form a proper tree framework. Pecan trees should be trained to a central leader training system (Figure 17). Select a vigorous upright shoot as your main leader and remove adjacent shoots. This is very important. For commercial plantings, lateral branches should not be allowed to form from the newly established central leader until a height of 5 feet is achieved. Lateral branches must be at least 5 feet from the ground to avoid interference with cultural practices such as herbicide spraying and mechanical harvesting. Lateral limbs will become scaffold limbs as the tree matures. Ideally, lateral branches should be selected about every 18 inches in vertical height and positioned in all quadrants of the tree. To allow the accumulation of photosynthate, laterals that develop below a height of 5 feet can be retained temporarily for a year or two, but then they should be pruned off. Sprouts emanating from the rootstock (below the graft union) should be removed as they form. Pruning as little as necessary during the first several years will hasten tree development.

Figure 17. A young pecan tree training to center leader system. Eventually branches lower than 4 to 5 feet above the ground will be removed.
Credit:

Mature pecan trees are not routinely pruned (Figure 18). Mature pecan trees are pruned to facilitate continued tree productivity as adjacent trees become crowded in the orchard. During the dormant season, prune all limbs closer than 5 feet from the soil surface. The cut should not be flush but rather a sufficient distance from the branch to create a stub that will eventually be covered with bark tissue; otherwise the location of the pruned-off limb will sustain wood rot and eventually leave a hole in the trunk. The crotch angle is the angle the lateral branch makes with the central leader. Crotch angles between 70 and 90 degrees are preferred. Narrow, or Y angles, are to be avoided because they are prone to breakage (Figure 19). For narrow or Y angles, remove one of the shoots early in development, preferably during the first year that they form.

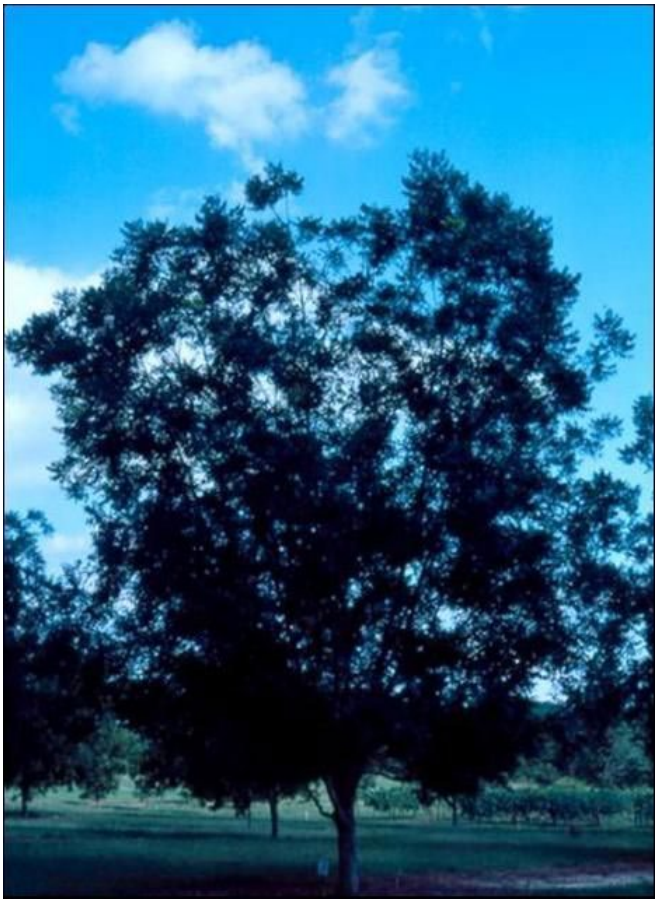

Figure 18. A mature pecan tree grown at a low density.
Credit:

Figure 19. The center leader of this immature pecan tree has broken because of the narrow crotch angles of subtending lateral branches.
Credit:

There is usually a reduction in yield associated with pruning that may last several years. Yield can be essentially zero for three years of growth after scaffold limbs are pruned to stubs. Severe pruning can promote a return of the tree to a juvenile (nonreproductive) state. A reduction in yield with pruning will also occur for trees destined for eventual tree removal.

Irrigation

The amount of water a pecan tree requires depends on the tree's age and the season of the year. A hot, dry period will require more irrigation than a prolonged wet period. Irrigation is most critical during the establishment year. A mature tree will not be greatly damaged by a lack of irrigation, although yield and nut quality can be greatly reduced. For the first 2 years, a pecan tree may only require 10 gallons every day. Young trees will perform quite well with drip irrigation. Drip irrigation is a microirrigation system that saves water and nutrients by dripping it slowly to the roots of plants. It can be either from above the soil surface or below the surface. Irrigation once every other day is usually satisfactory. Initially, one dripper per tree is adequate, but this should be expanded to at least two per tree by the fifth year. As their root systems expand, orchards will benefit from Microjet® irrigation. Overhead irrigation is not as efficient and can increase the incidence of leaf diseases. Mature bearing trees can require more than 400 gallons per tree per day or 11,000 gallons per acre per day. Obviously, this amount of water requires a considerable delivery system for small- to medium-sized plantings in the form of a large well and irrigation pump. It is not uncommon for irrigation pumps to be running continuously during certain times of the year supplying water to sections of a moderate- to large-sized orchard on a staggered basis.

Fertilization

It is best to conduct a soil fertility test prior to planting. Collect soil samples from different areas of the field and give the samples to your county Extension agent. The county agent will send samples to the University of Florida Extension Soil Testing Laboratory for analysis at a nominal fee.

When planting pecan trees, or any other trees, do not put fertilizer in the planting hole. Rather, provide a light application (1 pound per tree) of 10-10-10 (N-P_2O_5-K_2O) plus microelements in early March and again in June. A 10-0-10 fertilizer can be substituted for 10-10-10 if soils contain sufficient P. In addition, rather than applying fertilizer twice a year, a smaller proportional quantity can be applied every 6 to 8 weeks. Do not apply all the fertilizer in a clump around the base of the tree; instead, spread out the fertilizer in a circle with a 3-to-5-foot diameter around the trunk of the tree. Avoid placement of fertilizer directly against the trunk. The tree will get much more of the water and fertilizer you provide for it if you control weeds. Control weeds near young trees with herbicides, hoeing, or mulches such as straw, hay, or black plastic on the surface of the soil. During the winter and summer of the following year, apply fertilizer at the rate of about 2 pounds per tree.

After the establishment year, about 2 pounds of fertilizer should be applied for each inch of trunk diameter (measure 1 foot above the soil) during the winter and summer. If tree growth is less than 2 feet per year, the quantity of fertilization should be toward the higher end of this rate. You may want to do a leaf analysis, particularly if deficiency or toxicity symptoms occur in leaves or if limb growth is insufficient. Deficiency or toxicity can be diagnosed by a discoloration of the leaves or a malformation of the leaves. (See the "Nutrient Deficiencies" section of this publication for more information about leaf analysis.) There should be 8 or more inches of terminal growth for older trees (10 years and older). For bearing trees, 2 to 4 pounds of fertilizer should be applied per inch of trunk diameter in February and again in June. Some growers prefer to bury fertilizer at 10 or more sites below the tree canopy to reduce runoff and increase fertilizer use efficiency compared to broadcast applications. Large trees (30 inches or more in diameter) may require 60 to 120 pounds of fertilizer in February and again in June. Conversions to per acre rates can be performed by multiplying the number of trees per acre by the above rates.

Nutrient Deficiencies

Leaf nutrient status can be determined by contacting your county Extension agent. The county agent will submit leaf samples to the University of Florida Extension Soil Testing Laboratory for analysis at a nominal fee. Table 3 describes the low, sufficient, and high ranges of nutrient concentrations of pecan leaflets. It is recommended to sample leaflet pairs from fully expanded leaves in the mid-portion of the terminal growth 56 to 84 days after the initiation of terminal growth.

Some symptoms of nutrient deficiency are fairly easy to identify. Nitrogen deficiency will result in light-green or light-yellow foliage, particularly in the lower limbs. In certain cases, there will be premature leaf abscission of these leaves. A nitrogen deficiency can reduce the growth rate of young trees and can reduce the yield of

bearing trees. Supplemental application of ammonium sulfate or ammonium nitrate can be supplied if nitrogen is deficient.

Phosphorous and potassium deficiency symptoms seldom occur in pecan trees, although it is possible that leaf levels of potassium may be in the deficiency range. It is unlikely that phosphorous deficiencies will occur in pecan leaves. Magnesium deficiency has rarely been observed especially if using a balanced fertilizer containing magnesium. Magnesium deficiency is characterized by interveinal chlorosis with marginal yellowing of leaves.

Many pecan orchards require supplemental applications of zinc in the form of zinc oxide or zinc sulfate in the fertilizer. Zinc deficiency is characterized by a bronzing and a crinkling of the leaves and a reduction in leaf size. In severe cases there can be twig dieback. Zinc deficiency is most pronounced at a pH above 6.0. A few ounces of zinc sulfate applied to the soil will correct a zinc deficiency for young trees, while several pounds may be required for older trees. If zinc sprays are used, 2 pounds of neutral zinc per 100 gallons of water are recommended. In many cases, zinc deficiency can be avoided by regular application of a balanced fertilizer.

Nickel deficiency can result in dwarfed, rounded leaflets, a condition known as mouse ear. Previously, mouse ear was incorrectly attributed to manganese deficiency. As in the case of zinc deficiency, it is most common at high soil pH. It can be corrected by application of nickel Plus™ (10-0-0) at 1 to 2 pints per acre. The enzyme urease requires nickel to convert urea to ammonia and carbon dioxide, and nickel is critical for amino acid metabolism.

Tree Production and Alternate Bearing

Pecan yield and quality are influenced by tree age, cultivar, and management program. Certain precocious cultivars can produce a small crop (10 to 30 pounds per tree as young as 6 years old), but other cultivars such as 'Stuart' require 10 years to bear a crop. Trees planted at a high or moderate density approach maximum yield per acre but can quickly become overcrowded, resulting in a reduction in yield. Few pecan orchards produce more than 1,500 pounds per acre over a sustained period.

Alternate bearing is a phenomenon where trees bear heavy and light crops in alternate years. Often, many or most cultivars can have high and low yields synchronously. In a high-yield year, water, nutrients, and sugar production by photosynthesis are sufficient to mature a large quantity of nuts. Certainly, plant hormones play a role as a plant signal in alternate bearing. It is likely that carbohydrate reserves will be depleted by the end of the bearing year and yield the following year will be low. There is probably a natural tendency for alternate bearing as an adaptive response to reduce pest pressure by not allowing a consistent supply of nuts for pests every year.

Alternate bearing is accentuated by any factor(s) that can deplete the tree's energy reserves. This can include inadequate insect or disease control, insufficient fertilization, lack of water, and tree overcrowding. Diagnosing the actual cause of alternate bearing can be difficult. Premature defoliation can enhance the depletion of carbohydrate reserves and can be a predictor of low yield the following year. Premature defoliation during late summer can exacerbate alternate bearing because of the depletion of carbohydrates associated with the formation of new leaves. If possible, healthy foliage should be maintained until the first frost in November.

Neglected or Abandoned Pecan Orchards

A substantial proportion of the pecan acreage in Florida consists of neglected or abandoned trees. Many trees that appear in homeowner settings can also fit into this category. After a few years of neglect, tall weeds will be prevalent in the orchard. Orchards that have been abandoned for about 5 years will contain saplings growing within and between rows. Broken pecan limbs will also be prevalent. After about 15 years, an abandoned pecan orchard can resemble a forest in which scattered pecan trees compete for sunlight in the canopy.

The decision to renovate a neglected orchard will depend not only on the length of time it has been abandoned, but also on the specific pecan cultivars. If the trees are recommended cultivars (as indicated in the "Cultivar Selection" earlier in this publication) and if there is little work required to bring the trees back into production, then renovation is an option. If either of these conditions is not met, then renovation will not be

cost effective. Homeowners or landowners may still want to renovate for aesthetic purposes. Homeowners should be prepared for additional limb breakage a few years following fertilization of a neglected orchard. Oddly, poorly maintained orchards often sustain less wind or storm damage than well-maintained trees.

If you decide to renovate, remove competing vegetation, including saplings, and create a weed-free in-row strip about 10 feet wide. Cattle can be grazed on the land for a short time if the vegetation is deemed suitable, and goats will eat just about any vegetation. After renovation, the pecan foliage should shade out any competing weed growth. Remove all scaffold or lateral limbs that fall below a height of 5 feet above the ground. You may have to remove limbs that are too close together. If trees are overcrowded and need to be thinned, they may need to be pruned and alternate trees eventually removed. Apply fertilizer at the rates indicated above, although low fertilization rates may reduce limb breakage of a neglected orchard. Correct nutritional deficiencies by first conducting a leaf nutrient analysis (as indicated in the "Nutrient Deficiencies" section), and then by applying the needed nutrients.

Mistletoe is a parasite of pecan trees and diverts nutrients from the tree (Figure 20). The only method to remove mistletoe is to cut it out below the point of attachment, since the root system of mistletoe deeply penetrates the wood of pecan trees. Spanish moss appears as a green-gray moss that hangs on tree limbs. Spanish moss is related to the Bromeliads. Spanish moss is not technically a parasite, though it is a symptom of low tree vigor (Figure 21). Spanish moss obtains carbon for photosynthesis and nutrients for other metabolic processes from the air or from the substrate surface. The biggest problem of Spanish moss is tree shading. If you wish to control Spanish moss, apply 10 pounds of copper sulfate per 100 gallons of water during the dormant season. Lichens are symbiotic combinations of algae and fungi that adhere to bark and even rocks. When lichen is prevalent on trees, it is a symptom of low tree vigor, but no control of lichen is recommended because it does not harm the tree.

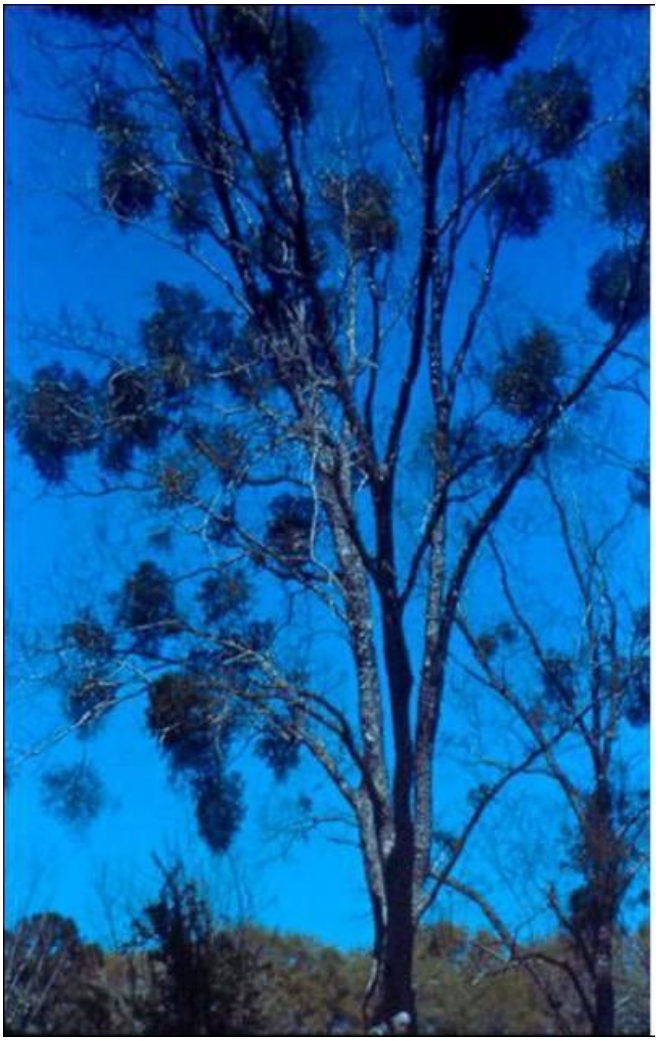

Figure 20. A mistletoe infestation on a mature pecan tree visible during the dormant season.
Credit:

Figure 21. A pecan tree with a heavy infestation of Spanish moss during the dormant season.
Credit:

Mammal and Bird Pest Problems

Squirrels are the main mammal pests of pecans. Estimates in Georgia indicate that one squirrel can consume 50 pounds of nuts per year. They also break twigs. Squirrel damage may begin in September and last until the nuts are harvested. Squirrels are particularly damaging for pecan trees that are near woodlands or adjacent to other trees because the squirrels never have to touch the ground to reach the pecan tree. Running on the ground of a field is hazardous to squirrels because it leaves them vulnerable to predation from hawks, owls, and other mammals. Live traps can be used with peanut butter as bait. Hunting squirrels is another option for commercial orchards. It is sometimes impractical to control squirrel populations; it seems as if there is a never-ending supply of replacement squirrels. Rabbits can also be a problem. They girdle young pecan trees during the first two years of tree establishment. With that being said, it is especially difficult for homeowners in residential areas to control squirrels because control measures are difficult to implement. No poisons or chemicals are currently registered for control of squirrels in Florida.

Deer may damage trunks and limbs by rubbing their antlers against them. This problem can be especially severe in areas with a high deer population where control measures will be necessary. The easiest control measure is to construct a wire fence with posts around each tree. Another option is to hunt the deer, but remember not to hunt deer out of season. Deer are not usually a big problem after the first 10 years of establishment, when the trunk of a pecan is sufficiently strong to withstand damage from deer.

The number of pecan nuts a flock of crows can consume is substantial. Noisemakers and hunting are options for commercial orchards, but there are no good options for crow control in a homeowner setting.

Marketing Situation

Economic advantages to pecan production are that they are a perennial tree crop with an extended harvest period (up to 50 or more years), and much of the culture and management and harvesting operations can be mechanized. By contrast, mechanization can be considered a disadvantage for small to medium-sized orchards, because specialized spraying and harvesting equipment are required. A mature pecan tree can be 70 or more feet tall and the spray equipment to reach to such great heights is unique to pecans. Custom spraying and harvesting can assist the owners of small pecan acreages.

A major disadvantage of pecan culture is the length of time before pecans come into significant production (5 to 10 years). Therefore, the time it takes to receive a return on an investment can be substantial. Similarly, the length of time necessary to fully renovate a neglected orchard may also be an impediment.

The establishment of pecan orchards is a long-term and expensive endeavor. Growing pecans in Florida will not likely be profitable unless the best cultivars are used under optimum management practices. A minimum acreage to justify a commercial orchard is typically quite large and may be 50 or more acres. This size is required to justify the expenditure for specialized sprayers and harvesters. A minimum of 8 to 10 years is usually required to bring pecan trees into good production. Land costs in Florida vary greatly, but it is probably not practical to grow pecans commercially where land is more than about $2,000/acre, because the price reflects the fact that the land could have other, more lucrative uses. However, pecan orchards as early as 1900 have often been established principally as an investment in

real estate. Given an establishment cost of $1,000 and an annual expenditure of $500, after 10 years the outlay could be $6,000/acre excluding land costs before any production occurs. About ½ to ⅔ of the costs are due to variable costs (materials, equipment, and machinery), and the remainder are fixed costs (depreciation, interest, and overhead).

Until recently, the price of pecans has been relatively stagnant at about $1.00 to $1.75 per pound for in-shell nuts. However, over the last 5 to 8 years there has been an increase in the price of pecans due to increased demand from China and other countries. There have also been substantial efforts to improve pecan marketing, such as promoting pecans as a good source of high-density lipoproteins.

Suggested Further Reading

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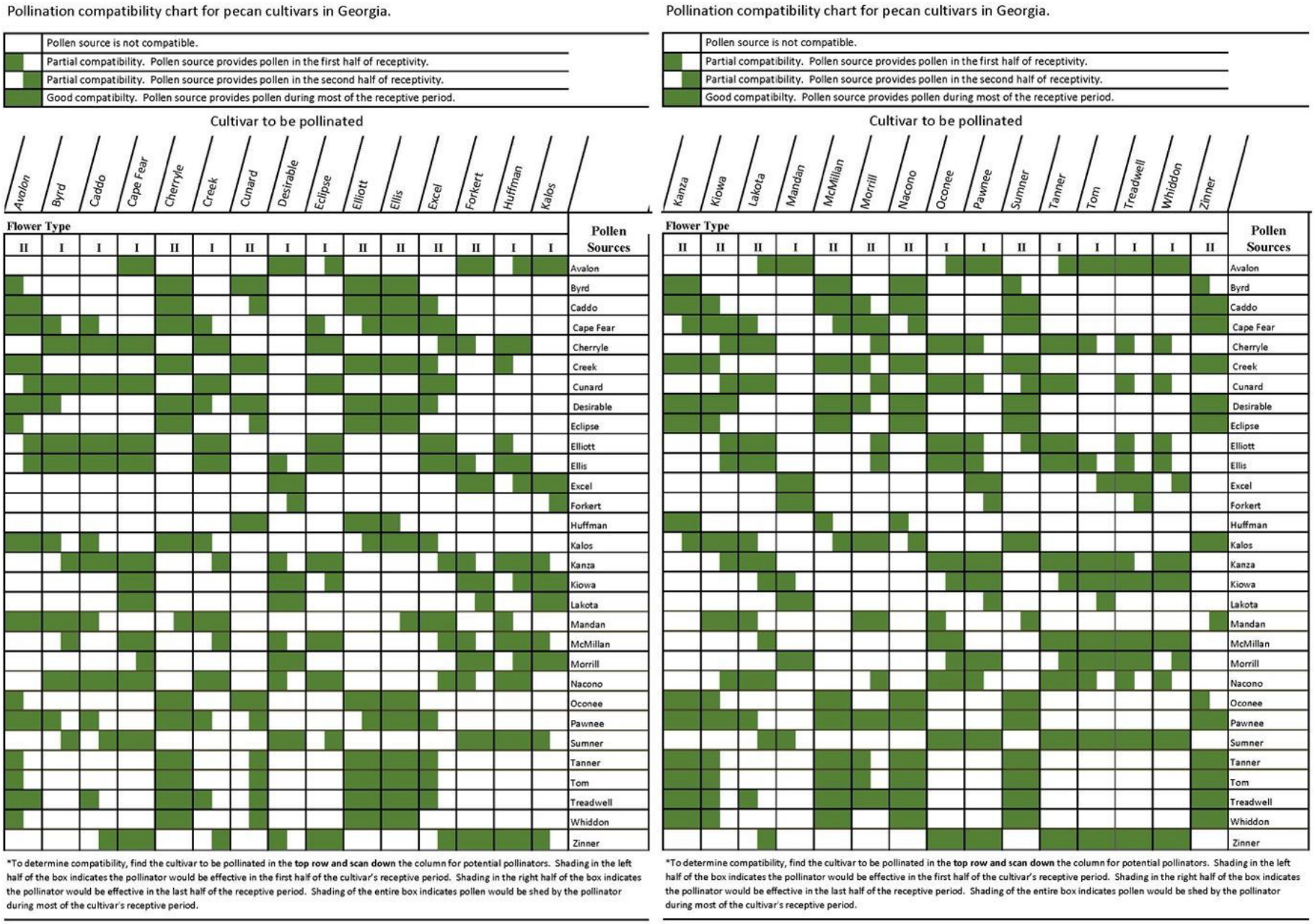
Figure 22. Pollination compatibility chart for pecan cultivars in Georgia.
Credit: https://pecanbreeding.uga.edu/content/dam/caes-subsite/pecan-breeding/docs/cultivar-list/2021-Pollination-Compatibility-Chart.pdf



Tables

Table 1. Pecan cultivars recommended by the University of Florida (UFL), University of Georgia (UGA), and Auburn University (AU).[w]

Cultivar	Pollination type[x]	Yield[y]	Nuts/lb	% kernel	Resistance to scab	Harvest date	Recommendation status[z]		
							UFL	UGA	AU
'Adams 5'	?	2	81	53	Excellent	7-Oct	?	?	CR
'Amling'	I	2	60	53	Excellent	17-Oct	TR	CR	CR
'Apalachee'	I	4	80	57	Average	7-Oct	?	?	R
'Avalon'	II	3	47	54	Excellent	3-Oct	TR	TR	?
'Baby B"	II	3	67	50	Good	28-Sep	?	?	R
'Byrd'	I	3	46	62	Average	22-Sep	NR	TR	CR
'Caddo'	I	4	70	54	Average	11-Oct	CR	R	R
'Cape Fear"	I	3	55	51	Average	19-Oct	CR	CR	NR
'Creek'	I	3	54	50	Average	18-Oct	NR	CR	CR
'Desirable'	I	4	47	52	Poor	14-Oct	CR	R	CR
'Eclipse'	?	4	61	56	Good+	8-Sep	TR	?	R
'Elliott'	II	2+	76	51	Good	12-Oct	R	R	CR
'Excel'	II	3	45	49	Excellent	13-Oct	R	TR	R
'Forkert'	II	3+	53	57	Average	19-Oct	CR	R	CR
'Gafford'	I	4	53	50	Excellent	18-Oct	?	?	R
'Giftpack'	II	4	61	56	Average	10-Oct	?	?	R
'Gloria Grande'	II	3-	44	48	Good+	20-Oct	CR	NR	NR
'Headquarters'	II	3	53	57	Excellent	17-Oct	?	?	R
'Kanza'	II	2	65	52	Excellent	20-Sep	NR	R	CR
'Kiowa'	II	4	48	58	Average	21-Oct	CR	CR	NR
'Lakota'	II	4	74	57	Excellent	25-Sep	R	TR	R
'Mandan'	I	2	50	57	Average	21-Sep	?	TR	CR
'McMillan'	II	4	56	51	Good+	12-Oct	TR	TR	R
'Oconee'	I	?	48	54	Average	12-Oct	NR	R	NR
'Pawnee'	I	3	49	57	Poor	17-Sep	CR	R	NR
'Stuart'	II	3	55	46	Average	15-Oct	CR	CR	?
'Sumner'	II	3+	50	52	Good+	29-Oct	R	R	CR
'Surprize'	I	3+	49	49	Average	1-Nov	?	?	CR
'Syrup Mill'	I	4	65	47	Average+	20-Oct	?	?	CR
'Zinner'	II	3	48	56	Good+	12-Oct	NR	TR	R

w Adapted from Wells and Conner (2015) and Goff (2015)

x Pollination status: Type I = protandrous; Type II = protogynous

y Yield rating: 1 = low, 2=average, 3 = good, 4 = excellent

z Recommendation status: R = recommended, CR = conditionally recommended, NR = not recommended, TR = recommended for trial

From Jones et al. (1991) and Smith et al. (2012).

Table 2. Recommended nutrient levels of pecan leaves.

Element	Low	Sufficient	High
%			
N	<2.40	2.4–3.0	>3.0
P	<0.14	0.14–0.30	>0.3
K	0.75–1.24	1.25–2.50	>2.5
Ca	<1.00	1.00–1.75	>1.75
Mg	0.21–0.29	0.30–0.60	>0.6
S	<0.2	0.2–0.35	>0.35
ppm			
B	<15	15–50	>50
Cu	<6	6–30	>30
Fe	30–49	50–300	>300
Mn	<200	200–500	>500
Zn	<50	50–150	>150
Ni	<2.5	>2.5	?

[1] This document is HS982, one of a series of the Horticultural Sciences Department, UF/IFAS Extension. Original publication date May 2004. Revised July 2006, August 2012, November 2015, January 2019, and December 2022. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

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