#### PEGAN 101 PECAN 101 PECAN

Pecan Enterprise in the Southern Great Plains

by: Steve Upson, Charles Rohla, Ph.D., James Locke, Job Springer NF-HO-12-01 THE SAMUEL ROBERTS **NOBLE** F O U N D A T I O N Agricultural Division

### **Table of Contents**

Introduction	
Preplant Considerations Goal Setting Equipment Requirements Soils Irrigation Water Farm Access Cultivar Selection Weed Control (prior to planting) Soil Testing Irrigation System Selection and Installation	1
Crop Management Orchard Establishment Training and Pruning Nutrition Irrigation Scheduling Crop Load Management Orchard Floor Management	
Pest Management Insects Disease Applying Pesticides Safely Wildlife	21
Harvest Guidelines Preparation Harvesting	
Post-harvest Handling Cleaning Sizing Drying Grading Pricing Storage Food Safety Pecan Sanitizing Regulations	
Economics Marketing Pecan Budgets	
Pecan Management Calendar Establishment, Year 1 Pre-production, Year 2 Pre-production, years 3-6 to 8 Production years, years 6-8+	
Additional Information	34

### Introduction

Pecan is an important crop in the Southern Great Plains. Recent USDA crop statistics report 175,542 acres of pecans in Texas and 141,765 acres in Oklahoma, with the majority of the acreage consisting of native pecans. Spurred on by record prices received by growers in 2010 due to increased global demand for pecans, many new commercial, improved cultivar orchards are being established and neglected orchards are being renovated.

Pecans are a natural health food. Research conducted at Loma Linda University (www.ilovepecans.org/ pr\_20110111.html) and published in January 2011 shows that pecans contain compounds with antioxidant properties that may contribute to disease prevention.

Earlier research at Loma Linda showed consumption of pecans reduces the buildup of LDL cholesterol, the so-called bad cholesterol, which can lead to heart disease. Pecans contain more than 19 vitamins and minerals, including vitamins A and E, several B vitamins, folic acid, calcium, magnesium, phosphate, potassium and zinc. The oil in pecans is 92 to 97 percent unsaturated, classifying the crop as a heart-healthy food.

According to the USDA National Agricultural Statistics Service, the average in-shell wholesale value of improved varieties marketed in Oklahoma during 2008-2010 was \$1.73 per pound. Growers who market their crop directly routinely obtain twice this amount or even more, depending on location. Improved variety trees can average more than 1,000 pounds of nuts per acre if properly managed.

## Preplant Considerations

#### **Goal Setting**

When formulating goals for your orchard, consider the feelings of family members, your financial situation, the farm- or business-related talents family members have (or don't have) and more. Consider these questions: Do you consider caring for an orchard a hobby and a way of achieving a quality of life for the family? By planting a pecan orchard, are you simply trying to keep your property zoned as agricultural to qualify for certain tax exemptions? Do you want your orchard to produce a supplemental or full income for your family?

If you are serious about the orchard generating income, consider these

questions: Are you realistic about how much income can be realized? Who will do the work? Do you have business skills and can you perform necessary crop management to make the enterprise succeed?

All too often, growers err on the side of planting more trees than they can manage. Improved variety orchards can require as much as \$4,500 per acre to bring into production, and often there may not be enough money to accomplish basic management needs. It's easy to read about growing pecans; however, it takes time and experience to become a successful grower. For this reason, beginning growers need to start small so they can learn as they go. Once the basics are understood, then the orchard can be expanded to the size that money, labor and available natural resources will allow.

When developing goals, make them SMART: specific, measurable, achievable, realistic and timely. Smart goals are focused and real-world-based. For more information on goal setting and a worksheet to help you specify goals for your pecan business, refer to *Goal Setting for Farm and Ranch Families* at pods.dasnr.okstate.edu/docushare/dsweb/ Get/Document-1674.

#### **Equipment Requirements**

The minimum equipment required to manage and harvest pecans includes an air-blast sprayer, tree shaker and harvester. This assumes that the grower owns or has access to a tractor with the horsepower required to power the equipment.

During orchard establishment, minimal equipment is needed. An auger is required for planting trees. A water tank is required to water trees at planting. A bumper pull trailer is useful for transporting trees to the planting site.

A backpack- or all-terrain-vehicle (ATV)-mounted spot sprayer is required to apply herbicide around the base of newly planted trees to control weeds. A separate sprayer will be needed to make zinc and occasional pesticide applications to small trees. As the orchard matures, a boom sprayer will be needed to maintain a weed-free zone in each tree row. You'll also need a mower to maintain the groundcover between tree rows.

As the trees grow larger, more powerful

and expensive equipment is needed. Air blast sprayers must have the capacity to reach the top of the trees. Three-pointmounted air blast sprayers equipped with 50- to 100-gallon tanks are ideal for spraying small trees just coming into production or small orchards that are a few acres in size. Additionally, pushpowered and ATV-pulled harvesters are available for small-scale operations.

On mature, producing orchards, 100 gallons of spray solution per acre is required to apply most pesticides. Sprayers having a minimum 500-gallon capacity are recommended. Tractor horsepower requirements for operating large pull-behind sprayers range from 45 to 120 horsepower.

Shakers must be large enough to clamp the largest tree, but not so large that young trees cannot be clamped or are damaged by the weight of the shaker. A shaker capable of shaking trees up to 38 inches in diameter, requiring a minimum 45 horsepower to operate, is available from Savage Equipment (www. savageequipment.com).

To lower start-up costs, many growers opt to purchase used equipment. Used equipment can be purchased from other growers, at auctions and from equipment dealers. Also check the classified section of *Pecan South* magazine (tpga. org/magazine.html). It's an excellent source for used equipment. To help pay for equipment, many growers offer spray and harvest services to neighboring orchards. Typical custom management rates range from 50 to 80 percent of the crop received by the manager.

Displays and demonstrations of pecan equipment are available at the annual Oklahoma Pecan Growers Association meeting, Texas Pecan Growers Association meeting and at pecan field days held throughout the growing season.

Growers planning to market in-shell or shelled pecans directly to the public will need to invest in additional specialized equipment, including a nut sizer, sanitizer, cracker and sheller.



(above) Once pecan trees mature, an air blast sprayer is needed to apply pesticide to the tops of trees. Three-point-mounted sprayers with 50- to 100-gallon tanks are sufficient for small trees or small orchards. Sprayers with a minimum 500-gallon capacity are recommended for mature, producing orchards.



(top, left) A tree shaker is an important piece of equipment for the producing pecan orchard. Shakers must be large enough to clamp the largest tree, but not so large that young trees cannot be clamped or are damaged by the weight of the shaker. Shaking time generally ranges from six to 10 seconds. (top, right) Small producers may opt to hand-harvest nuts, simply picking them up from the orchard floor. Large pecan operations rely on commercial harvesters to quickly and more efficiently collect the nuts. Regardless of the collection method, nuts should be harvested immediately after shaking. (bottom) To save money, many pieces of equipment can be purchased used or modified from existing machinery. This is an example of a boom sprayer that has been modified to maintain a weed-free strip in the tree rows.

#### Soils

When evaluating a prospective site for establishing a commercial pecan orchard, start by evaluating the soil. While pecan trees will grow on many types of soils, they prefer deep, well-drained soils. Shallow upland soils with poor drainage or very sandy soils with low waterholding capacity are usually not good choices for commercial pecan production.

Start your evaluation by consulting the county soil survey. It will include detailed information on the texture, depth, water infiltration rate, water-holding capacity, basic fertility, drainage characteristics, slope, and other physical and chemical characteristics of the soil in question. Printed copies of the soil survey are available from the Soil Conservation Service office. Soil surveys for most counties are available online at websoilsurvey.nrcs. usda.gov/app. You also want to evaluate the soil in person. Check soil depth and layers by digging into it with a shovel, posthole digger or backhoe. Dig several feet deep in several spots. An important factor is the depth to rock - the deeper, the better.

Soil drainage, both surface and subsurface, is important to a pecan site. Sites that do not drain well are not suitable for pecan production. Some sites located adjacent to streams could be classified as wetlands, which may rule out their use for pecan orchards. If in doubt, check with your local county NRCS Service Center (offices.sc.egov.usda.gov/locator/ app?agency=nrcs).

Surface drainage problems, exclusive of designated wetlands, can often be corrected during site preparation. This should always be done before planting. Seek the assistance of the NRCS when designing a drainage plan for your site.

When evaluating a site for internal or subsurface drainage, start by observing other trees in the area. In soil that is saturated with water for long periods, oxygen is displaced, preventing root growth. Look for signs of terminal dieback, thin or sparse canopy, or generally unthrifty (stunted) growth. Areas that remain wet for extended periods following a heavy rain are poorly drained.

To determine the internal drainage of your soil, dig a hole 32 inches deep with a posthole digger. Fill the hole with water and allow it to drain, then refill it with water. Evaluate how long it takes



(top) In soil that is saturated with water for long periods, oxygen is displaced, preventing root growth. These trees are experiencing a condition called terminal dieback, indicative of poorly drained soil. (bottom) A simple test can determine the internal drainage of the soil. First, dig a hole 32 inches deep with a posthole digger. Fill the hole with water and allow it to drain, then refill it with water. Evaluate how long it takes this second fill to drain. If water is left in the hole after 48 hours, then the soil is restricted in its ability to drain internally. this second fill to drain. If water is left in the hole after 48 hours, then the soil is restricted in its ability to drain internally. Expect significant reduction in production on sites with 12 inches of drainage or less. If the drainage is between 12 and 32 inches, the production potential will be increased in proportion to the observed drainage. On sites that exhibit 32 inches of drainage within 48 hours, production potential may range as high as 2,000 pounds per acre.

The water table (the level below the soil surface which is completely saturated with water) is another important factor to consider during site analysis. Because tree roots will not grow into the water table, the water table should be at least 5 feet below the soil surface to provide adequate rooting area. The water table can vary in depth during different times of the year and is usually at its greatest depth during summer. The water level in nearby waterways can be an indicator of water table depth.

#### **Irrigation Water**

Large quantities of good quality irrigation water are necessary for intensive management of an improved variety pecan orchard. Sources of irrigation water include groundwater (subsurface) and surface water, i.e., streams and lakes.

In both Oklahoma and Texas, stream water is the property of the state and use requires a water permit. Groundwater, on the other hand, is owned by the property owner. However, if you are irrigating anything larger than 3 acres or using more than 2 acre-feet of water per year in Oklahoma, you are required to file for a water permit. In Texas, unless you own land in an area in which water is controlled by a conservation district, there are currently no restraints on the amount of water that can be pumped, as long as it is from beneath your land and not adjacent land. For information on applying for a water use permit in Oklahoma, see www.owrb.ok.gov; in Texas, see www.tceq.state.tx.us.

A common mistake made by many prospective pecan growers is to overestimate the capacity of recreational and stock ponds to supply water for irrigation. During the summer months, a mature pecan orchard can use as much as 2 acre-inches of water (54,000 gallons) per week. At this rate, a 1-acre pond with an average depth of 10 feet would be emptied in only six weeks when used to irrigate a 10-acre orchard. In reality, the time would be shorter because of evaporative loss from the pond surface.

The water source should be tested for quality before the orchard is planted. Analyses of electrical conductivity, total soluble salts, boron and sodium adsorption ratio are important factors to consider. Pecans are sensitive to salinity. Although rainfall is very low in salt content, some surface water and groundwater may have high salt levels. Irrigation water evaporates from the soil surface or is absorbed by plant roots, leaving salt behind. This causes the salt content of irrigated soils to build over time. If sufficient rainfall occurs, natural leaching will wash the salts below the root zone of the crop and production will not be affected. Ideally, the concentration of dissolved salts in irrigation water should be less than 1,200 ppm (parts per million). According to the Oklahoma State University (OSU) Pecan Management Course,

one should expect a yield reduction as the salinity increases above 1,200 ppm. The higher the salt content of the irrigation water, the more rapidly the soil salt content will rise.

Excessive sodium in irrigation water reduces water infiltration into the soil. It is toxic to plants at high concentrations, but is also of concern because of its effect on soil structure. High sodium concentrations in soil lead to dispersion of clay particles, which seals the soil pores and reduces the infiltration of water.

Pecans are also very sensitive to boron (B). Soil concentration above 1.0 ppm B will cause yield reduction. High boron in the irrigation water may eventually result in increased boron content.

For detailed information on submitting a water sample for irrigation quality analysis, refer to one of the following sources: Noble Foundation agricultural testing laboratory (www.noble.org/Ag/ TestingServices), Oklahoma State University (http://www.soiltesting.okstate.edu/ pricelist.htm) or Texas A&M (soiltesting. tamu.edu).

For a detailed discussion on irrigation water quality, refer to the fact sheet entitled *Classification of Irrigation Water Quality* (pods.dasnr.okstate.edu/ docushare/dsweb/Get/Document-2223).

#### **Farm Access**

If the pecan enterprise includes retail sales at the orchard, then market access can be an important component of site selection. Some fairly remote orchards have built good retail sales at the orchard. However, with more convenient access, e.g., highway visibility, the easier it is to attract customers. This is particularly true for walk-in sales.

#### **Cultivar Selection**

Cultivar selection is one of the most important decisions in establishing a pecan orchard. Hundreds of cultivars exist. Over the years, many native trees producing nuts with desirable characteristics have been named and grafted as cultivars. Only a very few of these have become established as outstanding cultivars. Most of the cultivars planted today have originated as controlled crosses from a public or private breeding program. For a list of recommended cultivars for Oklahoma and Texas, refer to *Pecan Varieties for Oklahoma* (pods. dasnr.okstate.edu/docushare/dsweb/Get/ Document-1027) or *Improved Pecans* (aggie-horticulture.tamu.edu/publications/ fruit-nut/improved-pecans.pdf). Another excellent source of information on pecan cultivars, complete with color pictures of the nuts and kernels, is available from Texas A&M at extension-horticulture. tamu.edu/carya/pecans/pecalph.htm.

When choosing cultivars, keep in mind that there is no such thing as a perfect cultivar. Every cultivar has strong and weak points. Some have more weak points than others. Criteria used to evaluate pecan cultivars include yield, nut size, shell thickness, kernel percentage, maturity date, disease susceptibility and cold hardiness.

Cultivars with larger nut size are more prone to poor kernel fill during periods of drought if not irrigated. Some cultivars tend to reach bud break (when the leaf emerges) too early in the spring, making them more susceptible to late spring freezes. Other cultivars mature late in the fall. If a freeze occurs before the nuts are mature (prior to shuck split), the nuts are worthless. Cultivars susceptible to scab, a fungal disease, will require fungicide treatments, especially when grown in low lying, humid areas with restricted air movement. Only cultivars with documented cold hardiness should be grown north of Interstate 40.

Pecan trees produce male and female flowers on the same tree, but at different locations. The male flower, the catkin, provides the pollen. The female flower, the pistil, forms the nut. With most pecan trees, native or improved cultivar, pollen produced by any one tree is incapable of pollinating a female flower on the same tree because the female flower is not receptive when the pollen is shed. Some trees shed pollen before the female flower is receptive (protandrous or early pollen shedding), and some shed pollen after the female flower is receptive (protogynous or late pollen shedding). Consequently, pecan trees require pollination by a different cultivar or a native tree.

An orchard should be composed of at least two early-pollen-shedding and two late-pollen-shedding cultivars to ensure adequate cross-pollination. The longest distance for the windborne pollen to travel should be about 150 feet. Thus, a block of a single cultivar should be no more than 300 to 320 feet wide with a suitable pollinator on either side.

Growers planting improved cultivar orchards without the benefit of irrigation will need to select cultivars that produce small nuts (about 70 nuts per pound). Non-irrigated orchards are generally managed at a lower intensity compared to irrigated orchards. Characteristics of a low intensity (low input) orchard include little or no fungicides, minimal insecticides, lower nitrogen and potassium fertilization, and infrequent fruit thinning. Sometimes low input orchards are double-cropped with livestock.



Pecan trees produce both male and female flowers on the same tree, but at different locations. The male flower, the catkin (above), provides the pollen. With most pecan trees, pollen produced by any one tree is incapable of pollinating a female flower on the same tree because the female flower is not receptive when the pollen is shed.



The female flower, the pistil (above), forms the nut. An orchard should be composed of at least two early pollen-shedding and two late pollen-shedding cultivars to ensure adequate crosspollination. A block of a single cultivar should be no more than 300 to 320 feet wide with a suitable pollinator on either side.

Because of their small size, nuts are sold mostly on the shelling market.

Customers purchasing pecans directly from the grower prefer large nuts. Producing large pecans does not come without a price. In general, the larger the nut, the more difficult and expensive it is to consistently grow a high quality crop.

#### **Orchard Design**

Ideal initial tree spacing for an irrigated orchard is 40 feet x 40 feet. Trees can be planted at a closer spacing providing greater early yields; however, the orchard will become crowded more quickly, requiring earlier tree removal to prevent yield reduction as the orchard ages.

A 40-foot x 40-foot spacing equals 27 trees per acre. Pollinator rows should be no more than eight rows apart (320 feet) and should remain in position after tree thinning. At this spacing, thinning should not be needed until the trees are about 20 years old. The first thinning should be initiated before more than 60 percent of the orchard floor is shaded at solar noon.

At about 35 years old, the final spacing should be 80 feet x 80 feet, with seven trees per acre. Temporary trees, to be removed during the first thinning, provide a good opportunity to plant cultivars that perform well when they are young, but develop problems when they are older. Trees used as temporaries may tend to overbear, have weak wood or produce poor quality nuts as the trees mature. The Caddo cultivar is a good example of a temporary tree.

Some growers prefer to leave more space between trees to allow intercropping during establishment. Hay is commonly grown in young orchards to generate cash flow. This may be economical in some cases, provided the forage crop does not compete with the trees for nutrients and water, and the haying equipment does not damage the trees.

The recommended spacing for non-irrigated orchards is 50 feet x 50 feet. For a detailed discussion on orchard design, refer to *Establishing a Pecan Orchard* (pods.dasnr.okstate.edu/ docushare/dsweb/Get/Document-1047).

#### Weed Control (prior to planting)

Perennial weeds, such as bermudagrass and johnsongrass, should be eradicated in the tree row before planting. During the summer or fall before planting, use a boom-type sprayer to apply glyphosate herbicide to control weeds in a strip 6 feet wide – 3 feet to either side of the designated tree row center line. Apply glyphosate at the rate of 1 quart per acre (4-pound-per-gallon formulation). Refer to the glyphosate label to determine if a surfactant is necessary.

#### Soil Testing

During the fall before the trees are to be planted, collect a soil sample from the planting site. The value of the sample is directly related to the care with which the sample is collected. Improperly collected soil samples are the weak link in the soil testing process. For test results to be useful, the sample must accurately reflect the variability and conditions in the field. A sample from a single spot cannot do this. For detailed instructions on collecting a soil sample and submitting a sample, see the Noble Foundation's *Soil Sample Entry Form* at www.noble.org/ Ag/TestingServices/SoilSampleForm.pdf.

A routine soil analysis is usually adequate. At the Noble Foundation, routine soil samples are analyzed for soil pH, lime requirement, nitrate nitrogen, phosphorus, potassium, calcium, magnesium, sodium, soluble salts, organic matter and calculated CEC. If your site is excessively well drained – a common characteristic of most sandy, coarse textured soils – a micronutrient analysis, including zinc, is also recommended.

Soil samples may be submitted to the Noble Foundation agricultural testing laboratory or taken to your county Oklahoma State University Extension office or Texas AgriLife Extension office. Your Extension agent or Noble Foundation horticulture consultant will make preplanting fertilizer recommendations based on test results. Another option available to you is to use test results in conjunction with the OSU fact sheet *Fertilizing Pecan and Fruit Trees* (pods. dasnr.okstate.edu/docushare/dsweb/Get/ Document-1010).

An acceptable soil pH is 6.2 to 7.0. Soil pH outside this range can affect nutrient availability. A low soil pH restricts root growth and can adversely affect kernel quality. If lime is required, the sample report will list the amount to apply to adjust the ph to 6.8. Lime is best applied in the fall or winter prior to planting.

Soil phosphorus (P) should test at least 65 pounds per acre and potassium (K) at least 250 pounds per acre. Compare the P and K levels from the soil test report with Table 1 in *Fertilizing Pecan and Fruit Trees*, and apply a broadcast application prior to planting if needed. For best utilization, the fertilizer should be incorporated into the soil soon after application.

Nitrogen (N) will be applied during the growing season and does not need to be applied prior to planting.

### Irrigation System Selection and Installation

Water can be delivered to the trees by several methods. Flood irrigation is generally low in initial cost, with less energy requirement, but it is also low in application efficiency (30 percent to 70 percent) and can interfere with orchard access during critical management periods. Flood irrigation can only be used on sites having a gentle, uniform slope.

Sprinkler systems, solid set or traveling gun, are commonly used in Oklahoma and Texas orchards. Because they are portable, traveling guns are less of an impediment to movement of equipment throughout the orchard compared to a solid set system. On the downside, most traveling guns require a high operating pressure, 100 psi and above, and have only 60 percent to 70 percent application efficiency.

Micro-irrigation systems incorporate micro-sprinklers, drip tubing or a combination of the two. Because of its low operating pressure and precise water placement, a properly designed microirrigation system can be over 90 percent efficient. However, such systems have high initial costs, are not portable and require very clean water because they are more susceptible to emitter plugging. Despite these limitations, micro-irrigation is the predominant irrigation delivery system used in commercial pecan orchards.

Soil type is generally the determining factor when selecting a micro-irrigation delivery system. Loam and clay loam soils are best suited to drip irrigation because water is capable of moving horizontally, limiting the number of









(top, left) The traveling gun impact sprinkler has traditionally been used in Oklahoma and Texas orchards. It has the advantage of portability, but is much less efficient than alternative micro-irrigation systems. (top, right) Impact sprinklers have a 60 percent to 70 percent application efficiency. (bottom, left) Loam and clay loam soils are best suited to drip micro-irrigation because water is capable of moving horizontally. Because of their low operating pressure and precise water placement, micro-irrigation systems can be over 90 percent efficient. (bottom, right) Micro-sprinklers may be a better choice when drip emitters wet the soil less than 6 feet in width. Although micro-irrigation systems have higher installation costs, their efficiency makes them the predominant irrigation system used in commercial orchards. emitters and/or emitter lines required to cover the entire rooting area of a tree. If a drip emitter wetted width is less than 6 feet, as on sandy soils, the number of emitters required becomes very large, making micro-sprinklers a better choice. However, drip emitters are sometimes used on sandy soils where there is an underlying loam or clay loam layer. In this situation, the underlying layer causes the applied water to move horizontally.

The pipe and pump must be compatible and capable of carrying the volume of water needed during peak demand times. Consult with an irrigation design specialist before purchasing equipment. Before talking with the designer, know the yield capacity of your well, results from your irrigation water quality test, the orchard soil type and the energy sources available for pump operation. Have clear objectives for the system with regard to initial capital cost limitations, labor requirements and degree of system automation.

Most irrigation systems in Oklahoma are designed to supplement rainfall rather than supply 100 percent of the trees' requirement. In Oklahoma, the irrigation system should be designed to deliver a minimum of 3,000 gallons of water per acre per day during the summer. In most years, this amount is sufficient to create an adequate drought cushion, extending the time trees can go between rainfalls before experiencing drought stress.

Micro-irrigation systems should be designed to apply the recommended daily amount in 10 hours or less per zone, with a maximum system operating time of 20 hours per day. Irrigating any zone longer than 12 hours may result in waterlogging and insufficient oxygen for roots.

Getting a head start on irrigation system installation will reduce the amount of hand watering required until the system is fully operational. At a minimum, the pump should be installed along with the head unit (check valve, pressure regulator, filter, fertilizer injector, etc.) and all main lines prior to planting.

### Crop Management

#### **Orchard Establishment**

It is recommended that trees being planted in an orchard be propagated to a proven cultivar. This is usually done by grafting or budding (using a bud for propagation instead of graftwood), and can be done before or after the tree is planted. Grafted trees consist of a rootstock and a propagated cultivar. A rootstock imparts certain desirable traits to a tree such as vigor, uniformity, disease resistance and cold hardiness. The primary concern of rootstock to Oklahoma's pecan industry is cold hardiness, especially north of Interstate 40. Seedling rootstocks from northern cultivars, e.g., Giles, Peruque and Kanza, better enable the tree to withstand Oklahoma's range of weather. Trees grafted onto southern nuts, e.g., Riverside or Elliot, are more likely to be damaged by early or late freezes, or exceedingly low winter temperatures that can occur in Oklahoma. Seedling trees from nuts native to the area also tend to tolerate cold better than trees from nuts produced farther south.

Pecan trees are available from nurseries as grafted or ungrafted (seedling) trees. Grafted trees cost more than ungrafted trees. Ungrafted trees must be grafted in the orchard, usually after the second growing season, which means an additional year or two of establishment. For more information on grafting, refer to the following OSU fact sheets: *Bark Grafting Pecans* (pods.dasnr.okstate.edu/ docushare/dsweb/Get/Document-1040); *Splice and Tongue Grafting Pecans* (pods. dasnr.okstate.edu/docushare/dsweb/ Get/Document-1020); *Patch Budding*  *Pecans* (pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-1049); and *Four-flap Grafting of Pecans* (pods. dasnr.okstate.edu/docushare/dsweb/Get/ Document-1034).

Grafting is both a science and an art. Repetition is required to become proficient in grafting. Because most growers are not seasoned grafters, the most popular option chosen to establish an orchard is to plant grafted trees.

The most skilled grafter will have limited success unless he has access to healthy graftwood. The buds on the graftwood contain the growing points which will constitute the new and improved tree. It is critical that they be alive and healthy at the time of grafting or budding. Graftwood is collected during the dormant season before the buds start to swell, usually late January to early March in Oklahoma, then stored under moist (not wet), cool (not freezing) conditions until time to graft or bud, which is usually late April through May in Oklahoma. For more detailed information on collecting and storing graftwood, refer to Collecting and Storing Pecan Propagation Wood (pods. dasnr.okstate.edu/docushare/dsweb/Get/ Document-1048).

Graftwood can also be purchased. A list of propagation wood suppliers in Oklahoma is available from OSU at www. hortla.okstate.edu/pecan/images/graftwood.pdf. A few pecan nurseries carry graftwood. Call to check on availability.

At the nursery, pecan trees are either grown in the field and harvested as bareroot trees or produced in containers. Bareroot trees are typically dug up during the dormant season and shipped during late winter for planting in late February or March. Container-grown trees are usually more expensive, but offer the grower flexibility with respect to planting time since they can be planted in the fall or the spring.

Proper planting is important to tree survival. Regardless of the type of tree used, the most important practices during the first year are watering, weed control and control of leaf-feeding insects. Bareroot trees should be planted before they reach bud break in the spring. February or early March is best. Select the best adapted cultivars for your location. The pecan treetop is dormant at planting time, but the roots are not. It is extremely important to prevent drying or freezing of the roots during or after planting. Damp burlap or another suitable cover should be used at planting time to prevent damage to the tree roots from exposure to sun or wind.

Dig a hole 8 to 10 inches wide and 18 inches deep. The hole needs to be wide enough to accommodate the root system of the tree without twisting the roots. A tractor-powered auger is a time saver when planting large numbers of trees. A word of caution when using an auger to prepare planting holes – in moist clay soils, the auger has a tendency to seal off the sides of the hole, which can limit drainage and possibly damage the roots. Be sure to scarify the sides of the planting hole prior to planting. Welding a few bolts or pieces of rebar onto the side of the auger is an effective scarification technique.



(top, left) Pecan trees are either grown in the field and harvested as bareroot trees or produced in containers. Bareroot trees, such as this one, are typically dug up during the dormant season. Bareroot trees should be planted before they reach bud break in the spring – February or early March is best. (top, right) Container-grown trees are usually more expensive, but offer the grower flexibility with respect to planting time since they can be planted in the fall or the spring. Regardless of the type of tree used, the most important practices during the first year are watering, weed control and control of insects. (bottom) A tractor-powered auger saves time when planting large numbers of trees. However, in moist clay soils, the auger can seal off the sides of the hole, which can limit drainage and possibly damage the roots. To prevent this, bolts have been welded to this auger to scarify the hole and facilitate drainage.







(top, right) Identify the previous soil line on the tree. The final planting depth should be about 1 inch shallower than it was in the nursery.



(bottom, left) In addition to positioning the tree 1 inch shallower than its nursery depth, fill in the soil according to drainage. Leave a shallow basin around the tree in well drained soils. Build a slight mound around trees in poorly drained soils. (bottom, right) Once the tree is in the ground and the soil has been settled through watering, remove about one-third to one-half of the top of the tree. Trim the taproot to about 18 inches long. Trim off all broken roots. Set the cut surface of the taproot on the bottom of the hole so it will not settle after watering. Final depth of the tree should be about 1 inch shallower than it was in the nursery.

On well drained soils, plant the tree leaving a shallow basin around the tree to make watering easier. On poorly drained soil, leave the soil slightly mounded around the tree so water will not collect around the tree after a rain.

Fill in around the tree roots with the same soil removed from the hole and tamp with the shovel handle until the hole is three-quarters full. Water the tree to settle the soil. Finish filling the hole and water again. Finally, remove about one-third to one-half of the top of the tree.

Container trees can be planted any time of year, but are best planted in early fall - September or early October - so some growth can occur before the first freeze. Dig a hole about twice the diameter of the container and about the same depth as the soil line in the container. Remove the tree from the container and trim off any roots that are growing in a circular fashion on the bottom. Knead the soil ball to loosen the roots. Set the root ball on the bottom of the hole and backfill with the soil from the hole. Tamp the soil around the root ball and water thoroughly. The green, growing top of the container tree is normally not pruned at planting, but may require tipping if the tree droops excessively.

Trunk guards (tree protectors) should be installed around the trunks of newly planted trees. Trunk guards are made of vinyl or heavyweight paper and can be cut to length for a custom fit. Trunk guards offer protection from sunscald and herbicide overspray. Trunk guards are available from nursery and horticulture supply companies.

Water is the most important factor in tree survival the first year. Formulate a watering plan before the trees are planted. Watch the trees for signs of borer infestation the first two years.

Always get trees from reputable sources. The trees should be healthy and of the cultivar specified in the order. A misidentified cultivar may go unnoticed for several years and is difficult to correct.

Weed competition is second only to water as a tree-growth-inhibiting factor



the first two or three years after planting. Grass and broadleaf weeds compete with the trees for water as well as nutrients. Some weeds exude substances that are injurious to pecan roots, inhibiting growth and delaying establishment of the orchard.

For maximum tree growth, the 6-footwide weed-free strip down each tree row established the previous summer should be maintained the first two years. In year three, the strip should be widened to 12 feet. If a weed-free strip cannot be maintained, a weed-free strip cannot be maintained, a weed-free circle around each tree is the next best option. Maintain a 6-foot-wide weed-free circle around each tree the first two years and increase it to 12 feet wide beginning in year three.

Glyphosate is the best herbicide option for controlling a mixture of annual and perennial broadleaf and grassy weeds. Use a shield to protect the trunk of new trees when applying glyphosate if the trees are not equipped with trunk guards. Selective herbicides such as Poast<sup>®</sup> and Select<sup>®</sup> are labeled for the control of grassy weeds in pecan orchards and will not harm trees if inadvertently sprayed. Check the label for rate and timing of application.

Organic mulches can also be used to control weeds and conserve moisture in newly established orchards. As an (above) To avoid grass and weed competition during the first two years, a 6-foot-wide weed-free strip should be maintained along tree rows. In year three, the strip should be widened to 12 feet.

added benefit, organic mulch serves as a slow release nutrient source as the plant materials decompose. If the orchard floor consists of bermudagrass, don't expect an organic mulch to provide adequate weed control. Occasional glyphosate treatments will be required to halt the intrusion of bermudagrass into the mulched area. For more information on orchard establishment, see *Bareroot Planting Basics* (www.noble.org/Ag/Horticulture/ BarerootPlanting).

#### **Training and Pruning**

Training is required to produce trees that will withstand the rigors of weather, crop load, harvest operations, cultural practices and pest control operations. Training includes such tasks as selection and maintenance of a central leader and selection of wide-angled scaffold branches that are uniformly spaced around the trunk.

To further explore these topics, here are some common terms used in the industry:

- Central leader The main trunk from which scaffolds emerge.
- Scaffold branch The main branch from the trunk, which forms the structure of the tree.
- Crotch angle angle of attachment of the lateral branch to the parent branch.
- Apical dominance the influence of the terminal bud in suppressing the growth of buds below it. The tallest branch on the tree has a similar effect as it will out-compete shorter branches.

Pecan trees grow in stages. The juvenile or seedling stage lasts the first five to six years or more after emergence of the seedling. During this time, most pecan trees tend toward a central leader growth habit. There is strong apical dominance and no fruiting wood is produced.

After juvenility, the wood becomes mature. The tendency then is away from the central leader to more branching and production of fruiting wood. Grafted trees show this tendency the first year after grafting. They require training from the outset to build a sturdy framework.

During the first growing season, when new terminal shoots are 4 to 6 inches long, select the uppermost vigorous shoot to be the central leader and remove all other competing shoots. Upright branches with terminals at the same height as the central leader will compete for carbohydrates, thus inhibiting growth of the central leader.

To encourage maximum caliper (trunk diameter) development, pinch out (remove with the fingers) the growing points of all shoots arising from the trunk leaving them 6 to 10 inches long. These stubby shoots are only temporary, but contribute to the growth of the tree without increasing in length. Repinching of these temporary shoots may be necessary if the tree makes vigorous growth.

During the first dormant season, tip all side shoots. Leave the leader 12 to 15 inches taller than any competing branches. If the leader is long and weak, cut it back about one-third. If you cut back the leader, shorten competing branches accordingly.

In the second full leaf season, begin to plan scaffold branches. The first scaffold should be about 5 to 7 feet high and facing the prevailing wind. All scaffold branches should have a 45 to 90 degree angle of attachment and be spaced 10 to 12 inches apart, and, to the degree possible, be evenly distributed around the trunk. Side limbs selected to become permanent scaffold branches are not headed back (shortened in length) unless they are taller than the central leader or are considerably longer than other scaffold branches. Remove the tips from side shoots that will not be used as scaffold branches.

In the second dormant season, remove any lateral branches more than 1 inch in diameter and below the height of the first scaffold. Remove any shoots along the central leader that have very narrow crotch angles. If more shoots are needed from which to select scaffold branches or if the leader is spindly, cut the leader back by about one-third. This encourages buds to break and new shoots to develop below the cut.

In subsequent years, continue the process of selecting scaffold branches. Training procedures may be repeated each year until the desired tree height is obtained or the tree height becomes too tall to continue training.

On certain occasions when suitable branches are unavailable, you will be forced to select scaffold branches with narrow crotch angles. Narrow crotch angles are inherently weak because bark gets trapped between the limb and the trunk as they both grow in diameter and prevents them from binding together. The crotch angle can easily be widened with limb spreaders when the branches are small. For additional information, refer to *Training Pecan Trees* (pods. dasnr.okstate.edu/docushare/dsweb/Get/ Document-1028).

During the life of the orchard, occasional pruning will be required to maintain tree health and vigor. Limbs that cross over other limbs or compete for the same space should be removed. Broken limbs resulting from wind or ice storms will require removal prior to harvest. Limbs that die as a result of shading or pest infestation are unproductive and require removal.

Thinning cuts are used to remove an entire branch at its point of origin. In order to prevent damaging the trunk when large branches are removed, a three-step cut (also known as a jump cut) is used. The first cut is made at least 12 inches from the trunk on the bottom of the limb to be removed, about one-third through, stopping before the saw pinches. The second cut is made on the top of the limb and 6 inches outside (towards the branch tip) the first cut. This allows the limb to split off at the first cut. The third cut is made by jumping over the first cut and removing the remaining stub at the point of attachment just outside the collar.

Large limb removal is usually done during the dormant season due to time availability, but can be made during the growing season to correct storm damage or other problems. The use of wound dressing in a commercial setting is generally not practiced because the benefit has not been documented. It may have aesthetic benefits in urban settings.

#### Nutrition

Maintaining healthy, well nourished trees is critical to producing good yields of high quality nuts every year. Investment in a good nutrition program affects this year's crop as well as the crop potential for next year.

The soil test is the proper measure for determining fertilizer requirements prior to planting. Soil testing is generally useful for preplanting needs only. The nutrient content of the tree and the soil are not well correlated since soil nutrients are not always available to the tree.

During establishment, pecan trees can be fertilized by the following general schedule using urea (46-0-0). If the soil test report indicates a phosphorus and/ or potassium deficiency, and fertilizer has

(opposite) This young tree has been trained to a central leader (the main trunk). The central leader should be left 12 to 15 inches taller than any competing branches. Scaffold branches, which emerge from the side of the tree, should have a 45 to 90 degree angle of attachment to the trunk and should be spaced 10 to 12 inches apart.



not been applied, apply a complete fertilizer such as 13-13-13 instead. The following rates are given on a per tree basis. Trees must be irrigated in the absence of rainfall to allow them to utilize fertilizer. Spread fertilizer on the ground around the base of each tree, avoiding concentrating it near the trunk.

Year 1: Do not fertilize the first year until there is sufficient growth (8 to 12 inches). If sufficient growth occurs, then fertilize with 1/3 pound 46-0-0 or 1 pound 13-13-13. Beginning at bud break, apply foliar zinc every 14 days through the end of July. Apply a mixture of 2 pounds 36 percent  $ZnSO_4$  per 100 gallons for large plantings or 1 1/2 tablespoons per gallon for small plantings. Be sure to wet all foliage.

Year 2: (apply *before* bud break) 1/2 pound 46-0-0 or 2 pounds 13-13-13. Follow Year 1 zinc recommendations.

Year 3: (apply in March) 1 pound 46-0-0 or 3 pounds 13-13-13. Follow Year 1 zinc recommendations.

Year 4 and beyond: Fertilize in accordance with a leaf analysis report.

The most reliable indicator of pecan tree fertility requirements is leaf analysis. Leaf analysis may be used to diagnose or confirm a particular nutrient problem in an orchard after symptoms are present. More importantly, leaf analysis can determine nutrient shortages or excesses before symptoms develop and yield is reduced. Frequently, it reveals that certain fertilizers being used are not needed, resulting in a more economical fertilizer program.

Leaf samples may be submitted to the Noble Foundation agricultural testing lab or taken to your county Oklahoma State University Extension office or Texas AgriLife Extension office. Your county Extension agent or Noble Foundation horticulture consultant will make pecan fertilizer recommendations based on test results. For detailed instructions on taking and submitting a leaf sample, see the publication *Plant Nutrient Analysis* (www.noble.org/Global/ag/testingservices/ LeafAnalysisInfoSheet.pdf).

If the soil pH has not been determined within the past five years, a soil test may be useful. Otherwise, a soil sample will not be necessary unless indicated by the leaf analysis recommendation.



(above) To perform a leaf analysis, collect 100 to 150 pairs of leaflets from the middle leaves along stems. Avoid leaves damaged by insects or disease.

#### Irrigation Scheduling

Irrigation scheduling (applying the proper amount of water at the proper time) saves water, reduces nutrient leaching, improves crop (nut) quality and saves money. Irrigation scheduling requires an understanding of the crop rooting depth, the soil water-holding capacity, the crop water use rate and the irrigation water delivery system. The water application depth and tree root depth must coincide. The effective rooting depth of most pecan trees is 3 to 4 feet, but most water and nutrient absorption occurs in the top 2 feet of soil.

Frequent application of relatively small amounts of water can reduce the soil volume explored by the root system, leading to increased irrigation dependency.

The soil water-holding capacity varies with soil type. Generally speaking, the water-holding capacity of a soil increases with decreased particle size. A sandy loam soil can hold about 1.25 inches of water per foot of soil whereas a silt loam can store up to 2.75 inches of water per

Table 1. Influence of Soil Texture on Available Water-holding Capacity		
	Available Water-holding Capacity	
Soil Texture	(inches of water per foot of soil)	
Sand	0.25 - 1.00	
Loamy sand	0.75 - 1.50	
Sandy loam	1.25 - 1.75	
Loam and silt loam	2.00 - 2.75	
Clay loam	1.75 - 2.50	
Clay	1.25 - 2.25	
Source: Fact sheet 657: Irrigation Scheduling with Tensiometers,		
Rutgers Cooperative Extension		

foot of soil. The only exception to this rule is clay, which is composed of smaller particles than a silt loam, but holds less water. Because it has lower water-holding capacity, sandy loam will need moisture, either from irrigation or rainfall, more often to meet the water requirements of a pecan tree.

The maximum allowable deficit refers to the amount of moisture that can be removed from the soil before crop damage occurs. Critical times of water need in the season include initial shoot growth from bud break to mid-May, post-pollination in mid-June, nut sizing in July and nut filling in September/ October. Depleting soil water below 50 percent during these critical times can slow tree growth, as well as reduce yield and quality.

The following examples illustrate the importance of soil type in determining maximum allowable deficit on a site using an effective rooting depth of 5 feet and maximum allowable deficit of 50 percent:

#### Example 1:

Soil type: Eufaula fine sand: waterholding capacity = 4/5 inches per foot of soil; 5 feet x 4/5 inches per foot x 50/100 = 2 inches. Trees can remove 2 inches of water from the soil without serious moisture stress.

#### Example 2:

Soil type: Durant loam: water-holding capacity = 2 1/5 inches per foot of soil; 5 feet x 2 1/5 inches per foot x 50/100= 5 1/2 inches. Trees growing in this soil can remove 5 1/2 inches of water from the soil without suffering serious moisture stress.



Irrigation interval, or time between irrigations, is determined by the length of time required to remove the water stored in the soil. That time varies with the evapotranspiration (ET) rate. Evapotranspiration refers to the loss of water to the atmosphere from ground evaporation and from leaf surfaces (transpiration). Higher ET rates mean shorter intervals are required between rainfall or irrigation. High solar radiation, high air temperature, high wind and low relative humidity act in concert to increase ET. On average, the maximum ET rate in central Oklahoma is about 0.3 inches per day from about mid-July to mid-August.

Table 2. Irrigation Guidelines for Using Tensiometers			
Soil Moisture and		Soil Tension	
Irrigation Status	Soil Texture	(centibars)	
Soil at field capacity (no irrigation required)	Sand, loamy sand	5 - 10	
	Sandy loam, loam, silt loam	10 - 20	
	Clay loam, clay	20 - 40	
50% of allowable	Sand, loamy sand	20 - 40	
(irrigation required)	Sandy Ioam, Ioam, silt Ioam	40 - 60	
(ingation required)	Clay loam, clay	50 - 100	
Source: Fact sheet 657 Irrigation Scheduling with Tensiometers,			
Rutgers Cooperative Extension			

(above) A tensiometer measures the adhesion of water to soil particles to determine soil moisture. It is a useful tool to aid irrigation scheduling.

At that rate, it would take about 18 days to deplete 50 percent of the stored water in the Durant loam soil.

The Pecan Irrigation Planner, a tool developed by the Oklahoma Mesonet staff, uses cumulative ET and rainfall values to calculate water balance for each weather monitoring station located in Oklahoma. Each county has at least one weather station. The water balance represents the amount of water a grower needs to apply since his last irrigation. The Pecan Irrigation Planner is a free service and can be accessed at agweather. mesonet.org/index.php/data/section/hort.

Tensiometers, trade name Irrometer<sup>®</sup>, and granular matrix sensors, trade name Watermark<sup>®</sup>, are examples of instruments that measure soil moisture and offer the grower another tool to schedule irrigation. As soil water content decreases as a result of evapotranspiration, the energy required by the crop to extract water increases due to increased adhesion (tension) of the water to soil particles. Irrometer<sup>®</sup> and Watermark<sup>®</sup> sensors are designed to measure this tension. Soil tension levels used to schedule irrigation vary with soil texture. With loamy sand, irrigation should begin when soil tension reaches 30 centibars (a unit of tension) and cease when it falls to 10 centibars. A soil tension reading of zero indicates complete saturation. In a finer textured soil, such as silt loam, there is no need to irrigate until soil tension reaches 50 centibars. These levels assume a 50 percent maximum allowable water deficit.

To provide an accurate picture of the soil profile moisture content, these instruments should be installed in tandem and placed within a foot of each other under the canopy of a healthy tree within the wetting pattern of a dripper or microsprinkler. The manufacturer recommends installing one instrument at 18 inches and the other at 36 inches. For additional information on using Irrometer<sup>®</sup> and Watermark<sup>®</sup> sensors to schedule irrigation, see www.irrometer.com/basics.html.

#### **Crop Load Management**

Excess fruit load causes several problems, including poorly developed kernel, especially in large-fruited cultivars. Overbearing also makes trees more susceptible to limb breakage and cold damage, as well as shuck disorders such as stick-tights and shuck decline.

Peach growers routinely remove part of the crop to assure larger, higher quality fruit. The same principle applies to pecan. During heavy crop years, thinning the nut load increases kernel percentage and grade, as well as nut weight. It also improves return bloom of some cultivars, reducing yield fluctuation from year to year and the tree's susceptibility to cold injury.

Pecan trees have a natural tendency to produce a heavy crop one year followed by one or more years of low production. This phenomenon, known as alternate bearing, can be reduced by judicious fruit thinning. Properly practiced, pecan fruit thinning can help ensure consistent yields of high quality nuts. Growers who can deliver consistent yields of high quality nuts can demand the highest price regardless of the market, retail or wholesale. Pecan cultivars vary in their tendency toward alternate bearing. Those that yield the most in the shortest time after establishment also tend to be the most severe alternate bearers. Flowers that produce



next year's crop are initiated during the time the current year's crop is maturing. Therefore, stress during flower initiation (caused by excess fruit load) affects next year's crop.

The more leaves the tree has per nut, the greater the chance that adequate carbohydrates will be available for both tree growth and nut production. Increased problems with over-production and poor fruit quality as trees mature are related to a decrease in the number of leaves per fruit, especially in heavy crop years. Nut thinning increases the leaf to nut ratio. Research has shown that each nut requires at least 10 leaves to produce a high quality nut.

Fruit thinning decreases total yield per tree in heavy crop years; however, research has shown this yield depression is compensated over time by stabilizing yield from year to year. This translates to a more stable cash flow from year to year.

Nut thinning before nuts begin to actively compete for a fixed amount of carbohydrate reserve provides each remaining nut with a greater supply of carbohydrates from which to draw. It also provides the tree with enough reserves to support a flower crop for the following season.

Research has shown that nuts should be removed when the ovule (immature seed)

(above) Properly managed nut thinning can help ensure consistent yields of high quality nuts. This cross section of a nut shows an ovule (immature seed) that is 50 percent expanded. This is the proper stage to thin nuts in large-fruited cultivars.

is 50 percent expanded for large-fruited cultivars such as "Pawnee" and up to 100 percent expanded for smaller-fruited cultivars such as "Kanza," but before the kernel enters the dough stage in either case. Determination of nut development is done by cutting nuts to expose the ovule.

The calendar time for thinning varies with cultivar and orchard location. Pawnee is usually ready to thin the first week of August in the Dallas vicinity and during the second week of August in the Oklahoma City area.

Thinning the nuts while they are too small requires force that can damage the tree. Thinning too late (after the nuts enter the dough stage) eliminates thinning benefits on kernel quality, return bloom and cold hardiness.

Nut thinning can be accomplished with a conventional tree shaker equipped with donut pads, which prevent injury to the tree trunk. As an additional precaution, apply a coating of grease between the rubber flap and the donut pad. This

Table 3. Optimum Crop Load Based on Cultivar Nut Size toEnsure Nut Quality and Return Bloom		
	Example	
Nut Size	Cultivar	Optimum Load
Greater than 70 nuts per pound	Kanza	60% to 70% fruiting shoots
50 to 70 nuts per pound	Pawnee	50% to 60% fruiting shoots
Less than 50 nuts per pound	Mohawk	45% to 50% fruiting shoots

allows movement at that point and prevents movement of the bark during tree shaking.

To determine if a tree requires nut thinning, count 100 terminal shoots in mid-canopy and calculate the percentage of shoots with at least one nut. With some repetition in counting fruiting shoots, you'll be able to judge crop load by simple visual estimation.

As the percentage of fruiting shoots increases above the optimum nut load, nut weight, return bloom, kernel percentage and grade decrease. The amount of shaking required for proper thinning varies with cultivar and requires good judgment by at least one observer on the ground. As the tractor operator shakes the tree, the observer must watch a predetermined area and estimate the percentage of fruiting shoots remaining on the tree. Do not look at the number of nuts on the ground. This tempts the shaker to stop too soon.

Heavily loaded Mohawk trees often need more than half of the crop removed to ensure quality nuts at harvest. Trees should be shaken in two to three second spurts until thinning is complete. Try variations in shaking – time, orientation, etc. – to determine the method that works best in each situation.

Proper management of crop load requires the grower to be thoroughly familiar with the orchard. Not all cultivars or trees within a cultivar will require nut thinning in a single year.

For a more detailed discussion of crop load management, see *Pecan Crop Load Management* (pods.dasnr.okstate.edu/ docushare/dsweb/Get/Document-1051).

#### **Orchard Floor Management**

The orchard floor in most commercial improved variety pecan orchards consists of ground cover between the tree rows, with a 12-foot-wide weed-free strip down each tree row. The ground cover, usually bermudagrass or a warm-season native sod, is maintained by mowing, and the weed-free strip is maintained by herbicide application and/or mulching. The mowed ground cover middle prevents or reduces erosion, and improves wet weather access for spraying and other orchard operations.

A vegetation-free orchard floor is discouraged due to increased erosion, decreased wet weather orchard accessibility and a dusty surface during harvest. Tillage equipment is prone to inflict injury to trunks and frequently damages shallow feeder roots.

A good orchard floor cover does not compete excessively with trees for moisture or nutrients. The bulk of the pecan's nutritional needs are met by small feeder roots, which are located near the soil surface. These roots come into direct competition with vegetation on the orchard floor. An effective orchard floor management program integrates the needs of the cover with the needs of the trees with respect to rooting depth, extent of rooting and time of year when water and nutrient demands peak.

Bermudagrass and other warm-season grasses are highly competitive with pecan trees for soil moisture and nutrients. Less competitive ground cover options include cool-season annual or perennial grasses, cool-season grass/legume combinations and legume combinations. Legumes, such as clover and vetch, have the added benefit of fixing soil nitrogen, thereby reducing the pecan nitrogen requirement. Research has confirmed that total nitrogen production from some legumes exceeds 100 pounds per acre. Examples of cool-season grasses include ryegrass and rescuegrass. Examples of cool-season grass/legume combinations include rescuegrass/arrowleaf and red or white clover. Specific examples of legume combinations include Dixie crimson clover/hairy vetch and Kenland red clover/ Louisiana S-1 white clover. Avoid using fescue as a ground cover, as it forms clumpy growth with age, making harvesting difficult.

Know the specific growing requirements of a ground cover when choosing which ones to establish. Ryegrass establishes and performs much better on heavier soils, while rescuegrass does much better on sandier soils. White clovers are more flood tolerant than red and annual clovers. Perennial legumes, e.g., red and white clover, are better adapted to finer textured soils, such as silt and clay loams, than are annuals, e.g., arrowleaf and crimson clover.

Following are resources for more information on selection and establishment of pecan ground cover:

- MBS Seed, Ltd. Planting Chart (www. mbsseed.com/planting%20chart.
- htm#cool season forages and crops) *Use of Legumes in Pecan Orchards* (pods.
- dasnr.okstate.edu/docushare/dsweb/ Get/Document-2570)
- Explore Forage Alternatives in Southern Plains Pecan Orchards (www.noble.org/ Ag/Forage/ForageAlternatives)

Most growers use a combination of pre-emergent and post-emergent herbicides to control vegetation in the tree rows. Pre-emergent herbicides are applied to a weed-free soil surface before the weeds germinate. After activation by rainfall, pre-emergent herbicides kill weed seeds as they germinate. Surflan<sup>®</sup> is an example of a pre-emergent herbicide labeled for use in pecans. Post-emergent herbicides kill weeds after they have germinated and started to grow. The chemical must contact the target plant. These chemicals may be translocated (move within the plant) or contact (kill only the plant part the chemical touches). Roundup<sup>®</sup> (glyphosate) is an example of a post-emerge herbicide. A common practice is to apply a tank mix of pre-emergent and post-emergent herbicide in late winter to both control any winter weeds that might be present as well as kill any warm-season weed seed that may germinate later in the season.

Post-emergent herbicides can be used as needed throughout the growing season to maintain a weed-free strip down each tree row.

Before applying any herbicide, be sure to consult the label. Do not exceed the rate specified on the label or trees may be injured. No single pre-emergent herbicide will control all weed species. Rotate herbicides from year to year to avoid resistant weed buildup and to prevent herbicide accumulation in the soil.

Weed Control in Pecans, Apples and Peaches (pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-1017) contains additional information on weed control in orchards.



(above) Vegetation-free orchard floors are discouraged due to increased erosion, decreased wet weather orchard accessibility and a dusty surface during harvest. The cool-season ryegrass floor in this orchard is less competitive with the trees than common warm-season alternatives such as bermudagrass.

### Pest Management

#### Insects

Over 100 species of insects are known to be pecan pests; however, only a handful cause significant economic damage on a yearly basis. Historically, the two most destructive pecan insects are the pecan nut casebearer and the pecan weevil.

The pecan casebearer larva (worm) feeds on developing nutlets (small immature nuts). From late May to early June in Oklahoma, casebearer moths begin to emerge and lay a single egg on a developing nutlet. Eggs change color from white to pink to red as they mature in four to six days. The larva is about 1/2 inch long when fully mature. One larva may bore into multiple nutlets and may destroy an entire cluster. A second generation of larvae, approximately 42 days later, can cause additional damage, but this is usually limited to single nuts.

Trapping of adult moths can be used early in each season to mark the arrival of the insects into an area and provide a guide on when to begin scouting for eggs and subsequent damage. Traps can be placed in the orchard in mid-May and monitored regularly until first capture of adult male moths. Approximately 12 to 16 days after first capture, larvae will begin to enter nutlets. Therefore, scouting for eggs should start 10 days after the first capture of adult moths. Scouting can be conducted by checking a minimum of 310 pecan clusters across an orchard. If two or more infested clusters (eggs or larval damage) are found before 310 nut clusters are examined, an insecticide application is warranted because the population is large enough to damage more than 5 percent of the crop.

An excellent tool to assist growers scouting for casebearer is the IPM PIPE website at pecan.ipmpipe.org. The site can aid decision making by producers by providing near real-time information from the field on pecan nut casebearer. Traps and models should be used as tools that can aid in the decision making process. They do not, however, replace the need for careful and timely scouting.

For additional information on the biology and control of this pest, see *The Pecan Nut Casebearer* (pods.dasnr. okstate.edu/docushare/dsweb/Get/ Document-1314).

Insecticide treatment guidelines are covered in *Commercial Pecan Insect and Disease Control - 2011* (pods. dasnr.okstate.edu/docushare/dsweb/Get/ Document-1330).

The pecan weevil is the most destructive late season pecan pest. The adult pecan weevil is a light brown, 1/2-inch-long beetle with a long snout. In Oklahoma, adult weevils start emerging from the soil as early as August and feed on nuts in the water stage (the stage of nut development when water fills the kernel cavity), causing them to drop. Weevil emergence varies by location, depending on soil type and soil moisture content. Weevils often emerge en masse, following a soaking rain.

The amount of loss from adult feeding averages about one nut every four days; therefore, early nut loss is minor compared to that inflicted later in the season when females lay eggs. In addition, feeding by adult female weevils late in the season can cause black pitting on the kernel, similar to that seen with stink bugs.

After the kernel has entered the gel stage (the stage of nut development when a gel fills the kernel cavity), the nut is susceptible to egg laying by female weevils and subsequent attack by pecan weevil larvae. A female weevil may deposit two to four eggs within each pecan and may produce over 50 eggs during her lifetime. The most susceptible time for egg laying occurs once the pecans have entered the dough stage (when the fruit is nearly hardened and contains well developed kernels).











(top, left) From late May to early June in Oklahoma, pecan casebearer moths emerge and lay eggs on developing nutlets. After the eggs hatch, the fully mature larva will become about 1/2 inch long. (top, right) One pecan casebearer larva may bore into multiple nutlets and can destroy an entire cluster. (bottom, left) The pecan weevil is the most destructive late season pest. The adult pecan weevil is a light brown, 1/2-inch-long beetle with a long snout. In Oklahoma, adult weevils start emerging as early as August. (bottom, right, two photos) Pecan weevils deposit eggs into nuts. Hatched larvae consume the kernels while the nuts are still attached to the tree. Creamy-white-colored larvae emerge in late fall from a round hole chewed through the shell by the insect.



(above) Circle weevil traps monitor for the presence of pecan weevil in an orchard. The Circle trap is the best monitoring tool because of ease of deployment, cost, simplicity and compatibility with orchard floor maintenance.

After hatching, larvae consume the kernels while the nuts are still attached to the tree. Fully grown, creamy-whitecolored larvae emerge in late fall through a round hole chewed through the shell by the larvae. Following emergence from the nut, pecan weevil larvae will burrow into the soil to various depths, depending on the soil type and moisture condition where they land. After one year in the soil as a mature larva, pupation will occur. The pupal stage lasts for about three weeks, then the adult stage is formed; however, adult weevils remain in a protective earthen cell in the soil for an additional year before they exit the orchard floor to begin the cycle again. This makes the total time from first

entering the soil as larvae to exiting as adults approximately two years in 90 percent of the population. Ten percent will take three years to complete the cycle.

Traps are used to monitor the presence of pecan weevil in the orchard. The best means of monitoring for weevil emergence is the Circle trap because of its ease of deployment, cost, simplicity and compatibility with orchard floor maintenance. Thresholds using Circle traps have been established at 0.3 weevils per trap per day when utilizing 20 traps on 10 trees and encircling each of the trees.

When weevil threshold is reached and the pecans are in the dough stage of development, insecticide application is warranted. In areas where best management practices have been neglected for a long period of time, weevil populations can build up to levels that may require four to six applications per season; however, over a period of two to three years with good population management, pecan weevils may be managed with only two applications per year. Biology and Control of the Pecan Weevil in Oklahoma (pods.dasnr. okstate.edu/docushare/dsweb/Get/ Document-4530) has more information on this costly pest.

Insecticide treatment guidelines for pecan weevils are covered in *Commercial Pecan Insect and Disease Control - 2011* (pods.dasnr.okstate.edu/docushare/ dsweb/Get/Document-1330).

Circle traps are available from Circle's Pecans (www.circlespecans.com); Great Lakes IPM (www.greatlakesipm.com/ circletrunktraps.html); and Susan Ihle (918) 367-6168.

On occasion, other insects can cause serious damage to pecans. Some of these include fall webworm, walnut caterpillar, green stink bug, hickory shuckworm, pecan phylloxera and various species of aphids. OSU's entomology and plant pathology website (entoplp.okstate.edu/ ddd/hosts/pecan.htm) has more information on these insects.

#### Disease

The most serious disease affecting pecan is scab. Pecan scab is a fungal infection and can occur throughout the Southern Great Plains, but is more common in the more humid eastern portion of the region. The disease is characterized by small, dark, circular, olive to black spots on foliage and nut shucks. These spots may fuse to form large, blackened areas. If the disease is not controlled, entire crops of more susceptible cultivars and of some native and seedling trees may be lost during periods of frequent rain or extended dew.

Pecan scab is effectively controlled by use of resistant cultivars, promotion of drainage and air movement in the orchard, and timely applications of fungicides. For resistant cultivars, a maximum of three fungicide applications is needed. The first of these is made at the completion of pollination, which is usually at the time of the first application for pecan nut casebearer. A first cover application is made two to three weeks after that and is followed by a second cover application two to three weeks later. For moderately to highly susceptible cultivars, additional applications will often be needed.

To determine if additional fungicide applications are warranted, growers in Oklahoma can consult the Pecan Scab Advisor, a weather-based disease forecasting system accessible on the Internet at agweather.mesonet.org/index.php/data/ section/hort. Texas growers and growers located in other areas of the pecan belt can consult the Pecan Scab Risk Map at pecan.ipmpipe.org/map/scab/.

Pecan scab fungicide treatment guidelines are covered in *Commercial Pecan Insect and Disease Control - 2011* (pods. dasnr.okstate.edu/docushare/dsweb/Get/ Document-1330).

When applying fungicide, it is important to rotate to different fungicide chemistries to avoid the development of resistance in pathogen populations.

For more information on the biology and control of scab and other pecan diseases, see *Pecan Diseases: Prevention and Control* (pods.dasnr.okstate.edu/ docushare/dsweb/Get/Document-1030).



(top) Pecan leaf scab, a fungal infection, is characterized by small, dark, circular, olive to black spots on the tree's foliage and nut shucks. (bottom) Spots indicate pecan scab infection on these nut shucks. Scab is the most serious disease affecting pecans, sometimes causing loss of an entire crop.

Table 4. Susceptibility of Pecan Cultivars to Scab			
<b>Highly Susceptible</b>	Moderately Susceptible	Low Susceptibility (resistant)	
Burkett	Caddo	Native Trees	
Squirrel's Delight	Colby	Barton	
Western	Creek	Choctaw	
Wichita	Giles	Graking	
	Kiowa	Kanza	
	Maramec	Lakota	
	Mohawk	Stuart	
	Oconee		
	Shawnee		
	Pawnee		

#### **Applying Pesticides Safely**

Proper application of pesticides is essential for efficacy and human and environmental safety. Review the product label before each use. Be sure you have all the materials necessary for a safe and proper application. Check the precautions section of the label to determine if you can safely apply the pesticide. Also check requirements such as days to harvest, temperature and wind speed restrictions to be sure you can use the pesticide when and where you intend. *Always read and obey label directions*. *The label is the law!* 

When applying pesticides, wear protective clothing and use the safety equipment the label requires. To prevent spillage of chemicals, always check application equipment for leaking hoses or connections, and plugged, worn or dripping nozzles before adding pesticide. Before applying, clear all people, pets and livestock (if there is a grazing restriction) from the area.

#### Wildlife

Wildlife reduces pecan production by damaging the pecan tree, eating the nuts or caching nuts. Blue jays, crows and squirrels are the major depredators and can cause significant economic losses.

Growers can employ various management practices to reduce the severity of depredation. Harvesting as early as possible is one of the best means to manage wildlife damage. Earlier harvest reduces wildlife losses by reducing the time the crop is exposed to depredation. Control measures should be started before the damage problem has reached serious proportions and wildlife become accustomed to feeding in the orchard. It usually is more difficult to discourage wildlife once they start frequenting an area.

Blue jays are more of a problem in native orchards than improved cultivar orchards because improved cultivar nuts are too big for the bird to fit in its bill. However, they have been known to carry off large nuts by pecking a hole in thin-shelled cultivars and using the hole for leverage to carry the nut. Shooting is an economically effective management practice, but a depredation permit must be obtained from the U.S. Fish and Wildlife Service because blue jays are protected under the Migratory Birds Treaty Act.

Oklahoma USDA Wildlife Services contact information is at www.aphis. usda.gov/wildlife\_damage/state\_office/ oklahoma\_info.shtml.

Texas contact information is at www.aphis.usda.gov/wildlife\_damage/ state\_office/texas\_info.shtml.

Crows prefer the larger, thinner-shelled cultivar nuts. Crows are social birds, and most damage control techniques attempt to capitalize on this behavior. The best results are obtained using a combination of several crow control methods.

Hunting reduces crow numbers, but its greatest value is in reinforcing scaring devices. In Oklahoma, crows are game animals with a split season from early October through mid-November and early December through early March. Crows are most effectively hunted with an electronic call about once per week during the open season.

Many wildlife harassment or scaring devices are available. Pistol- and shotgun-fired screamer and exploding shells are popular among growers.



Propane cannons frighten crows by loud detonations from ignited propane gas at prescribed intervals. Crows quickly get accustomed to cannon blast frequency, so the frequency and direction of the blast must be changed every couple of days. Manufacturers generally recommend one cannon per 20 acres.

Chemical control options are available for crows. Avitrol is a restricted use chemical frightening agent registered for use on whole kernel corn baits that are then presented to the crows at a pre-baited site. The few birds that ingest the treated corn behave erratically, emit cries and frighten other crows away from the area before they eventually die. The success of using this product varies, in part due to difficulty in getting crows to baited corn consistently. Consult the label for use instructions.

Squirrel depredation of pecans can be reduced by habitat modification. Well managed pecan orchards do not naturally support high densities of squirrels. The orchard acts as a large food plot where squirrels from the surrounding habitat come to feed. Little economically significant damage occurs beyond about 100 yards from the edges of the orchard adjacent to woodland. Squirrels are insecure and vulnerable to predation when crossing openings. Clearing a strip of trees between any wooded areas and (above) Loud blasts from propane cannons are effective for frightening crows from pecan orchards.

the edge of the orchard will reduce the foraging effectiveness of squirrels traveling between the surrounding habitat and the orchard.

Hunting can help reduce squirrel numbers. Both gray and fox squirrels are significant pecan depredators and they are game animals in Oklahoma. The hunting season for both gray and fox squirrels is May15 to Jan. 31.

In Oklahoma, squirrel trapping is legal only after securing a depredation permit from the Oklahoma Department of Wildlife Conservation (www.wildlifedepartment.com). Focus trapping on an area 100 feet wide in the part of the orchard that is adjacent to native woodland.

Pocket gophers can be troublesome during establishment of new trees. In light soils, they burrow under the ground and feed on tree roots, causing death in some cases. *Controlling Pocket Gophers* (pods.dasnr.okstate.edu/docushare/ dsweb/Get/Document-2709) has additional information.

The Internet Center for Wildlife Damage Management website (icwdm. org ) is an excellent resource for wildlife damage identification and control.

### Harvest Guidelines

#### Preparation

Pecans are mature and ready to harvest when the shucks begin to open. Shucks must split before the first killing frost or the nuts will remain as "stick-tights" enclosed in the shucks, making the nuts worthless.

If cattle graze in the orchard, they should be removed at least two months before harvest to allow time for the manure to decompose to prevent contamination of the nuts. Any low hanging branches that could interfere with harvest should be removed. Remove any sticks that litter the orchard floor. The orchard floor (ground cover) should be mowed at frequent intervals late in the season to prevent the accumulation of plant residue which could interfere with nut harvest.

#### Harvesting

When 70 to 80 percent of the nut clusters have open shucks and kernel moisture is below 10 percent, harvesting can begin. Some pecans will be on the ground at this time. Start by shaking a test tree. If 80 percent of the nuts drop after 10 seconds or less, proceed to harvest other trees of the same variety. Harvesting trees too early may damage the bark because sap is still flowing. Harvesting too late increases loss due to wildlife depredation and allows nutmeats to darken and lose quality.

Most growers shake nuts onto the ground using mechanical shakers. Small growers who don't have access to a shaker or growers harvesting trees too small to be shaken mechanically can use a rigid cane or PVC pole to thresh the limbs.

The three-point-mounted, tractorpowered shaker with a hydraulic clamping device is the most inexpensive shaker and is used in the majority of Oklahoma orchards. The self-propelled, suspended head, hydraulic-powered shaker is faster and more maneuverable compared to three-point-mounted shakers. Because it is substantially more expensive, selfpropelled shakers are used primarily in orchards greater than 200 acres.

Some varieties will drop almost all of their nuts with just one shaking, while other varieties require a second shaking a couple of weeks after the first. The length and intensity a tree is shaken will depend on crop load and tree size. Large trees can handle more severe shaking and require longer shaking time, compared to small trees. Shaking time generally ranges from six to 10 seconds. To avoid trunk damage, the shaker clamp should be padded and in good repair. The shaker operator needs to be sure that the clamp is fitted tightly enough on the trunk to prevent any slippage between the clamp and the trunk.

Pecans may be hand-harvested, mechanically harvested or a combination of the two. Hand-harvesting involves shaking the nuts onto large tarps, then transferring them into sacks or other types of containers, or simply shaking the nuts onto the orchard floor and picking them up. The ground cover must be mowed short to enable the pickers to harvest the crop in a timely manner.

From an economic standpoint, large, commercial-scale harvesters cannot be justified when harvesting a few acres of trees. Small-scale, human-powered harvesters have been developed with the small-scale or hobby grower in mind. Examples of this type of harvester include Bag-A-Nut<sup>™</sup> (www.baganut.com) and The Nut Buddy (thenutbuddy.com).

In commercial-scale variety orchards, nuts are harvested after being windrowed with a sweeper or harvested off the entire orchard floor. Regardless of the method used to harvest, the nuts should be harvested immediately after shaking.



(above) When the shucks begin to open, as seen in this photo, pecans are mature and ready for harvest. When 70 to 80 percent of the nut clusters have open shucks and kernel moisture is below 10 percent, harvesting can begin.

## Post-harvest Handling

#### Cleaning

Harvested nuts are transferred to trailers or large bins and transported to a cleaner. For small jobs, trailer-mounted field cleaners are available. Multiplecomponent, stationary cleaners housed in a building can operate in any weather and can process greater quantities of nuts compared to field units.

In a typical cleaning operation, the following tasks are accomplished. First, small sticks are removed. Next, clods larger than the nuts are removed. The nuts then pass through a series of hullers to remove any loose shucks sticking to some nuts. Next, an air stream blows out leaves and light nuts that didn't fill out or were eaten by insects. Finally, the nuts pass over an inspection table where workers remove cracked nuts, sticktights, nuts with weevil holes, irregularly colored nuts or other damaged nuts.

#### Sizing

Following cleaning, the nuts should be sized to ensure uniform lots. Generally, the larger kernel varieties bring a higher price. Mixing large nuts with small nuts will result in a lower grade for a shipped lot. The more expensive sizers are capable of separating nuts into sizes less than 1/2 inch to over 1 inch in diameter.

#### Drying

To take advantage of higher prices for early season pecans and reduce loss due to wildlife depredation, some growers choose to harvest earlier with nuts at moisture contents up to 20 percent. This moisture content needs to be lowered to 4 percent for the nuts to develop good eating quality and prevent molding. Peanut drying trailers are commonly used by pecan producers to dry whole pecans. Heat is added to the air passing through the pecans to lower the relative humidity and speed the drying process. Temperature in drying trailers or bins should not exceed 90 degrees F. With adequate warm air movement through the pecans, it will take approximately 40 hours to reduce nuts with 20 percent moisture to 4 percent moisture. Pecans with 8 percent moisture will take approximately 12 hours to lower moisture percentage to 4 percent. Vendors offering moisture testers include Southern Nut 'n' Tree (www.sntequipment.com) and Rural King (www.ruralking.com/grainmoisture-tester.html).

#### Grading

Before marketing pecans, they need to be graded. Knowing ahead of time the quality of the nuts will allow you to anticipate the price they will bring, whether they are marketed wholesale or direct to the public. Grading consists of determining the percentage of edible kernel and percentage of kernel grades.

For accuracy, it is important to sample the entire lot of pecans, whether it is a few hundred pounds or several thousand pounds. To take a representative sample, withdraw at least 1/10 of 1 percent by weight of the lot being sampled. Nuts should be drawn equally throughout the lot by probing the top, middle and bottom of the container.

The drawn sample should be thoroughly mixed. From that composite sample, prepare three separate 1 pound samples. Crack each of the three samples carefully by hand and separate the nutmeats. Separate the edible from the inedible kernels. Calculate the percentage of edible kernel for each sample. Divide the weight of the edible kernels by the weight of the sample to obtain percent edible kernel. The average of the three represents the percent kernel for the lot. However, if extreme variance occurs, three additional 1 pound samples should be cracked. An average of the 6 pounds will then be used to determine the percent kernel. The inedible kernels and pieces should be weighed and reported as a percentage of the lot.

Classifications of Kernels	
Grade	
Classification	Description
No. 1	Kernel bright colored, full bodied, solid
	(Fancy Product)
No. 2	Kernel lightweight, bright in color; full bodied, slightly off-color
	(Choice Product)
No. 3	Kernel amber colored, either full bodied or lightweight
	(Standard Amber, Cutting Stock)

Edible kernels should be further broken down into percentages of No. 1, No. 2 and No. 3 kernels. For example, if the percentage of edible kernel was 40 percent, it might be broken down as 35 percent – No. 1 kernels; 2 percent – No. 2 kernels; and 3 percent – No. 3 kernels.

Kernels showing the following defects will be rejected as inedible:

- Poorly developed and shriveled, i.e., wafers.
- Kernels with insect stings or blotches.
- Kernels with green, gray, brown, yellow or black discoloration, or any mold.
- Kernels showing discoloration on the back of the center ridge of the kernel.
- Kernels with adhering fuzzy material of contrasting color that covers 50 percent or more of the kernel.
- Kernels that consist of hickory hybrids (hicans) and nuts from prior years.

Kernels with adhering fuzzy material that covers less than 50 percent of the kernel will be downgraded accordingly. If more than 5 percent of the sample is cracked nuts, they should be hand-shelled and weighed separately from the rest of the sample, giving a percentage of meats derived from cracked nuts. This portion will be downgraded one grade. A more detailed description of grades and guidelines for shelled pecans is published by the National Pecan Shellers Association at www.ilovepecans.org/pecguide.pdf.

#### Pricing

Pricing of pecans is based on percent edible kernel and percent grade classification. No. 1 kernels receive the negotiated price per point. One point is 100 percent kernel, i.e., pecans that grade 50 percent usable nutmeat require 2 pounds of in-shell pecans to make one point. In our example above (assuming a price of \$1 per meat point), if the sample is 35 percent No. 1 kernels, the value is \$1 x .35 =\$0.35/pound of in-shell weight. If the total percentage of No. 2 and No. 3 kernels is 5 percent or less, these are valued at two-thirds the value of the No. 1 kernels (i.e., if the total of the No. 2 and No. 3 kernels is 5 percent, the value is \$1 x 2/3 [\$0.667] x .05 = \$0.033). The value of this example lot is \$0.35 plus \$0.033 = \$0.383 per pound of in-shell pecans.

If the sum of the percentage of the No. 2 and No. 3 kernels is more than 5 percent, then the value of these kernels should be negotiated between buyer and seller. These calculations assume the moisture percentage of the in-shell pecans is 4 percent. Wholesale pecan buyers base their offering price on many factors, including current season pecan crop as well as volume of nuts in storage and projected crop for next year.

Wholesale price quotes for pecans can be found on the USDA Agriculture Marketing Service website at www.ams. usda.gov/AMSv1.0/ams.fetchTemplate-Data.do?template=TemplateN&page= SpecialtyReportsPecanIndex.

Market-savvy growers stay in touch with buyers throughout the season. The retail price for premium quality pecans is affected very little by the current wholesale price.

#### Storage

Growers who choose not to market their pecans during the harvest season will need to place the crop in cold storage. Nutmeats will discolor and turn rancid at warm temperatures due to high oil content. In general, the lower the temperature, the longer the storage life of in-shell and shelled pecans. Freezing does not damage pecans since their moisture content is low.

#### Food Safety

Food safety concerns are increasing as once unheard of illness-causing microorganisms become more prevalent and as products previously considered safe cause an increasing number of illnesses each year. Produce, recently thought of as a safe product, has been identified as a cause of major foodborne illness outbreaks in recent years.

The three main types of hazards found in food products are chemical, physical and biological. Biological hazards include bacteria, viruses, fungi and parasites. The most common biological hazards of concern in pecans are molds and bacteria. Both may be controlled by proper sanitation and handling procedures in the orchard, as well as during storage, cleaning, sorting, cracking, shelling and packaging operations.

Contamination may occur before or after harvest, typically as a result of contact with contaminated water, contaminated soil, direct contact with animal manure, contaminated humans and contaminated equipment or facilities.

Controlling food safety hazards is about identifying sources of risk, developing measures to minimize those risks and documenting what is done. Following are some specific suggestions for minimizing food safety hazards in the orchard and during processing and storage.

Contaminated spray water can pose a significant risk, especially as harvest approaches. Test all water sources for fecal coliforms prior to using.

The most likely source of contamination while pecans are on the ground is animal manure, though contaminated irrigation water may also pose a risk. Research suggests that the pathogenic bacteria E. coli O157:H7 may survive in untreated manure for two months to a year. Therefore, it is prudent to take extra precautions to limit sources of contamination for at least two months prior to harvest. This includes removing cattle from the orchard at least two months before harvest. It is best to also remove cattle from adjacent pastures if runoff from those fields into the orchard is likely to occur. If manure-based compost is applied to the orchard, it should be properly composted. Compost should reach a temperature of 131 degrees F to 149 degrees F for at least three days during composting to ensure safety.

Proper hygiene procedures for orchard workers are important, especially during harvest. Toilets and hand-washing stations must be available and accessible to workers in order to avoid potential contamination. Workers who handle the nuts during cleaning, grading, shelling and packaging operations are prime sources of potential contamination because the crop is concentrated in a relatively small area. Infected workers (whether showing symptoms or not) can easily contaminate the nuts they handle if they do not wash their hands after sneezing or using the restroom. This is particularly true for workers handling shelled nuts. Proper worker hygiene procedures should be established and included in hygiene and health training programs.

Birds, insects, rodents and domestic animals should be kept out of processing and storage areas. If birds roosting or nesting in exposed rafters are a problem, metal screening may be installed to keep them out. A proper pest control plan can prevent infestations. This plan typically includes traps for rodents and spray programs for insects. The plan should be properly documented. It is especially important to be aware of EPA regulations for pesticide use in food processing facilities. Spraying and trapping alone are not enough; proper cleaning and maintenance of food processing and storage areas are vital parts of any pest control program.

A single dirty piece of equipment can contaminate a large number of nuts that pass through it. A dirty storage area may contaminate many or most of the nuts stored in it. Therefore, proper maintenance, cleaning and sanitation of both equipment and facilities are vital to any food safety program. For additional information on safe handling of food on the farm, see *Food Safety Begins on the Farm* (sfp.ucdavis. edu/pubs/articles/foodsafetybeginsonthefarm.pdf).

#### Pecan Sanitizing Regulations

Growers who market cracked or shelled pecans directly to the public are required to comply with sanitary regulations. In Oklahoma, the Oklahoma Department of Health regulates pecan processing and publishes guidelines for cleaning and sanitizing of pecans during the shelling process. Custom crackers (individuals who contract with clients to crack their pecans) are not required to sanitize pecans and processing equipment, but are required to post signs and attach labels declaring their exemption.

Both custom crackers and shellers are required to comply with state regulations for food processing facilities. In addition, shellers are required to:

- Thoroughly clean in-shell pecans prior to sanitizing to remove all foreign matter.
- Sanitize in-shell pecans using a hot water dip, a chlorine dip, hot air or steam.
- Handle sanitized pecans in such a way as to avoid recontamination.
- Sanitize all equipment used for handling, storing or transporting sanitized pecans and/or pecan meats using hot water, chlorinated water, hot air or steam.

Chlorinated water is the easiest and most cost-effective method of sanitizing in-shell pecans. State regulations specify a 1,000 PPM chlorine dip (1 gallon of household bleach [5.25 percent sodium hypochlorite] to 49 gallons of water) for sanitizing in-shell pecans. Allowing a contact time of 30 seconds, enough to thoroughly wet the surface of the pecans, should be adequate to properly sanitize the nuts. All nuts must be completely immersed in the dip.

Chlorinated water is also the easiest and most cost-effective method of sanitizing equipment. State regulations specify that pecan-handling equipment may be sanitized by immersion in or exposure to a flow of chlorine solution of not less than 200 PPM strength (1 tablespoon household bleach [5.25 percent sodium hypochlorite] per gallon of water) for at least two minutes.

Even the best sanitizing steps will not minimize risk if nuts are recontaminated after sanitizing. Do not use the same containers to store or transport unsanitized and sanitized nuts. Only use foodgrade containers that seal tight. Store containers off the ground and secure from contact with pests.

For legal purposes, keep a record of cleaning procedures. Document such things as cleaning schedule, type and strength of sanitizing agent, description of pest control program and any corrective actions taken in response to product contamination. Records connected to any single crop of nuts should be kept on file for a minimum of two years.

To view the complete set of regulations governing pecan sanitation in Oklahoma, go to www.ok.gov/health/documents/ Water%20Vending260.pdf.

# Economics

#### Marketing

Pecans can be marketed wholesale or directly to the consumer. Selling wholesale is the standard method for moving the largest volume of nuts in the shortest time. Growers who plan on wholesaling their pecans should contact a buyer before the pecans are ready to sell. Local county Extension offices and the Noble Foundation are good places to contact for assistance in locating local buyers for smaller lots. Larger quantity buyers advertise in Pecan South (www.tpga. org/magazine.html) and Georgia Pecans (www.georgiapecan.org/subscriptions.da), as well as other trade-related magazines. Buyers are frequently listed with pecan grower associations, such as the Oklahoma Pecan Growers Association (www.hortla.okstate.edu/pecan/opga) and the Texas Pecan Growers Association (www.tpga.org).

Marketing your pecans directly to the consumer offers the opportunity to skip the middleman and obtain retail instead of wholesale prices. The key to selling pecans retail is to offer a quality product. Never sell poor or low quality pecans to the consumer. If the quality is there, the consumer will pay the price and return for more. If the quality is low, however, forget about repeat buyers. Types of direct to the consumer sales include orchard sales, roadside stands, farmers' markets and Internet sales.

#### **Pecan Budgets**

Establishing an irrigated pecan orchard requires a large initial capital outlay; however, it can be very profitable over the long term. Establishment costs can range as high as \$2,000 per acre.

Job Springer, a Noble Foundation agricultural economist, conducted a net present value (NPV) analysis to determine the profitability of a 100-acre irrigated improved pecan orchard over 20 years. A 20-year period was chosen to capture the establishment period and several years of full production. Projections showed that after 20 years, the irrigated improved pecan orchard would have recovered the orchard's start-up costs (machinery and equipment). The results of the analysis





(top) "Super sacks" loaded with pecans sit ready for bulk delivery. Wholesale marketing is the standard method for moving the largest volume of nuts in the shortest time. (top) Direct to the consumer sales, such as orchard sales, roadside stands, farmers' markets and Internet sales, offer the opportunity for growers to obtain full retail value for their crop. The key to retail sales is to always offer a high quality product. (photo: courtesy of Landgraf Farms) using 2005 to 2009 average prices showed that the NPV of the irrigated improved pecan orchard exceeded \$2,200 per acre. This means that the sum of each year's net returns over the selected 20-year period discounted to 2011 dollars would be over \$2,200 per acre. This analysis assumes no significant income was generated prior to Year 7, and the average yield for a 20-year-old irrigated variety orchard is 1,500 pounds per acre.

The sample budget for the irrigated improved pecan orchard may be

downloaded in Microsoft Excel format at www.noble.org/global/ag/horticulture/pecan-budgets/irrigated.xlsx. A second sample budget for an un-irrigated improved pecan grove is available at www.noble.org/global/ag/horticulture/ pecan-budgets/non-irrigated.xlsx.

# Pecan Management Calendar

#### Establishment, Year 1

January to February

Soil test to determine initial phosphorus, potassium and lime needs for both pecans and the intended orchard floor crop. Apply fertilizer and lime as required.

#### February to March 15

Plant bareroot pecan trees. Cut the tops of bareroot trees back one-third to one-half (make sure to cut above the graft) and cut the roots off to 18 inches long prior to planting. Ensure the cut-off root is at the base of the hole and that the tree cannot settle below the original soil line. It is better to plant somewhat shallower than to be deeper than the original soil line.

Install tree protectors to help protect the young trees from animal, herbicide and sunscald damage to the young trunk.

#### April

Beginning at bud break, apply foliar zinc every 14 days through the end of July. Apply a mixture of 2 pounds 36 percent  $ZnSO_4$  per 100 gallons of water for large plantings or 1 1/2 tablespoons per gallon for small plantings. Spray all the foliage to wet well. Do not use a sprayer that has been used to apply herbicide. May

If sufficient growth has occurred, spread approximately 1/3 pound 46-0-0 fertilizer on the ground around the base of each tree. Avoid concentrating it near the trunk. Do not fertilize trees until sufficient growth occurs.

#### May-September

Apply glyphosate herbicide as needed to control weeds in a 6-foot strip down the tree row (3 feet to either side of the tree) or a 6-foot-diameter circle surrounding the trees (3 feet in each direction from the trunk).

If applied with a spot-sprayer, use a 1 percent glyphosate solution in water (1 gallon of a 4-pound-per-gallon formulation per 100 gallons of water). If applied with a calibrated boom-type sprayer, use 1 pound of glyphosate per acre (1 quart of a 4-pound-per-gallon formulation per acre). Refer to the glyphosate label to determine if a surfactant is necessary. Do not allow herbicide to contact young tree trunks or foliage.

Apply supplemental irrigation as needed. If an irrigation system is not available, a nurse tank or similar device will be necessary to water trees by hand until they are established. Cease supplemental irrigation by Sept. 15.

Select the central leader to be the future trunk and remove growing points from the remaining shoots. Removal of growing points may need to be repeated during the growing season.

#### December-February (during dormancy)

Remove the top 4 inches of the central leader (only if it made significant growth) and remove growing points from all lateral shoots.

#### Pre-production, Year 2 March

Spread approximately 1/2 pound 46-0-0 fertilizer on the ground around the base of each tree. Avoid concentrating it near the trunk.

#### April

Beginning at bud break, apply foliar zinc every 14 days through the end of July. Apply a mixture of 2 pounds 36 percent  $ZnSO_4$  per 100 gallons of water for large plantings or 1 1/2 tablespoons per gallon for small plantings. Spray all the foliage to wetting. Do not use a sprayer that has been used to apply herbicide.

#### May-September

Inspect tree protectors and replace or repair if required. Apply glyphosate herbicide, as needed, to control weeds in a 6-foot strip down the tree row (3 feet to either side of the tree) or in an 8-footdiameter circle surrounding the trees (4 feet in each direction from the trunk). If applied with a spot-sprayer, use a 1 percent glyphosate solution in water (1 gallon of a 4-pound-per-gallon formulation per 100 gallons of water). If applied with a calibrated boom-type sprayer, use 1 pound glyphosate per acre (1 quart of a 4-pound-per-gallon formulation per acre). Refer to the glyphosate label to determine if a surfactant is necessary. Do not allow herbicide to contact young tree trunks or foliage.

Apply supplemental irrigation as needed. If an irrigation system is not available, a nurse tank or similar device will be necessary to water trees by hand until they are established. Cease supplemental irrigation by Sept. 15.

Continue to train the central leader to become the main trunk by removing growing points. This shoot should be maintained at least 12 to 15 inches longer than any of the lateral limbs.

December-February (during dormancy) Remove the top 4 inches of the central leader if it made extremely significant growth. Select side limbs to become the permanent scaffold branches. Do not remove these growing points unless they are longer than the central leader. Select branches that have at least a 60 degree angle from the trunk and are above the minimum intended height from the ground (usually at least 5 feet).

### Pre-production, years 3-6 to 8 March

In Year 3, spread approximately 1 pound 46-0-0 fertilizer on the ground around the base of each tree. Do not concentrate application around the young tree trunks. In years 4-6 to 8, add soil-applied fertilizers according to leaf analysis from previous years.

#### April

Beginning at bud break, apply foliar zinc every 7 to 14 days through the end of July. Apply a mixture of 2 pounds 36 percent  $ZnSO_4$  per 100 gallons and spray the foliage to wet well. **Do not use a sprayer that has been used to apply herbicide.** 

#### May-September

Inspect tree protectors and replace or repair if required. Apply glyphosate herbicide as needed to control weeds in a 12-foot strip down the tree row (6 feet to either side of the tree) or in a 12-footdiameter circle surrounding the trees (6 feet in each direction from the trunk). If applied with a spot-sprayer, use a 1 percent glyphosate solution in water (1 gallon of a 4-pound-per-gallon formulation per 100 gallons of water). If applied with a calibrated boom-type sprayer, use 1 pound glyphosate per acre (1 quart of a 4-pound-per-gallon formulation per acre). Refer to the glyphosate label to determine if a surfactant is necessary. Do not allow the herbicide to contact young tree trunks or foliage.

Monitor pecan scab model at www. okstate.edu/~mesonet/scab and spray as indicated. Pecan scab needs to be prevented rather than treated after symptoms are visible.

If irrigation is available, apply supplemental irrigation as needed. Cease supplemental irrigation by Sept. 15.

Continue to train and develop tree architecture as described in Year 2 until the tree becomes too large to train.

#### Production years, years 6-8+ March

Apply soil-applied fertilizers according to leaf analysis from previous years.

#### April

Beginning at bud break, apply foliar zinc. Apply a mixture of 2 pounds 36 percent  $ZnSO_4$  per 100 gallons of water and spray the foliage to wet well. The trees should now be large enough to require a tree sprayer to obtain adequate coverage.

#### May-September

As needed, apply glyphosate herbicide to control weeds in a 12-foot strip down the tree row (6 feet to either side of the tree) or in a 12-foot-diameter circle surrounding the trees (6 feet in each direction from the trunk). If applied with a spot-sprayer, use a 1 percent glyphosate solution in water (1 gallon of a 4-pound-per-gallon formulation per 100 gallons of water). If applied with a calibrated boom-type sprayer, use 1 pound glyphosate per acre (1 quart of a 4-pound-per-gallon formulation per acre). Refer to the glyphosate label to determine if a surfactant is necessary. Do not allow herbicide to contact foliage.

Scout for aphids, web worms, stink bugs, etc., and treat when needed.

Monitor the pecan scab model at www.okstate.edu/~mesonet/scab and spray as indicated. Pecan scab needs to be prevented rather than treated after symptoms are visible.

If irrigation is available, apply supplemental irrigation as needed. Cease supplemental irrigation by Sept. 15. May

Continue foliar zinc applications at approximately 21-day intervals. Install pheromone traps for first generation pecan nut casebearer, begin monitoring trap counts, scout for eggs when indicated and spray when necessary.

#### June

Continue foliar zinc applications at approximately 21-day intervals.

#### Mid-July

Collect and submit leaf samples.

#### Late July-September

Install and monitor pecan weevil Circle traps. Spray for weevils when necessary.

#### September

Prepare for harvest by cleaning up dead limbs, trash, etc., and mowing vegetation short.

#### October

Begin wildlife (crow, blue jay, squirrel, etc.) control measures.

#### November

Harvest as early as crop maturity allows. Sometime between years 14 and 20, the orchard will probably need to be thinned.

## Additional Information

#### **Evaluating Pecan Problems**

aggie-horticulture.tamu.edu/fruit/pecan1.html This publication contains keys for diagnosing problems encountered with all parts of a pecan tree; nuts, shoots, leaves and roots.

#### Oklahoma Pecan Management Course

www.hortla.okstate.edu/pdf/2011pecanmgmt.pdf This is a seven-month course with sessions scheduled once per month, in March, April, May, July, August, September and October. The course is also offered online in a self-study format at pecan.okstate.edu.

#### Texas Pecan Short Course

Texas A&M University hosts this five-day short course during the last week of January each year. Contact Kay Sanders at Texas A&M for registration information at (979) 845-7692 or by email at <u>k-sanders@tamu.edu</u>.

#### Pecan IPM PIPE

(Pest Information Platform for Extension and Education) pecan.ipmpipe.org

This interactive website is designed to familiarize pecan producers with the primary nuisance and beneficial arthropods associated with pecans and provide real-time pest-related information to aid in decision making.



AL DUILDE

1 and

E.

the sector of a transmission of the sector of a large distance sector a



2510 Sam Noble Par Ardmore, Okla. www.noble.org