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HS984

The Pecan Tree[1]

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Historical Information

The 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.

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 having unique traits. The annual value of pecans in the United States is 100 to 200 million dollars.

Distribution

The pecan, [*Carya illinoensis* (Wagenh.) K. Koch] is a deciduous tree native to North America. It belongs to the same family (Juglandacae) as English walnut, black walnut and hickory. The pecan tree is native to the Mississippi floodplain which has deep, fertile, well drained soils. 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 at least 50% of the total production within the United States. Florida produces from 5 to 10 million pounds of pecans annually. Assuming an on-farm value of $1.00 per pound the total value of the pecan crop for Florida has been 5 to 10 million dollars annually.

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/semi-arid growing season and well supplied with irrigation are optimum for commercial pecan production because of a reduction in the incidence of

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leaf fungal disease. Other regions of production include Australia, Brazil, Israel and South Africa.

In Florida, pecan trees can be found in all regions between Pensacola and Miami. Most of the total acreage (5,000 acres) is located in north Florida althoughmany of the peacns grown in the state are not well managed. Tree growth may be satisfactory in the southern half of the state; however, nut production is usually low due to inadequate cold during the winter and enhanced disease pressure due to higher rainfall. The majority of the production statewide is not well managed in respect to irrigation, and weed, insect and disease control and the quantity and quality of the pecan crop is reduced.

Botany

Pecan trees are very large and are 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) flower catkin and is arranged in groups of 2 to 8 and are joined 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 seasons wood, but in actuality are produced on short current seasons growth. Pistillate flowers are also produced on current years growth. Pistillate flowers arise from the most apical (one or two) buds on each shoot, while staminate flowers arise from most primary and secondary buds, except the terminal buds. Primary, secondary and tertiary buds in a given node have the potential to produce staminate and pistillate flowers along the length of 1year-old shoots. Nuts typically occur in clusters of 2 to 6 nuts (Figure 3). For a given pecan 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.

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 on orchard investment. 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 a poor nut fill (low percentage kernel), particularly with older trees (Sparks 1992).

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

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

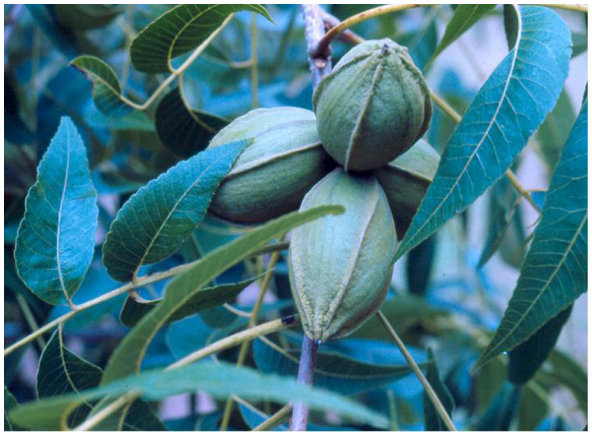

Figure 3. Pecan fruit prior to dehiscence (or shuck split).

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

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 location 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 soil 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. Soil should be prepared by plowing under and disking all vegetation prior to planting. 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 as 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 an important feature of soils for pecan trees. Thus, shallow soils or sandy soils may require more frequent irrigation because they hold less water.

The optimum soil pH for pecan is 5.5 to 6.5. At the lower end of this range, micronutrient deficiency symptoms such as rosette (zinc deficiency) or mouse ear (manganese deficiency, or more recently ascribed to nickel deficiency) should be less common. 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. Dolomite should be applied in the fall and it 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 closely mowed during late summer and fall. 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 nuts on the ground 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 since 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 or more feet apart. However, newly planted trees at this spacing create a very inefficient use of land and equipment. There are no dwarfing rootstocks for pecan, and satisfactory cultivars that have a dwarfing growth habit are not available. Cheyenne is a cultivar that is 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 spacing beyond about 15 years is not feasible (Figure 5) since 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. A few growers plant pecans from 50 to 70 feet apart and use the land between small trees to intercrop an agronomic crop as indicated above.

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 since 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.

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

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. A bareroot tree at least 6 feet in height is recommended. Many pecan trees die as a result of drying out in the hours or days before they are planted. Heal 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 a high humidity. During planting the best procedure is to soak trees in water to avoid having the roots dry out because of wind or sun.

Pecan trees require a large hole for proper transplanting. Holes 2 feet in diameter and at least 2 to 3 feet deep are satisfactory. The best way to dig holes of this size is by using a PTO-driven auger. Plant trees to a depth similar to what 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 to cut or 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 simplifies the problem of retention of water during the application of water. Water at least once every week unless rainfall is sufficient until the irrigation system is established. Remove 1/3 to 1/2 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 sunscalding and bark splitting of young trees.

If trees are planted in a region where livestock is grazing 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 and damaging the trees.

Propagation in the Nursery

The criteria that nurserymen use to select pecan seed (pecan nuts) for rootstock are the availability of a nut with a high uniform percentage kernel at a reasonable price. Usually small-sized nuts are used. 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. This is accomplished by mixing seeds with moist (not wet) peat moss, saw dust or sand then storing them at about 35 F for 8 to 20 weeks. This is usually initiated at the beginning of January. Nuts are ready for planting when nuts begin to germinate as evidenced by nut splitting. Nurserymen 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 as 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.

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 1/2 inch. Trees are budded in June, July or August when the buds are mature. If budded in the spring, the sap should be flowing and buds are from stored wood or from one year old wood. The bark of buds and 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 or patch budding can be performed any time during the growing season when the bark slips from the cambium freely. Patch budding has been largely replaced by the seion. For ring budding, a ring of bark containing a bud from the bud stick of the same diameter is placed where the ring was removed from the stock (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 is capable of supporting itself. Patch budding involves inserting the bud in a similar fashion to the scion. 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. Using this method, sticks of the budwood smaller than the stocks can be utilized. 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.

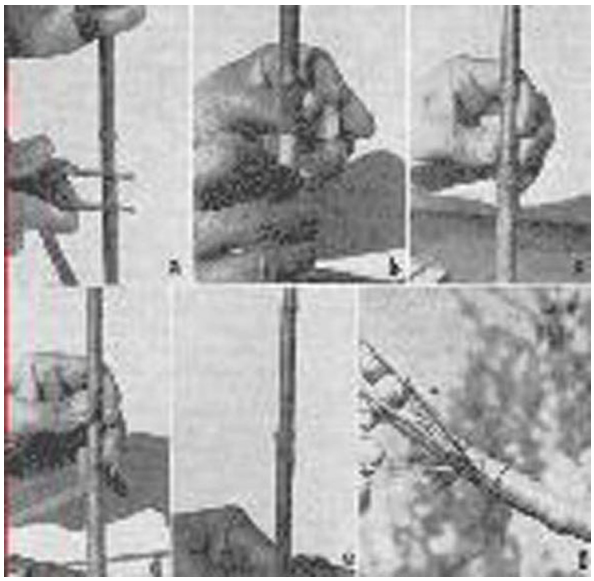

Figure 7. Patch budding pecans. A) Make 2 parallel cuts extending halfway around the stock with a double-blade knife. A single vertical cut is made at one side connecting the parallel cuts. Similar parallel cuts are made above and below the desired bud on the budstick. Then 2 vertical cuts are made above and below the desired bud on the budstick. Then 2 vertical cuts are made 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.

Grafting and Budding Small Trees

Seedlings too small to bud during the second summer can be grafted the following winter, although some year old seedling may be large enough to graft after the first season. The whip and tongue graft (Figure 8) is used almost exclusively. The scions are grafted just below the soil surface. January and February are the best months for grafting. In the spring there may be numerous shoots from thje stock and these will have to ne 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 mature trees involves cutting back the tree to several short branches during the dormant season. Retaining branches 4 to 6 inches in diameter ensures 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 8). 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 tight 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.

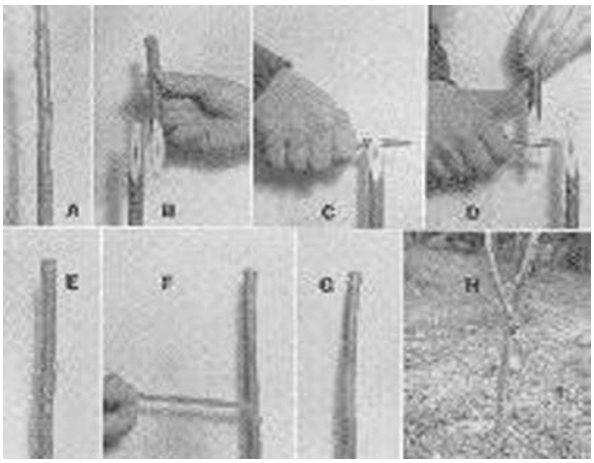

Figure 8. Whip grafting pecans. A) Select a scion which closely corresponds to the size of the stock to be grafted. Cut the scion 4 to 6 inches in length. Scions should have 2 or 3 well-developed buds. B) Make a diagonal cut 1 1/2 to 2 inches in length at the base of the scion. Make a diagonal cut the same length on hte stock. All cuts should be straight and smooth. C) Make a cleft cut down the stock. The cut should be about 3/4 inch in length and one-third of the distance down from the tip of the diagonal cut. D) Make the same type of cleft cit 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 drying out. H) Whip grafted tree.

Propagation of Mature Trees

Pecan trees are found in practically every county in Florida. The major production areas are the north and northwestern parts of the state. Tree growth is often satisfactory in the southern half of the peninsula but nut production is relatively low because of higher winter temperatures, higher rainfall and increased disease problems.

Cleft Grafting

Branches (or a tree trunk if it is a small tree) should be cut back to 3 to 4 inches in diameter during the dormant season. Create a split down the middle of the cut stub of the branch or trunk with an appropriate cleft grafting tool. Insert scions that are about 3/4 inches in diameter, such that the vascular cambium of the split branch or trunk and the tapered scion wood are aligned. The cut stub should be covered with grafting wax. The scion should be held in place with budding tape to help ensure that the scion does not pull away from the cut stub. If the graft fails to form, then trees can be budded in the fall.

Inlay Bark Graft

Scion wood for inlay bark grafts should be cut in late February from 1 or 2-year-old shoots in 12-inch lengths and stored at 32 to 40 F in moist sawdust or sphagnum moss (Figure 9). Grafts are placed 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 3/4 inches long at the basal end. This is placed against the limb and outline cuts are made through the bark of the stock. The bark is then removed and the scion is fitted tightly in the groove. Two small nails, 3/4 inches long, are nailed through the grafts to hold them firmly in place. All cut surfaces are coated 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. A plastic bag is then pulled down over the stock covering the foil and tied 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 1/2 way the following winter if both scions on a limb grow.

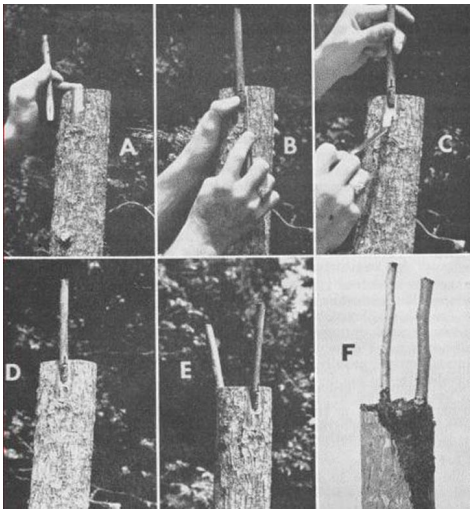

Figure 9. Inlay bark graft method. A) Pare down the rough, scaly portion of the bark to provide a smooth surface for making the outline of the scion. B) Lay the beveled side of the scion against the pared place on the stock. With the point of a knife, cut through the bark of the stock along each side 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.

Pollination

Pecan trees are wind pollinated. Pecan trees have monoecious flowers (i.e. separate male and female flowers) (Figure 1). The staminate (male) flowers (also known as catkins) appear as fluffy multi-lobed finger like projections. Catkins are borne on last years wood. The pistillate (female) flowers resemble a small star and are borne on current years 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 (Table 1). When a given cultivar sheds pollen prior to stigma receptivity it is known as protoandrous, whereas if stigma receptivity occurs prior to pollen shedding it is known as protogynous.

Cultivar Selection

Of the approximate 200 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, 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 susceptibility to pecan scab. Pecan scab is a fungal disease that affects developing shoots, leaves and nuts. Often, 4 to 9 fungicide applications yearly are required to control this disease. A listing of highly recommended cultivars, recommended cultivars and conditionally recommended cultivars will follow. A good source of information concerning pecan cultivars is Sparks (1992). For more information on the characteristics of other cultivars you may also refer to an EDIS publication entitled, "Pecan Cultivars for North Florida". A summary of the characteristics of the most promising cultivars are presented in Table 1. In addition the time of stigma receptivity and pollen shedding are presented in Table 2.

Highly Recommended Cultivars

Cape Fear: Cape Fear originated in North Carolina (Figure 10a). It is protandrous and precocious. Pollen shedding in Cape Fear is very early. Elliott or Stuart are fair pollinizers for Cape Fear and vice versa. Cape Fear trees are vigorous and upright with an opened growth habit. It is a strong tree with a deep taproot. Cape Fear is moderately precocious. Cape Fear has been a consistent producer at the NFREC-Monticello. Nut weight is typically 7.5 to 8.2 g (58 nuts per pound) with a 55% kernel. Kernel color is light and attractive in appearance. Nut shape is broad oval to oblong. Shell thickness is medium-thin. Resistance to scab is good, and resistance to other leaf diseases is fair.

Elliott: The origin of Elliott is northwest Florida (Figure 10b). It is protogynous. Elliott is not precocious, but more precocious than Stuart. Stigma receptivity occurs early in the season. Cape Fear and Desirable are good pollinizers for Elliott. Elliott is moderately vigorous and is a strong tree with a deep taproot. Elliott has produced a moderate-sized crop at the NFREC-Monticello. Nut size is small, typically 5.5 g (82 nuts per pound) with a 54% kernel. Nut shape is fairly round with a pointed apex. The shell is medium thick. Kernel color is light and quality and flavor is very good. Another redeeming quality of Elliott is excellent resistance to scab and other leaf diseases. Elliott has a low chilling requirement and is suited for areas further south than some other pecan cultivars.

Moreland: Moreland is a disease-resistant cultivar that has produced consistently high yields at the NFREC-Monticello (Figure 10c). Moreland originated in Louisiana. Trees are moderately vigorous and produce a dense canopy. It is protogynous and moderately precocious. Cape Fear or Desirable is a good pollinizer for Moreland. Nut weight is about 8.2 g (55 nuts per pound) and percentage kernel is about 55%. It resembles Schley in appearance; however, it is not as bright in color and is harder to crack by hand and mechanically. Nut shape is slightly ovate to oblong and shell thickness is medium. Moreland is highly resistant to scab and other leaf diseases. Cape Fear is a good pollinizer for Moreland.

Figure 10. Highly recommended pecan cultivars for north Florida: a) Cape Fear b) Elliott c) Moreland.

Recommended Cultivars

Curtis: Curtis was initially selected from a tree in Orange Heights, Florida (Figure 11a). Curtis is protogynous. Curtis is a good late season pollinizer. It has produced consistently high yields at the NFREC-Monticello. Nut size is small (5.0 to 5.5 g) and shape is slightly pointed toward the apex. Shell thickness is medium thin with 53% kernel. Kernels are dark and have a speckled appearance. It is adapted to regions further south than many cultivars as it has a low chilling requirement, but a high heat requirement for budbreak. The tree is of low to moderate vigor with slightly spreading upright growth. Curtis is fairly resistant to pecan scab and other leaf diseases; however, due to small nut size, a

dark speckled kernel and late maturity it is not highly recommended.

Sumner: Sumner was a seedling selected in southern Georgia (Figure 11b). It is a largely overlooked cultivar. Trees of Sumner are moderately strong and upright in growth habit with a moderately open canopy. It is protogynous, precocious and prolific. Sumner is a good late-season pollinizer. Desirable is a suitable pollinizer for Sumner. Nut size is large (9.5 g or 48 nuts per pound). Overall nut quality is good, although kernels can be somewhat dark. Nut shape is oblong with an obtuse base and a pointed apex. Nut maturity is late. Sumner has a high resistance to scab and other leaf diseases.

Figure 11. Recommended pecan cultivars for north Florida: a) Curtis b) Sumner.

Conditionally Recommended Cultivars

Stuart: Stuart is the most common pecan cultivar grown in the southeastern United States and in the world (Figure 12a). Some of the predominance of Stuart is the name recognition of this cultivar. Trees are strong and upright, and do not require as much training or pruning as other cultivars. One of the limitations of this cultivar is that it may take 10 years for it to come into bearing. Stuart is a late-season pollinizer. Stuart is protogynous, and is a good pollinizer for Desirable. Nut size is medium-large (8.3g or 52 nuts per pound). Nut shell is moderately thick. Nut shape is oblong to slightly ovate with a narrow basal end. Percentage kernel is usually low (often 45 %). Kernel color is average and quality is variable. Stuart was once resistant to scab, but is now considered moderately susceptible to scab and other leaf diseases. If Stuart is in a mature planting it is worthy of retention; however, since it is not precocious, it is not highly recommended for new plantings in Florida.

Desirable: Desirable originated in Mississippi (Figure 12b). It has been planted extensively in the southeastern United States, often as a pollinizer for Stuart. Wood of Desirable is weak. Desirable is protandrous and moderately precocious. Desirable produces abundant pollen early in the season and is a good pollinizer for many pecan cultivars. Nut size is large (9.5 g or 48 nuts per pound) with a 53% kernel. Kernel color is light and quality is good. The sides of the nut are concave and uneven. Desirable is said to be one of the most consistent cultivars in annual production in Georgia, but has not been a consistent producer in Florida. Desirable is susceptible to scab and other leaf diseases, and should only be grown in Florida under a strict fungicide spray program.

Gloria Grande: Gloria Grande was discovered in South Carolina (Figure 12c). It is a strong tree and resembles Stuart in tree and nut characteristics. Tree growth habit is even more upright than that of Stuart. It is protogynous, but not precocious. Nut size is large (9.6 g or 47 nuts per pound). Nut fill is higher than Stuart and is usually in the range of 52 %. Kernel quality is good and color is light. Nut shape is oblong with an obtuse apex and base. Shell thickness is moderately thick. Gloria Grande is a late-season pollinizer. Desirable is a suitable pollinizer for Gloria Grande. Resistance to scab and other leaf diseases is high. Gloria Grande is a possible replacement for Stuart; however, because of insufficient experience with this cultivar in Florida it can only be conditionally recommended at this time.

Figure 12. Conditionally recommended pecan cultivars for north Florida: a) Stuart b) Desirable c) Gloria Grande.

Tree Training and Pruning

Trees at planting are normally a whip without branches. A newly planted tree should have between 1/2 and 1/3 of the top removed so as to bring roots and shoots into balance. Some terminology is in order. 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 13). 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. The reason why the minimum height of lateral branches is 5 feet is to avoid the lateral branches interfering 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 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.

Mature pecan trees are not routinely pruned (Figure 14). 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. A crotch angle is the angle the lateral branch makes with the central leader. Crotch angles between 70 and 90 degrees are prefered, and narrow or Y angles are to be avoided because they are prone to breakage (Figure 15). For narrow or Y angles remove one of the shoots early in development, preferably during the first year that they form.

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 following the time when scaffold limbs are pruned to stubs. Severe pruning can promote a return of the tree to a juvenile (non reproductive) state. A reduction in yield with pruning will also occur for trees destined for eventual tree removal.

Irrigation

The amount of water required for a pecan tree depends on tree age and 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

Figure 13. A young pecan tree training to center leader system. Eventually branches lower than 4 to 5 feet above the ground will be removed.

Figure 14. A mature pecan tree grown at a low density.

Figure 15. A center leader of immature pecan tree that has broken due to narrow crotch angles of subtending lateral branches.

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. Irrigation once every other day is usually also satisfactory. Initially, one dripper per tree is adequate, but this should be expanded to at least 2 per tree by the fifth year. Older orchards will benefit from Microjet^{R} irrigation as the root systems expand. Overhead irrigation is not as efficient and can increase the incidence of leaf diseases. Mature bearing trees can require more than 200 gallons per tree per day or 5,500 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 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. 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 putting any fertilizer adjoining the trunk. The efficiency of fertilizer and water utilization is much improved with weed control. Several months after planting and again in June, fertilizer can be applied at the rate of 1/2 pound per acre. Weed control for young trees can be accomplished by using 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, fertilizer can be applied 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 (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. A leaf analysis can be performed, particularly if deficiency or toxicity symptoms occur in leaves or if limb growth in insufficient. Deficiency or toxicity symptoms can be diagnosed by a discoloration of the leaves or a malformation of the leaves. 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 a broadcast application. 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 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. Based on the authors' experience the amount of nitrogen in the sufficient range appears to be lower than that listed in Table 2. A more accurate value for satisfactory values of N in pecan leaves may be closer to 2.3 to 3.2%.

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 been observed especially if not using a balanced fertilizer containing magnesium is used. 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.

Manganese deficiency can result in dwarfed rounded leaflets known as mouse ear. As in the case of zinc deficiency it is most common at high soil pH. It can be corrected by application of 2 to 10 pounds of manganese sulfate per tree. Recently it has been discovered that an application of nickel can reverse symptoms. Although there is increasing evidence that mouse ear may be due more directly to a nickel deficiency, the physiological basis remains unclear.

Tree Production and Alternate Bearing

Pecan yield and quality are influenced by tree age, cultivar and management program. Certain precocious cultivars, as young as 6 years old, can produce a small crop (10 to 30 pounds per tree, 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 of time.

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 are depleted by the end of the on year and yield the following year (the off year) is 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 exascerbate alternate bearing by 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. Pecan trees can be neglected for a few years where tall weeds are 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 where the pecan trees will 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 mix of pecan cultivars. If the trees consist of desirable cultivars (as indicated earlier in this publication) and there is little work 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. Ironically, poorly maintained orchards will often sustain less wind or storm damage than well maintained trees.

If renovation is decided upon, remove competing vegetation including saplings and create a weed-free in-row strip about 10 feet wide. On a short term basis, cattle can be grazed on the land if the vegetation is deemed suitable; just about any vegetation will be eaten by goats. After renovation, the pecan foliage should shade any competing weed growth. Remove all scaffold or lateral limbs that fall below a height of 5 feet above the ground. Limbs that are too close together may have to be removed. If trees are overcrowded and need to be thinned, they may need to be pruned and alternate trees eventually removed. Fertilizer should be applied at the rates indicated above, although low fertilization rates may reduce limb breakage of a neglected orchard. Nutritional deficiencies need to be corrected by first conducting a leaf nutrient analysis (as indicated above), and then by application of the limiting nutrients.

Mistletoe is a parasite of pecan trees, and diverts nutrients from the tree (Figure 16). 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 and is a symptom of low tree vigor (Figure 17). Rather it 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. A grower may wish to control Spanish moss. It can be controlled by applying10 pounds of copper sulfate per 100 gallons of water during the dormant season. Lichens are symbiotic combinations of algae and fungi. Lichens adhere to the surface of the bark and even rocks. When it is prevalent on trees it is a symptom of low tree vigor. No control of lichens is recommended, as it does not harm the tree.

Figure 16. A mistletoe infestation on a mature pecan tree during the dormant season.

Figure 17. A pecan tree with a heavy infestation of Spanish moss during the dormant season.

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 since 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 since the price reflects the fact that the land could have alternative 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 1/2 to 2/3 of the costs are due to variable costs (materials, equipment and machinery), and the remainder are fixed costs (depreciation, interest and overhead).

The price of pecans has been relatively stable over the last 10 years at about $1.00 to $1.50 per pound for in-shell nuts. The fact that pecans have not increased in value is, in part, due to a less than optimum level of organization among growers from different states. It should be mentioned that recently there have been substantial efforts to improve pecan marketing, such as promoting pecans as a good source of high density lipoproteins.

Mammal and Bird Pest Problems

Squirrels are the main mammal pests of pecans, and 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 a woodland or adjacent to other trees, such that, squirrels never have to hit the ground to reach the pecan tree. Running on the ground of a field is hazardous to squirrels as they are subject 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, as it seems as though there is a never ending supply of replacements. 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 via rubbing their antlers against pecan wood. This 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 like squirrels, it sometimes seems as though there can be a never ending supply of them. Remember not to hunt deer out of season. Deer are not usually a big problem after the first 10 years of establishment as the trunk of a pecan is sufficiently strong to withstand deer.

The number of pecan nuts a flock of crows can consume is substantial. Noise makers and hunting are options for commercial orchards, while there are no good options for pecans in a homeowner setting. Rabbits can girdle young pecan trees during the first two years of tree establishment.

Potential insect and disease problems of pecan trees and nuts are very numerous. The reader is referred to the University of Florida Insect Control Guide for the control of insects and the University of Florida Plant Disease Management Guide for the control of plant pathogens.

Suggested Further Reading:

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Sparks, D. 1992. Pecan Cultivars, The Orchards Foundation. Pecan Production Innovation, Watkinsville Georgia.

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Table 1. A summary of pecan varieties.

Variety	Harvest season	Scab Resistance	Precocity*	Ease of cracking	% Kernel	Kernel quality	Pollination**
Cape Fear	Early	Fair	Good	Good	Fair	Fair	Protandrous
Curtis	Late	Good	Fair	Good	Good	Good	Protogynous
Desirable	Mid-Late	Good	Fair	Good	Good	Good	Protandrous
Elliott	Mid	Good	Fair	Fair	Good	Good	Protogynous
Gloria Grande	Early	Good	Poor	Poor	Good	Good	Protogynous
Moreland	Mid	Fair	Fair	Good	Fair	Good	Protogynous
Stuart	Mid	Fair	Poor	Poor	Fair	Fair	Protogynous
Sumner	Late	Good	Good	Fair	Good	Good	Protogynous

*Precocity refers to the age when a tree begins to bear. A good precocious variety will normally bear a few nuts the fourth year.

**With a protandrous variety, the pollen (male) is mature most years before the stigma (female) is receptive. With a protogynous variety, the stigma is receptive most years before teh pollen is mature. It is desirable to interplant protandrous and protogynous varieties.

Table 2. Average Periods of Pollen Shedding and Stigma Receptivity, Tifton, Ga. From Worley et al. 1983.

Cultivar	Period of stigma receptivity	Period of pollen shedding
Cape Fear	April 22-May 4	April 23-April 30
Desirable	April 23-May 4	April 22-May 30
Sumner	April 23-May 4	April 24-April 30
Curtis	April 26-May 3	May 1-May 11
Elliott	April 19-April 30	April 29-May 6
Gloria Grande	April 23-May 2	May 1- May 12
Stuart	April 28-May 6	May 3-May 12

Table 3. Recommended nutrient levels of pecan leaves.

Element	**Low**	Sufficient	High
		%	
N	2.40-2.69	2.70-3.50	>3.5
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
		ppm	
B	<15	15-50	>50
Cu	<6	6-30	>30
Fe	30-49	50-300	>300
Mn	<200	200-500	>500
Zn	<50	50-100	>100

From Jones et al. 1991.