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SUSTAINABLE PECAN PRODUCTION

HORTICULTURE PRODUCTION GUIDE

ATTRA is the national sustainable agriculture information center funded by the USDA's Rural Business -- Cooperative Service.

Abstract: *In **Sustainable Pecan Production** we briefly introduce essential knowledge on the basics of pecan culture such as geography, native versus plantation systems, and economics. This is followed by notes on pecan farming techniques that emphasize **sustainable** and **organic** production methods: non-chemical weed control; orchard floor vegetation management using legumes; pecan nutrition with emphasis on organic fertilizer options; and recommendations for organic and least-toxic control of pecan insects and diseases. A selection of pecan literature and web resources available from the Extension Service and horticultural industry are provided as further sources of information.*

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The pecan, *Carya illinoinensis,* is the most important commercial nut crop in the eastern United States. Pecan culture, like most tree cropping systems, is inherently more sustainable relative to other forms of agriculture. Cultivation of the soil, which increases the risk of erosion, is rarely necessary in a bearing orchard. In a few sections of the U.S., pesticide use is minimal or unnecessary. Where insects and diseases are prevalent, some of the most complete and sophisticated IPM (Integrated Pest Management) programs have evolved to meet the challenge.

Pecans also provide us with the oldest and largest example of agroforestry in North America—the grazing of livestock in native pecan groves. (See the box on page 4 for more information.)

For general information on pecan production (planting, pruning, cultivar recommendations, irrigation, harvest, and orchard management) we suggest the excellent resources already compiled by the Cooperative Extension Service. See the **Pecan Resources** section at the end of this package for a listing of pecan literature and web resources.

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Pecan Culture

There are two pecan cultivation systems in the U.S. and Mexico: native pecan groves and varietal pecan orchards. Varietal pecans—which are planted as orchards but can also be topworked onto native trees—are also known as "papershells." Management of pecan groves and orchards differ to a degree with respect to cultural inputs, pest management, and economic returns.

The Native Pecan Grove

The pecan is native to alluvial soils of the lower Mississippi River and its tributaries, as well as

other river bottoms throughout its range. The pecan extends southward into Central Mexico, and ranges northward through Texas, Louisiana, Mississippi, Arkansas, Oklahoma, Kansas, and Missouri. It extends as far north as southern Nebraska, Iowa, Illinois, and Indiana, to the Texas panhandle in the west, and western Kentucky and Tennessee to the east.

Pecan trees grow in bottomlands along with other hardwoods; often these bottoms are classified as climax pecan forests where pecan trees comprise more than 50% of the native forest biomass.

Bill Reid, pecan specialist at Kansas State University, summarized the five steps involved in converting a bottomland forest into a productive native pecan grove (1):

> First, all species of trees other than pecan are removed. A permanent ground cover is then established under the trees to facilitate harvest and to prevent soil erosion. After the initial forest thinning process, most native pecan areas are too crowded for optimum nut production. Old, weak, or diseased trees are removed to allow adequate space for younger, more productive trees. Nut production in the native grove is further stimulated by the annual application of nitrogen fertilizer. And finally, an insect management program is initiated to prevent serious yield losses from nut feeding insects.

Selective thinning of pecan trees should result in a density of 30 square feet of cross-sectional trunk area per acre. This is equivalent to 30 trees per acre if all the trunks are, for example, 13½ inches in diameter measured at 4.5 ft above the ground. A larger tree of 23½ inches would result in a final spacing of 10 trees per acre (2).

Nuts from native pecans are small, but possess good flavor due to a high oil content. Wholesale nuts are shelled and sold as halves, or chopped and used in food preparation and baking. Retail sales, when feasible, can make an important economic contribution to the farm. Native pecan growers will often plant a block of papershells, or topwork native trees to a good cultivar. Thus, a mix of pecan sizes can be offered to entice customers to purchase retail. Special packaging and Thanksgiving and Christmas holiday sales are other marketing strategies that put more money into the grower's pocket.

Recent innovations in pecan culture that relate to **sustainable agriculture** include:

- legume management to supply nitrogen
- cover crop management to provide beneficial insect habitat
- monitoring of key insect pests with pheromone and weevil traps
- release of biological control agents in orchards
- cultural practices to improve economic returns
- adopting organic farming practices in pecan production
- new pesticides and insect growth regulators with low impact on the environment, also known as "least-toxic" or "soft" pesticides

Sustainable agriculture is a goal rather than a specific set of farming practices. A sustainable farming system strives to be productive and economically viable, yet at the same time preserving environmental quality and making efficient use of nonrenewable resources. Though biological practices and products are favored over chemical inputs, pesticides and fertilizers may be used within an IPM framework.

Organic farming is growing in the United States and soon there will be a National Organics Program regulated by the USDA. Certified organic production completely excludes synthetic fertilizers and pesticides for three years prior to harvest of the first crop.

Yields from well-managed native pecan groves average about 600 lbs. per acre, although yields over 1,000 lbs. per acre are not uncommon in well-managed groves. Wholesale returns to the grower have averaged around $.60 per pound in recent years, although $.80 to $.90 per pound have been obtained some years. Natives sold at the retail level bring around $1.00 per pound.

On average, the net return from native pecans sold wholesale is $100 per acre. An economic unit of native pecans—which is the acreage needed to finance pecan equipment and provide an annual income—is somewhere between 80–300 acres. That's a wide range, but it will ultimately depend on what percentage of farm income will come from pecans; family needs; equipment needs; condition of the grove;

wholesale versus retail markets; and geographical location.

Overall, the potential to get into native pecan production is not great. The best situation would be that of a landowner with existing bottomland hardwoods supporting native pecan trees. Advice on clearing and establishing a grove is available from Extension Specialists and private consultants. Otherwise, few farmers — new or experienced — possess sufficient capital to purchase 300 acres of rich bottomland stocked with native pecan trees. Such land frequently sells in excess of $2,000 an acre.

An alternative is to lease pecan land, manage the grove, and harvest the crop. The proceeds are split with the landowner on shares of 60/40 to 90/10, with the larger percentage going to the manager. Percentages vary depending on the input provided by the owner and manager. Apparently, this is a common practice in the native pecan industry. The biggest expense in a lease operation is the equipment required to manage a grove. Many leased groves are in fact managed by pecan farmers who take on extra acreage in order to make payments on their pecan equipment.

Low-input strategies are essential in the management of native pecan groves because nut yields, unlike those in pecan orchards, are inherently low. The only way growers can make the operation economically feasible is to cut input costs (1, 3).

One low-input strategy is to use legumes as an alternative source of nitrogen (N) fertilization. The nitrogen production potential of legumes varies between species, location, and growing season but can range from 75 to 250 lbs. N/acre.

In a three-year study funded by the U.S.D.A. Sustainable Agriculture Research and Education Program (SARE), researchers at Oklahoma State University evaluated legumes for their ability to supply nitrogen and provide habitat to beneficial insects.

A crimson clover-hairy vetch ground cover supplied the equivalent of 90–142 lbs. N/acre. A red clover-white clover mixture supplied up to 118 lbs. N/acre. White clover or red clover alone were less effective in supplying N than when grown together. Over the course of the study, leaf nitrogen concentrations were typically maintained above the minimum sufficiency level (2.25%) by either crimson clover plus hairy vetch, or red clover plus white clover (4–6).

In practice, Oklahoma growers favor the white clover-red clover mix— even though the nitrogen contribution isn't as great — since it lasts five or more years before the clover stand needs replanting, whereas the crimson clover-hairy vetch ground cover requires more frequent re-establishment.

Zinc, an important element in pecan nutrition, is commonly applied in 2–4 foliar applications per growing season to alleviate leaf symptoms of zinc deficiency. The standard threshold recommendation in the two major native pecan states, Oklahoma and Texas, has been 60 ppm and 80 ppm as determined by leaf analysis. Recent research by Darrell Sparks at the University of Georgia shows that most native pecan groves can forego this input. Instead, he suggests that zinc levels required for maximum vegetative growth and nut yields coincide with the threshold value for visible leaf symptoms of zinc. In other words, trees without visible leaf deficiency symptoms do not require zinc sprays (3).

Native pecan groves are often managed both for nuts and for grazing of livestock. In fact, pecan grove grazing is a well-known form of **agroforestry**. However, livestock should be removed at least two months prior to harvest to avoid potential bacterial contamination from feces.

While grazing cattle (or sheep) in pecan groves can generate additional income from the land as well as enhance nutrient cycling, there are certain grazing restrictions following pesticide application that growers need to be aware of. See **Recommended Intervals Between Last Application, Harvest, and Other Restrictions in Pecans** in the accompanying box for grazing restrictions in relation to choice of pesticide.

Agroforestry

Agroforestry is the deliberate growing of trees on the same unit of land as crops or livestock. The idea behind agroforestry is to derive both economic and ecological benefits, two key goals of sustainable agriculture.

Pecan **silvopasture** (livestock grazing) and **alleycropping** (alternating rows of annual crops and trees) systems are among the oldest examples of agroforestry in temperate climates.

Alleycropping, also known as intercropping, can be done with a wide range of vegetable, flower, field, and forage crops during the pre-bearing stage of pecans to help offset establishment costs. Nut trees are particularly well-suited to alleycropping because of the wide spacing between tree rows.

In the South, raising square bales of bermudagrass hay in the alleyways for the first 10 years is said to pay for the cost of orchard establishment. The caveat is that bermudagrass is a heavy feeder and haying requires supplemental fertilization and close attention to vegetation management to avoid competition with young trees.

Livestock grazing most often involves cattle, though intergrazing with sheep has increased in popularity. Regardless, grazing restrictions sometimes exist — either temporarily or permanently —following application of common pecan pesticides.

As an example, see the grazing restrictions associated with pesticides in the table below. Thus, one of the factors pushing pecan pest management towards "soft spray" and biological control programs is the desire to generate dual incomes from grazed orchards.

Low impact spray programs rely on pesticides with short term environmental persistence and low toxicity to beneficial insects and wildlife.

Resources on Agroforestry:

Agroforestry Overview, an ATTRA publication by Alice Beetz, is available *in-print* as well as *on-line*.
http://www.attra.org/attra-pub/agroforestry.html

Recommended Intervals Between Last Application, Harvest, and Other Restrictions in Pecans‡

Chemical	Interval Between Last Application and Harvest and Other Restrictions
Abound	Do not apply within 45 days of harvest.
Asana, Ammo	21 days. Do not feed or graze livestock on treated orchard floors.
Benlate, Topsin M	Do not apply after shuck split. 15 day waiting period before harvest.
Confirm	14 days to harvest. Do not graze livestock in treated areas or feed cover crops grown in the treated area to livestock.
Dimethoate	Do not apply within 21 days of harvest. Do not graze livestock in treated areas.
Dipel, Javelin	No grazing restrictions. 0-day waiting period.
Di-Syston	Do not harvest nuts within 80 days of treatment.
Enable	Do not apply after shuck split or within 28 days of harvest. Do not graze.
Fury	Do not apply within 21 days of harvest. Do not graze livestock on cover crops in treated areas.
Guthion	Do not apply after shuck split. Allow 21 days before grazing livestock.
Imidan	Do not apply within 14 days of harvest. Do not graze livestock on cover crops in treated areas.
Lorsban	Do not make more than 5 applications per season and do not graze livestock in treated orchard. Do not apply within 28 days of harvest.
Malathion, Sevin	No grazing restrictions. Sevin has a 14-day waiting period before harvest.
Orbit	Do not apply after shuck split. Do not graze or feed cover crops in treated areas.
Provado	Do not graze in treated areas. 0 days waiting between application and harvest.
Super-Tin 80W, Cyprex	Do not apply after shucks have started to open, and do not graze treated areas.
Thiodan	Do not graze cattle in treated groves and do not apply after shuck split.
Ziram	Do not apply within 55 days of harvest.

‡From: **Extension Agent's Handbook of Insect, Plant Disease, and Weed Control**. Cooperative Extension Service, Oklahoma State University. January 2000.

Management of a native pecan grove is an art as much as a science. The best way to learn about native pecans is to attend pecan field days, short courses, and annual growers' meetings. A short list of considerations associated with native pecan grove management includes:

- Clearing the site
- Selecting trees for nut production versus trees for firewood & timber
- Orchard floor management
- Legume establishment
- Plant nutrition
- Livestock grazing
- Grazing restrictions due to pesticides
- Low-cost approach to inputs
- Harvest preparation
- Cleaning, grading, and marketing nuts

Grazing, Legumes, and Bloating of Cattle

Bloating can result when cows graze on fresh, nitrogen-rich legumes on an empty rumen. What happens is that the legumes are so easily digested by rumen bacteria that massive quantities of gas are released, thus causing bloating to occur which can require the emergency aid of a veterinarian. Alfalfa, red clover, and white clover are most notable as problem legumes species, while crimson clover and hairy vetch are less worrisome.

Grazing on a grass-legume mix rather than a 100% legume stand is a standard grazing practice to avoid bloating problems. Feeding hay, or grazing on grass, before turning the animals onto the legume stand is a typical precaution. In general, legumes are an excellent forage and bloating does not occur very often (and only sporadically in the herd), especially when animals are acclimated to high levels of legumes in their diet. Finally, bloat blocks may be set out as a preventative nutritional supplement. Also see:

Tips to Avoid Bloat
http://www.dairyherd.com/nutr73.htm

The Papershell Pecan Orchard

The establishment of a pecan orchard by planting trees in rows is how most new growers enter the pecan industry. Trees can be purchased with the cultivar already budded to the top, or planted as a seedling and grafted in the field. (To be "true to name," a cultivar must be propagated asexually, i.e., by budding or grafting rather than propagation by seed).

There are hundreds of pecan cultivars, but only a few dozen make up the commercial industry. Papershell cultivars are classified according to size, percent kernel fill, and northern or southern range of adaptation. An economic unit for a pecan orchard—which is the acreage needed to finance pecan equipment and provide an annual income—is somewhere between 30-60 acres, depending on the economic model one uses. Prime bottomland farms in soybeans, corn, wheat, and alfalfa are usually good sites for pecan orchards, provided the soil drains well.

Yields from pecan orchards range from 800–1,200 lbs. per acre on average, though yields as high as 2,500 lbs. are not uncommon. Pecans are notorious for alternate bearing, with heavy harvests usually followed by one or two "off" years. Wholesale returns of $.80–.90 per pound are common. Retail prices range from $1.50–2.25 per pound, but prime quality nuts can also bring over $2.50. On average, net wholesale returns from a papershell orchard are $300–400 per acre.

One aspect of pecan culture that may be an eye-opener to the prospective orchardist is the equipment associated with pecan production and harvesting. A 1988 report listed an estimate of $45,000 new or $21,000 used for the minimum pecan orchard equipment—a 50–60 horsepower tractor, a 500 gal. PTO (power-take-off) sprayer, a 3-pt. hitch shaker, a pull-type harvester, and a pecan cleaner (7). Additional expenses to consider include a rotary mower, an orchard rake, a harvest sweeper, harvest bins, drying equipment, a shed for farm equipment and pecan nut cleaning and storage operations, an irrigation system, and tools. One horticulturist stated that "most folks grow into their equipment needs."

The papershell pecan industry has evolved as an important horticultural enterprise in non-native states like Georgia, Alabama, South Carolina, North Carolina, and Florida in the Southeast, and in New Mexico, Arizona, and California in the West.

Pecan orchard systems in the Southeast and West differ from each other primarily in the need for irrigation (in the West) and in the severity of pests and diseases (in the Southeast). Much of the disease and pest pressure in the Southeast is simply non-existent in the West.

Likewise, the establishment of pecan orchards is an important horticultural industry throughout the tree's native range in states like Texas, Oklahoma, Louisiana, and Mississippi. Management of these orchards closely resembles that of plantations in the Southeast due primarily to similar pest and disease problems.

Spacing, Trees per Acre, Planting

The spacing of pecan trees depends on geographical location. In their native and eastern ranges, pecan trees are commonly spaced on a 40 ft x 40 ft grid pattern, which is the equivalent of 27 trees per acre. After about 16–22 years, trees are thinned by half on a diagonal, thus leaving 14 trees per acre. At about 25–35 years old, the third and final thinning will leave a spacing of 80 ft x 80 ft with 7 trees per acre.

For a long time the pecan industry was based on a 35 ft x 35 ft tree spacing. However, recent economic analysis showed an initial 40 ft x 40 ft planting pattern is more profitable because the wider spacing allows the temporary trees more time to produce nuts before they are removed (8).

Establishing a Pecan Orchard, OSU Extension Facts F-6247, provides illustrations and details for pecan orchard layout and thinning operations, located on the web at: http://www.okstate.edu/OSU_Ag/agedcm4h/pearl/hort/frtnuts/f6247.htm

In the western range, where sunlight is more intense, trees are planted at 30 ft x 30 ft, which is the equivalent of 48 trees per acre. Ultra-high density western pecan orchards, spaced at 15 ft x 30 ft, are typically managed by mechanical hedging.

Pecan nursery stock is available from reputable pecan nurseries. There are several options to choose from, including bare root versus containerized nursery stock, and non-budded seedling rootstocks versus pre-budded rootstocks.

There is considerable variation in cold hardiness among rootstocks. Most commercial-scale pecan nurseries are in the South, and rootstocks are most likely to be seedlings from southern trees, which may or may not have the cold hardiness to withstand more northerly conditions.

Growers in more northerly regions should check with their Extension Service for advice regarding rootstocks, or ask for assurance from the nursery that the understock has the necessary cold hardiness. See the accompanying box on **Northern Pecan Varieties** for Extension specialists who can address this topic.

One method of pecan seedling production that is appealing from the sustainable angle is on-farm production of pecan seedlings using the "milk-carton" nursery production method developed at Oklahoma State University. These "super seedlings" are raised in square, bottomless containers (quart-size milk cartons fitted inside plastic milk crates) filled with a standard nursery mix.

When the seedling germinates, the tap root grows out the bottom of the container whereupon the root tip is exposed to the air and dies back. Repeated air root pruning stimulates vigorous lateral branching and results in a fibrous root system. From a container nursery production viewpoint, air root pruning is particularly appealing for strong tap-rooted trees such as pecans. Containerized trees are easy to transplant and with the added advantage of a vigorous, fibrous root system due to air root pruning they establish well in the field.

This method was first described in ***Growing Tree Seedlings in Containers*** (9), an out-of-print OSU agricultural experiment station bulletin written by Dr. Carl Whitcomb. Root-control nursery pots are now commonly available in the commercial nursery industry. ATTRA's ***Sustainable Small-Scale Nursery Production*** publication provides additional resources on this topic.

NORTHERN PECAN VARIETIES

Pecan varieties can be classified into Eastern, Western or Northern types based largely upon climate and geographical location. Eastern varieties are adapted to the humid southeastern states from Louisiana to Florida and have some scab tolerance or resistance. Since scab is not a problem in the arid West, western varieties do not have appreciable scab tolerance or resistance.

Northern pecan varieties are adapted to a shorter growing season (as few as 140–180 days) than eastern or western types (between 190–220 days). When eastern or western types are grown in northern areas, the nut fails to properly mature.

The adaptation of pecans to the northern half of the U.S. is gaining increased interest. In addition to regions within the northern pecan belt (northern Oklahoma, Kansas, Missouri, Nebraska, Iowa, Illinois, Indiana, Kentucky, and Tennessee), horticulturists have made selections that are hardy to Zone 4 and are planting pecans as far north as Ontario, Canada.

Dr. William Reid (10), at Kansas State University, or Dr. Bill Gustafson (11), at the University of Nebraska-Lincoln, can provide advice and recommendations to prospective orchardists in the upper U.S.

Names of standard northern varieties include James, Colby, Fritz, Greenriver, Major, Peruque, Witte, Posey, Giles, Hirschi, and Stark's Hardy Giant. Selections from Gustafson's collection — collected from pecan trees growing along the banks of the Mississippi and Missouri rivers — include Bolten's S-24, C.L. McElroy, Canton, Gibson, Lucas, Mullahy, and Norton (12).

Tree Care, Irrigation, Weed Control, Mulches

The first 3–5 years after planting are crucial to the survival and establishment of a tree. Sufficient soil moisture and a vegetation-free zone around the tree itself are foremost among the factors affecting tree survival. Supplemental irrigation is normally recommended, especially where precipitation falls below 32–36" per year.

Perhaps the most important factor affecting tree vigor is vegetation control underneath the tree canopy. Weeds are known to severely curtail pecan tree growth, and insufficient weed control is the most frequent reason new orchards fail or are slow to begin production. Apparently, interference from weeds is a combination of competition for moisture and nutrients as well as allelopathy (13). Recent research suggests that a 10-foot square area under newly planted trees should be vegetation free (14).

Though sustainable agriculture has a goal of reducing chemical inputs in general, herbicides are often used within a sustainable framework as an alternative to cultivation; to manage cover crops; or to create a sod-free strip in the tree row. Overall, herbicides account for a small percent of total active pesticide ingredients used in pecan production.

Summary of Pesticide Use in Pecans in Texas

Type of Pesticide	% of Total
Insecticides	75
Fungicides	23
Herbicides	2
Total	100

Source:

Crop Profile for Pecans in Texas
USDA Office of Pest Management Policy & Pesticide Impact Assessment Program
http://pestdata.ncsu.edu/cropprofiles/Detail.CFM?FactSheets__RecordID=291

Herbicides are restricted in certified organic production, however, and therefore the following weed control options will focus on non-chemical alternatives.

Mechanical cultivation by disking is an old weed control practice in pecan orchards. A recent study in Alabama provides insight into the relation between disking and soil moisture availability on pecan yields. Disking as a method of weed control was comparable to herbicide-treated plots when drip irrigation was used. However, when the pecan trees were not irrigated, yields from disked plots were reduced by half in comparison to weed-free plots treated with herbicides (15).

Mulches control weeds by excluding light and forming a physical barrier to growth. Organic mulches may be viewed as the ultimate soil treatment because they can suppress weeds, moderate soil temperatures, retain soil moisture,

and release nutrients and feed soil organisms during decomposition. **Sheet mulching** significantly enhances the efficacy of organic mulches. This is where a thick layer of straw, grass hay, or wood chips are laid on top of several layers of newsprint or heavy-duty kraft paper. Still, organic mulches biodegrade over time and require labor and materials to maintain.

Wood chips —which can often be obtained free by the truckload from municipalities and tree trimmers — make a superb organic mulch for trees. Research in Oklahoma showed that tree growth was significantly enhanced by the presence of a wood chip mulch, laid 12 inches deep in a 6-ft wide square around the base of the tree (16). This was combined with a 13-ft wide weed-free herbicide strip in the tree row. These horticulturists are saying that trees grow better when a wood chip mulch *and* a herbicide strip are used in combination.

Fungi inhabiting the cellulose-rich environment underneath a wood chip mulch may have an important role to play in tree health, too. Dr. Elaine Ingham, soil microbial ecologist at Oregon State University, says it is the **soil food web** that ultimately determines nutrient availability, disease occurrence, and related production factors. Wood chips, which are highly carbonaceous, foster a fungal-dominated environment ideal for trees and vines. Row crops and grasslands, by comparison, are dominated by a bacterial microflora (17).

Geotextile weed barriers (often called fabric weed barrier or landscape cloth) offer an effective long-term weed control alternative to chemicals, organic mulches, and cultivation. These materials suppress weeds but allow water and air infiltration. Growers can purchase pre-cut tree squares, obtain bulk material and cut it to size (e.g., 10'x 10'), or run the material down the entire row length (e.g., 10' to 15' wide strips). Higher grades of fabric mulch will last as long as 10 years.

Topping landscape weed barriers with a wood chip mulch is a common practice in the landscape industry, primarily for aesthetic purposes, but in field production it is not necessary and in fact can negate its intended purpose. Invariably, weed seeds land in the organic mulch *on top of the weed barrier* , subsequently germinating in this moist medium and sending roots down through the small pores of the fabric.

Regardless of which mulching system is employed, constant attention to weeds emerging *through the mulch* or on the *edges of the mulch* is critical. IPM farmers can use a post-emergent herbicide to deal with these renegade weeds, but organic growers committed to non-herbicidal weed control will have to be vigilant, especially during the first few years of a planting. Steam, used as a portable thermal weed control technique for spot treatment, is one option worth exploring in combination with geotextile mulches.

Living mulches, which are desirable cover crops planted in the alleyways between pecan trees, should be kept away from the trees themselves. Even legume cover crops, which can be so important in providing nitrogen to mature trees, should be excluded from the immediate area around young pecan trees or the trees can suffer from competition (14).

ATTRA's *Overview of Organic Fruit Production* publication contains a review of non-chemical weed control strategies relevant to tree crops.

Legumes in the Orchard

Legumes play an important role in sustainable pecan management because they fix nitrogen *and* enhance biological insect control. This latter aspect, the use of legumes to attract "food aphids" and the predators that feed on them and on associated pecan canopy aphids, is covered in more detail in the **Insect and Mite Pests** section.

The nitrogen (N) contribution from legumes is significant. Cover crop legumes fix 75–250 lbs. N/acre, depending on species and environmental conditions. At least half the total N fixed by legumes is released during decomposition the first year after legume dieback. In succeeding years of cover cropping, an increase in soil N is common. As pecan orchards need about 100–150 lbs. N/acre to maintain healthy, productive trees,

legumes seem like a perfect match. The Oklahoma State University study, previously cited, demonstrated that legume N is ample for native trees. Papershell trees, however, may require supplemental N inputs because orchard trees are more productive.

The choice of legume species will vary by climate and soil type, and therefore local recommendations should be obtained from the Extension Service. Several desirable qualities of an orchard legume and example selections are provided below.

Use of Legumes in Pecan Orchards (18), an Oklahoma State University report, identifies the legume characteristics that are most compatible with pecan production:

> First, a cool season legume is less competitive with the trees for soil moisture than a warm season legume, plus the cool season legume would stimulate an earlier increase in the beneficial insects.
>
> The legume should be tolerant to both sun and shade. Many pecan orchards are prone to flooding; therefore, flooding tolerance is desirable. Also, the legume must not cause an increase in undesirable insects, such as stink bugs, while attracting beneficial insects. The legume should be capable of fixing large quantities of N. Additionally, the legume must be capable of withstanding the traffic associated with orchard maintenance and harvesting.

The researchers in the Oklahoma study found a combination of self-seeding annual and perennial legumes performed the best. The annual legumes and seeding rates were 'Dixie' crimson clover at 10 lbs./acre and hairy vetch at 8 lbs./acre. The perennial legumes and seeding rates were 'Louisiana S-1' white clover at 2 lbs./acre and 'Kenland' red clover at 8 lbs./acre (5–6).

Pecan Production in the Southeast: A Guide for Growers (19), an Alabama Cooperative Extension Service publication, lists the preferred orchard cover crops for pecans in the Southeast as:

- Creeping red fescue
- Orchardgrass
- Centipedegrass
- Regal white clover
- Arrowleaf clover
- Merion bluegrass
- Common bermudagrass
- Louisiana S-1 clover
- Reseeding crimson clover

Though the Alabama publication states that deep-rooted, coarse, turf-producing grasses like Kentucky fescue and bahiagrass should be avoided, fescue is a common orchard grass in other parts of the pecan belt, especially where grazing is conducted.

Finally, successful legume establishment is a critical factor in how well a biological-nitrogen program will perform. In the Oklahoma study (4), Roundup® (glyphosate) herbicide was used to eliminate existing vegetation. Light disking followed by broadcast seeding and rolling benefited stand establishment. One alternative to herbicides includes partial tillage and legume establishment into the existing vegetation, thus arriving at a mixed grass-clover stand. Clean cultivation is the only practical non-herbicidal alternative if complete elimination of existing vegetation is desired.

Organic Fertilization

Fertilization of pecan trees is based on a soil test and leaf analysis. A soil test is taken in the year of establishment, and thereafter every 3 years, to monitor soil pH and nutrient levels. The most accurate indicator of orchard fertility, however, is nutrient status of the leaves. Leaf samples are taken in July and sent to a lab for analysis.

Nitrogen is the element that most influences pecan growth, and it is the element most likely to become deficient in a pecan orchard. Normal leaf concentrations of N fall between 2.3 and 3.0 percent. The minimum leaf nitrogen concentration for productive orchards is considered to be 2.2 or 2.3%.

This table, from ***Pecan Production in the Southeast: A Guide for Growers*** (19), shows how leaf analysis is related to fertilization.

General Fertilizer Guidelines Based on Leaf Analysis

Percent Nitrogen in Leaves	Pounds of Nitrogen to Apply Per Acre
Below 2.0	150*
2.1	140*
2.2	130*
2.3	120
2.4	110
2.5	100
2.6	100
2.7	100
Above 2.7	None, unless specifically suggested

*Use only on trees 30 years or older

In addition to leaf analysis, the terminal growth of pecan shoots can provide a visual indication of tree N status. Most pecan varieties fruit well when shoots are 4–8 inches long. Young, non-bearing trees should make more growth.

An interesting result of the USDA-SARE study in Oklahoma was a leaf N concentration of 2.6% when crimson clover-hairy vetch produced 166 lbs. N/acre.

Surface application of **compost** to pecan trees, especially in the weed-free zone, is a common practice in organic orcharding. In the early years, compost alone is often sufficient to enhance tree vigor, provided minerals are not deficient as determined by a soil test. Compost not only supplies mineral elements, but fosters soil microbial activity and contains beneficial by-products. In bearing orchards compost can be viewed as a supplement to nitrogen-fixing legumes.

Foliar applications of organic fertilizers and biostimulants, another common practice in organic orcharding, may be worthwhile in a young pecan orchard to enhance tree vigor. But in a mature pecan orchard, foliar feeding is questionable. In studies with commercial soluble fertilizers, some growers and researchers report positive effects, but others find no benefit. Pecan trees become so enormous and bear so much leaf mass that foliar-applied nutrients do not have sufficient impact to make a significant change in leaf analysis or nut yields. Western orchard trees, kept short by hedging, may be an exception.

On the other hand, foliar feeding can play an important role in pest management (altering leaf culticle structure and confusing insects, increasing soluble solids, and manipulating the foliar food web) and that may be a good enough reason for growers to employ this practice. In addition, organic materials such as seaweed and compost teas can be viewed as biostimulants that have a non-nutritive benefit akin to how compost functions in the soil beyond its N-P-K value.

Phosphorus (P) levels in orchard soils should be maintained for the nutrition of the pecan trees as well as the legumes. Normal leaf concentrations of P range between .12 and .20 percent. Rock phosphate is the chief source of P in commercial-scale organic production. Bone meal is a good source of P, and may be useful as a soil amendment at tree establishment, but it is too expensive to apply by the acre. Application rates of rock phosphate are considerably higher than single or triple superphosphate fertilizer, and may range from 300–1,000 lbs per acre.

Potassium (K) is the second most important element in pecan production, after nitrogen. Potassium deficiency can cause small, poorly-filled nuts, accelerate the tendency towards alternate bearing, and lower resistance to disease. Normal levels of leaf K range between 0.75 and 1.75 percent. Sulfate of potash-magnesia (Sul–Po–Mag®K–Mag®) is widely used in organic agriculture, especially in nut production. Certain brands of potassium sulfate (mined and untreated) can also be used in organic programs.

Zinc (Zn) is the other critical element in pecan nutrition. Normal leaf concentrations of Zn are between 50 and 150 ppm. A severe zinc deficiency, especially prevalent in highly calcareous soils, may lead to a physiological disorder known as pecan rosette. In calcareous soils with a pH over 7.0 (most of the western pecan belt), zinc is tied up by calcium into an insoluble form, and the application of foliar zinc is a standard practice.

In Oklahoma three foliar sprays per growing season at 6 lbs of 36% zinc sulfate per acre is common, whereas six sprays are common in south and west Texas. Zinc sulfate is an accepted material in organic certification programs.

Brent Wiseman (20), Coordinator for Organic Programs at the Texas Department of Agriculture, says that zinc sulfate mixed with seaweed and fish emulsion and applied foliarly is a common practice in Texas organic pecan orchards, though constant agitation of the spray tank solution is necessary to keep the solution from settling.

Additional concepts and practices associated with ecological soil management and organic fertilization are contained in the following ATTRA Publications:

- ***Overview of Organic Fruit Production***
- ***Sustainable Soil Management***
- ***Alternative Soil Amendments***
- ***Alternative Soil Testing Laboratories***
- ***Sources of Organic Fertilizers and Amendments***
- ***Farm-Scale Composting***
- ***Overview of Cover Crops and Green Manures***

Organic Fertilization Resources

Sources for Organic Fertilizers and Amendments
ATTRA
http://www.attra.org/attra-pub/orgfert.html

This is the ATTRA resource list on organic fertilizers that provides an extensive listing of dealers and suppliers carrying bulk organic fertilizers, listed state-by-state.

OMRI's Brand Name Products List
Organic Materials Review Institute
http://www.omri.org/brand_list.html

OMRI is the Organic Materials Review Institute. It provides a technical review of organic crop production materials (fertilizers and pest controls) supplied by manufacturers. Products that receive an Allowed or Regulated status can state that the product is "OMRI Listed" and may use the OMRI seal on packaging and literature.

The Brand Name Products List on OMRI's Website includes crop production materials Organized alphabetically by Generic Material, Supplier, and Product.

Alternative Soil Testing Laboratories Resource List
ATTRA
http://www.attra.org/attra-pub/soil-lab.html

Whereas the pecan industry is heavily Oriented to standard commercial fertilizer recommendations available from land-grant university soil labs, organic farmers may find the advice from crop advisors who specialize in organic fertilizer recommendations to be more helpful.

Alternative Soil Testing Laboratories also provides an extensive list of resources and web sites on alternative soil fertility concepts and practices.

Commercial Organic Nutrient Recommendations
University of Maine Soil Testing Service/Analytical Lab
http://anlab.umesci.maine.edu/handout/ organ01.HTM

In these handy tables from University of Maine you can quickly see how many pounds of organic fertilizer are needed to meet desired pounds of nutrient element per acre; e.g., 670 lbs fish meal equals 60 N lbs per acre, 890 lbs fish meal equals 80 lbs N per acre, and 1100 lbs fish meal equals 100 N lbs per acre.

Insect and Mite Pests

Introduction

In the East, in addition to foliar-feeding aphids and mites, there are several serious direct pests of the nut. Researchers have developed advanced IPM programs to minimize damage from these pests, and in most cases a biological control or otherwise organically acceptable control is available. However, two key pests throughout most of the eastern pecan production areas, the pecan weevil and the hickory shuckworm, present serious obstacles to organic production. In western production regions where pecan and its relatives (especially the hickories) are not native, some of the worst pecan pests have been left behind. In such areas the most troublesome pests are likely to be aphids and mites that feed on the foliage and stems.

Aphids and Mites

Aphids and mites are similar in that they are "indirect pests" (i.e., they feed on plant parts other than the harvested nut), have multiple generations through the growing season, and are often raised to pest status by the inadvertent killing of their natural enemies by pesticides targeted for them or other pests. This last characteristic has provided a major impetus for researchers to investigate the refinement of ecologically-based pest management systems to preserve the beneficial organisms and achieve natural biological control of aphids and mites.

Two species of yellow aphids attack pecans: the black-margined aphid (*Monellia caryella*) and the yellow pecan aphid (*Monelliopsis pecanis*). The primary damage caused by yellow aphid feeding is the deposit of honeydew on leaves, which supports the growth of sooty mold and reduces photosynthesis.

The black pecan aphid (*Melanocallis caryaefoliae*) can be more destructive than other aphids found on pecans. If left unchecked, its feeding can cause premature defoliation of the orchard. It is a pest in southeastern pecan groves and in Texas. While it can also be found in Oklahoma and Kansas, it rarely occurs in densities sufficient to cause concern.

There are many natural enemies of aphids and mites, including ladybeetles, lacewings, damsel bugs, assassin bugs, spiders, and predacious mites. The planting of cover crops to provide refuge, insect prey, honeydew, nectar, pollen, and a water supply for these beneficial insects is how growers and researchers are beginning to solve aphid and mite problems through biological control (5,21,22).

USDA-SARE research conducted in Oklahoma (5) and Georgia (21) evaluated cool-season legumes as beneficial insect refuge. The goal was to identify which cover crops support predators and parasites of pecan pests, and to identify when they actually migrate from the ground covers into the trees to achieve biological control of the pecan pests.

Research thus far indicates that predators like lady beetles and green lacewings are attracted to cover crops to feed on pea aphids, cowpea aphids, and blue alfalfa aphids which inhabit the legumes. The number and species of beneficials found in the tree tops varied, but an increase in canopy numbers of predators was apparent where a crimson clover-hairy vetch ground cover was grown (5).

Dr. Glenn 'Cat' Taylor (23), former pecan specialist (retired) at the Noble Foundation in Ardmore, Oklahoma, said the need for aphid insecticide application is regionally specific as determined by the presence of aphid species. As an example, the only aphid occurring in sufficient numbers in Oklahoma is the yellow aphid. He advises Oklahoma growers to go with a "soft spray" program — using pesticides with low-toxicity to beneficials and with short environmental persistence —and foregoing aphid control because the yellow aphid causes more concern than actual damage.

At the other extreme, aphid problems in Georgia are severe enough to warrant the registration and use of the highly toxic, systemic insecticide aldicarb for aphid control. Dr. Jim Dutcher (24) reported that a four-step, less-toxic alternative

has been developed for Georgia growers. The program includes: [1] a row of legumes planted in the aisle; [2] controlling fire ants by spraying the trunks with insecticides (fire ants are indiscriminate predators and kill beneficial insects that would otherwise prey on aphids); [3] irrigation to ameliorate the stress to trees caused by aphid feeding; and [4] releases of aphid predators.

In short, while pesticides may occasionally be necessary to control mite or aphid problems, the manipulation of the orchard floor to provide habitat for beneficials and the release of beneficials into the grove or orchard will in many cases be sufficient to control aphid problems. Arnold Brothers Biological Insect Pest Control (25) is an insectary in New Mexico specializing in aphid control for pecan orchards.

Pecan Weevil

The pecan weevil (*Curculio caryae*) emerges as an adult from the soil under or near pecan trees primarily during August and September. The weevils mate and begin feeding on the developing pecan nuts soon after emergence.

Females lay eggs in the nuts, the eggs hatch, and the larvae feed on kernels inside the nutshells for approximately six weeks. Larvae then burrow out through the shell, fall to the ground, and enter the soil where they pupate and overwinter as adults. If conditions are favorable over several years, weevil "populations can increase until virtually all pecan nuts are infested" (26).

The pecan weevil is present throughout most of the South wherever pecans and hickories grow and is considered the most important pest of managed pecans in the southeastern U.S. (27). A large percentage of damaged nuts can render a crop practically unmarketable.

Interestingly, the pecan weevil is mysteriously absent from certain areas within states where the weevil is otherwise common. As an example, Brent Wiseman explained that areas around Stephenville and El Paso, Texas, harbor few weevils while the central Texas region is heavily

Biological Control

Adverse weather, inadequate food supply or natural enemies may hold insect and mite populations below damaging levels. It is important to recognize the impact of these natural control factors and, where possible, encourage their action.

Biological control is the use of living organisms (parasites, predators and diseases) to reduce pest numbers. Important natural enemies of pecan pests include lacewings, spiders, lady beetles, assassin bugs, predatory mites and many kinds of tiny wasps that parasitize insect pests.

Biological control includes conserving, augmenting and importing natural enemies. Conserve existing populations of natural enemies in the orchard by minimizing insecticide applications and by using insecticides least toxic to the natural enemy.

Examples include B.t. (*Bacillus thuringiensis*) insecticides (Dipel®, Javelin®), which are toxic only to certain moth caterpillars and not to insect predators or parasites. Ground covers such as legumes can provide food and shelter for natural enemies. Unsprayed native pecans serve as reservoirs of natural enemies that can move into adjacent sprayed orchards.

Augmentation involves periodically buying and releasing natural enemies. Research is under way to determine if such releases control pecan pests effectively and practically. Natural enemies can also be imported from other countries, then colonized and released. Once established, these natural enemies maintain themselves without further releases.

Source:

Managing Insect and Mite Pests of Commercial Pecans in Texas
Texas Agricultural Extension Service, B-1238
http://entowww.tamu.edu/extension/bulletins/b-1238.htm

Resources:

Farmscaping to Enhance Biological Control
ATTRA
http://www.attra.org/attra-pub/farmscape.html

Suppliers of Beneficial Organisms in North America
http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm

infested. Consequently, ***location influences the degree to which pecan weevil control is necessary and where organic production is most feasible***.

The ***Pecan Weevil Wanted Poster*** from Texas A&M shows the distribution —the presence or absence — of pecan weevil in Texas. It is located on the web at:
http://pecankernel.tamu.edu/publications/pwwanted.PDF

Biological control options for pecan weevils are limited. Fire ants prey on pecan weevils, but they also prey on beneficials and are a nuisance to farm workers. Researchers have tried using soil-applied, beneficial, parasitic nematodes as well as entomopathogenic fungi, but nothing reliable has emerged from these efforts as yet.

Several methods have been developed to monitor weevil emergence, thus allowing for accurate spray timing. Heretofore, the two most important techniques have been the cone trap developed at Oklahoma State University (28), and the pyramid trap developed by USDA-ARS at Byron, Georgia (29). This latter trap is shaped like a pyramid, about 21 inches wide and 48 inches tall, painted brown, and capped with a screen funnel trap. When adult weevils emerge from the soil, they normally fly to the dark trunk of a pecan tree, but by whitewashing the tree trunks researchers found they could divert the weevils from the trunks to the traps. Ten to 15 traps per 100 acres is enough to monitor weevil emergence.

More recently, the Circle trap (named for its inventor, Kansas pecan grower Edmund Circle) has proved to be cheaper to construct and reliable as a monitoring tool, plus it is mounted on the trunk and therefore out of the way of grazing animals and mowing operations. Complete plans for fabricating this trap are available in ***Monitoring Adult Weevil Populations in Pecan and Fruit Trees in Oklahoma,*** OSU Extension Facts F-7190, on the web at:
http://www.okstate.edu/OSU_Ag/agedcm4h/pearl/insects/cropbugs/f-7190.pdf.

The only viable control for pecan weevil at the present time appears to be one or two accurately timed insecticide applications (e.g., Sevin®, Imidan®, Ammo®, Asana®, Fury®).

Pecan Nut Casebearer

The casebearer (*Acrobasis nuxvorella*) is a major pest in Texas, Oklahoma, Missouri, Kansas, Arkansas, and Louisiana, and occasionally reaches serious pest status further east. There is patchy distribution in New Mexico, but casebearers do not occur in Arizona or California.

The casebearer commits several types of damage. In the spring, partially grown larvae emerge from their overwintering site (a cocoon attached to a bud on a pecan twig) and burrow into buds and stems where they will pupate. Later in the spring (usually during May in most pecan growing regions) the moths emerge, lay their eggs on the tips of nutlets, and the resulting larvae feed on buds and the developing nutlets. These larvae will pupate within fruits, emerge as adults and again lay eggs on other fruits. The cycle continues throughout the summer, but third and fourth generation larvae usually cannot penetrate the hardened nut shell. The primary damage caused by the casebearer is dropping of nuts.

Monitoring is done by visual inspection of the nut tips. A hand lens can be used to look at nut tips more closely, though the trained eye is all that is necessary. The Texas Agriculture Extension Service and the University of Georgia have both developed models based on degree days that predict emergence and egg laying of the casebearer. Thus, monitoring of this pest can be very tightly managed by combining visual inspection with degree day reports from the Extension Service. Both the Georgia and Texas models can be seen at the ***Oklahoma Pecan Management*** website at:
http://www.hortla.okstate.edu/pecan/

Pecan nut casebearer pheromone traps, developed by Dr. Marvin Harris at Texas A&M University, are a recent innovation in pecan IPM monitoring.

A new low-impact pesticide effective against the casebearer is Confirm®, an insect growth regulator. Sprays of Confirm are most effective

when the majority of eggs on the nut tips are in the pink or red stage.

As the casebearer itself is a lepidopteran (moth) insect, organic growers can use the biological control *Bacillus thuringiensis kurstaki* (Bt). Trade names include Javelin® and Dipel®. Combined with a monitoring program, control is quite effective. Because *Bt* does not last long in the environment, sprays of *Bt* should be timed directly at the larvae rather than eggs. Apply when 1–2% of the nuts have been entered.

A rule-of-thumb method is to spray when the nut tips turn brown. This is not as accurate, so it is advisable if using this latter method to make a second application 7–10 days later.

Hickory Shuckworm

The adult hickory shuckworm (*Cydia caryana*) is a moth. Larvae of the shuckworm tunnel into pecan fruits from early spring until the shells harden in mid to late summer, thus destroying the fruit and resulting in premature nut drop. Three to four generations can occur each year. Later generations attack pecans after shell hardening; damage from larvae tunnelling into pecan shucks (hull) causes poor kernel filling and prevention of shuck split.

Early in the spring, the shuckworm feeds primarily on native hickory and is often found in phylloxera galls on pecan trees. Thus, one of the most effective control strategies for hickory shuckworm is targeting of phylloxera galls in spring. The soft-spray control method for phylloxera gall is a dormant application of horticultural oil. In northern production regions (Kansas, Missouri) where shuckworm pressure is not too high, the nut thinning process associated with hickory shuckworm may actually do more good than harm, according to Dr. William Reid at Kansas State University. The shuckworm is absent in the western pecan belt and in certain districts of other pecan-producing states.

Where it does occur, the shuckworm is considered a major pest for two reasons. The first reason is that, compared to the pecan weevil and the pecan nut casebearer, the shuckworm is difficult to monitor. The second reason is that soft spray options like *Bt* are limited because the larval stage is spent mostly inside the pecan shuck and, therefore, short-lived pesticides sprayed on the foliage have limited efficacy.

The standard tool for monitoring of shuckworm until recent years was a blacklight trap. However, such traps attracted all kinds of insects and it was a time-consuming process to separate and count shuckworm moths. More recently, a pheromone that attracts female shuckworm moths was identified at Oklahoma State University. Pheromone traps for the hickory shuckworm are available through commercial pest management suppliers.

Several pesticides are registered for shuckworm control, including the insect growth regulator mentioned earlier, Confirm®. Growers raising certified organic pecans will have to rely on accurately timed applications of *Bt*, or use appropriately registered botanical insecticides.

Phylloxera

There are five known species of phylloxera (a.k.a. "plant lice") that attack pecan, but the pecan phylloxera, *Phylloxera devastatrix* is generally considered to be the most economically important. The pecan phylloxera is most common in its native range through Texas, Oklahoma, Arkansas, Louisiana, and Mississippi. This aphid-like pest causes galls or knots to appear, primarily on leaves though it also occurs on fruits and stems. Severe infestations, when they do occur, can result in plant stress, defoliation, terminal dieback, and reduction in yield and nut quality. Phylloxera galls also serve as a host for developing larvae of the hickory shuckworm.

In native groves, removal of susceptible trees during normal thinning programs can reduce or eliminate phylloxera problems (8).

Some cultivars are known to be more susceptible to pylloxera than others. Resistant cultivars include Mohawk, Chickasaw, Cherokee,

Shawnee, Sioux, Kiowa, Caddo, Cowley, Shoshoni, and Sumner (30). Cape Fear, Mahan, Wichita, Cheyenne, and Tejas appear only moderately susceptible, while Apache, Riverside, Stuart, Success, Schley, and Desirable are known to be susceptible (30-31).

By the time galls appear it is too late to do anything, since the galls encase the insect and thereby protect it from insecticides. If damage is anticipated, a dormant oil can be applied as part of a certified organic program though control may not be as effective. Regular pecan insecticides are typically applied at bud break to one-inch shoot growth. If sprays are delayed past this period there is a risk the pest will already be sequestered within a gall.

Diseases

Pecan Scab

Pecan scab, caused by the fungus *Cladosporium caryigenum*, is the most serious disease of pecans. Scab pressure is particularly bad in the Southeast where humidity and rainfall are high. It presents few problems in West Texas, New Mexico, Arizona, and California. In northern pecan groves, where the climate is drier than in the deep South and where genetic variation keeps scab from becoming epidemic, fungicidal control is not a regular practice.

Dr. Bruce Wood (32), horticulturist with the USDA Fruit Research Station located in Byron, Georgia, explained that while scab-resistant cultivars exist, many of the best commercial pecan cultivars are susceptible. Additionally, scab resistance has been found to diminish over time. For instance, 'Stuart' was rated as very resistant to scab for over 40 years, but by 1956 was considered susceptible (33).

Nevertheless, where scab is a factor most horticulturists are now suggesting that scab resistance be taken into account when selecting varieties and planning an orchard. Susceptible cultivars simply require too many fungicide sprays to be profitable.

See the table in the **Appendix** for a list of pecan cultivars currently rated as scab resistant.

Standard pecan fungicides can provide adequate control for scab. Some of the copper fungicides are permitted in certified organic production. In any case, early-season control is important.

Failure to control scab on susceptible cultivars early in the season can lead to 50–100% crop loss (33).

Abound®, a new-generation fungicide synthesized from a compound first discovered in strobilurin mushrooms, is very effective against scab and registered for that use. However, due to Abound's mode of action, *C. caryigenum* could develop resistance if Abound is over-relied upon. Therefore fungicide rotation is strongly encouraged.

In the humid Southeast, the standard recommendation for scab control may call for fungicide sprays every 2–3 weeks from early spring to near harvest. Fortunately, models for scab prediction are being developed. One such model, developed by Sharon von Broembsen of Oklahoma State University, can be viewed at the ***Oklahoma Pecan Management*** website at: http://www.hortla.okstate.edu/pecan/.

Other Diseases

There are several foliar diseases, including powdery mildew, downy spot, zonate leaf spot, vein spot, leaf blotch, et al., which can be troublesome for pecans, but rarely outside of commercial plantings in the Southeast. In most cases, sprays for scab will also control these problems.

Appendix:

Scab Resistant Pecan Cultivars

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Pecan Experiment Field
Kansas State University
P.O. Box 247
Chetopa, KS 67336-0247
316- 597-2972
316- 597-2758 Fax

11) Dr. Bill Gustafson
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402-472-3674
402-472-3858 Fax
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980 NW Circle Blvd
Corvallis, OR 97330
541-752-5066
541-752-5142 Fax
Contact: Dr. Elaine Ingham
sfi@soilfoodweb.com
http://www.soilfoodweb.com

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Texas Dept. of Agriculture
P.O. Box 12847
Austin, TX 78711
512-463-7476

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23) Dr. Glenn 'Cat' Taylor (retired)
The Samuel Roberts Noble Foundation, Inc.
P.O. Box 2180
Ardmore, OK 73402
405-223-5810
[Scott Landgraff at The Noble Foundation can provide current pecan recommendations]

24) Dr. Jim Dutcher
Associate Professor of Entomology
Entomology Department
Coastal Plain Experiment Station
Box 748
Tifton GA, 31793
913-386-3567

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P.O. Box 450
Fairacres, NM 88033
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Print Resources

Pecan Grower's Handbooks:

Pecan Production in the Southeast: A Guide for Growers. 1989. Alabama Cooperative Extension Service, Auburn University. 230 pages. 300 full-color photographs. $45.00

Available from:
Alabama Cooperative Extension Service
Publications
6 Duncan Hall
Auburn University, AL 36849-5632
334-844-1592

Texas Pecan Grower's Handbook. 1994. Texas Agriculture Extension Service, Texas A&M University. 200 pages. $15.00.

Available from:
Extension Horticulture
Texas A&M University
College Station, TX 77843-2134
409-845-8904

New Mexico Pecan Growers' Handbook. 1991. Cooperative Extension Service, New Mexico State University. 214 pages. $35.00

Available from:
Dr. Esteban Herrera
New Mexico State University
Plant Sciences Dept.
Box 3AE
Las Cruces, NM 88003
505-646-0111

Books and Periodicals on Pecans:

Several good books and trade magazines on pecans are available from one source in Texas. Contact:

The Olde Pecan Bookstore
P.O. Drawer C
College Station, TX 77841
409-846-3285
409-845-1752 Fax
http://www.texaspecan.com/books.htm

Books:

Pecans—A Grower's Perspective. 1994. By Wes Rice. PecanQuest, Ponca City, OK. 198 pages. $57.50 hardback, $39.50 softcover.

Pecan Cultivars: Past and Present. 1985. By Tommy E. Thompson and Fountain Young. Texas Pecan Growers Association, College Station, TX. 265 pages. $19.95 hardback, $12.95 softcover.

The Pecan Tree. 1994. By Jane Manaster. University of Texas Press, Austin, TX. 109 pages. $17.95.

Pecan Pest Management in the Southeast. 1984. By H.C. Ellis, et al. University of Georgia Cooperative Extension Service, Athens, GA. 62 pages. $28.00.

Pecan Production in the Southeast: A Guide for Growers. 1996. By William D. Goff, John R. McVay, and William S. Gazaway. Alabama Cooperative Extension System, Circular ANR 459. 222 pages. $45.00.

Periodicals:

Pecan South (monthly), $18.00

The Texas Horticulturist (monthly), $12.00

The Pecan Newsletter, $85.00
[Pecan marketing information delivered in weekly issues through the harvesting and marketing season, late September thru late January].

All the periodicals listed above are available from The Olde Pecan Bookstore.

Pecan Grower (quarterly), $8.00
Available through:
Georgia Pecan Growers' Association
4807 Woodland Dr.
Tifton, Georgia 31794
912-382-2187

Electronic Resources on Pecan Production and Pecan Pest Management

An Introduction to the Genus *Carya*
National Clonal Germplasm Repository for Pecans and Hickories
http://extension-horticulture.tamu.edu/
/carya/species/index.htm

Pecan Cultivars Index
Pecan Genetics and Improvement Research, Agricultural Research Service, USDA
http://extension-horticulture.tamu.edu/
/carya/pecans/cvintro.htm

Growing Pecans in Kansas
Kansas State University Extension Service, MF-1025
http://www.oznet.ksu.edu/library/
/hort2/SAmplers/MF1025.htm

Growing Pecans in North Carolina
North Carolina State University
http://www.ces.ncsu.edu/depts/hort/
/hil/ag81.html

Pecan Cultivar Performance at the Coastal Plain Experiment Station, 1921-1994. Georgia Agricultural Experiment Station Research Bulletin 426. 34 p.
http://www.ces.uga.edu/pubs/PDF/RB426.pdf

IPM for Alabama Fruit and Nut Trees
Alabama Cooperative Extension Service
http://www.aces.edu/department/ipm/
/treefipm.htm

Pecan Diseases in Alabama
Alabama Cooperative Extension Service, ANR 606
http://www.aces.edu/department/extcomm/
/publications/anr/anr-606/anr-606.html

Pecan Entomology in Louisiana
Louisiana State University
http://www.agctr.lsu.edu/agcenter/research/
/pecan/MJH/ento.htm

Pecan Insects, Images & Descriptions in South Carolina
Clemson University
http://entweb.clemson.edu/cuentres/cesheets/
/pecan/

Pecan Pest Management: Insects and Diseases
University of Missouri-Columbia, MP711
http://muextension.missouri.edu/xplor/miscpubs/
/mp0711.htm

New Mexico State University Pecan Publications
http://www.cahe.nmsu.edu/pubs/_h/

The New Mexico State University website hosts about 36 different fact sheets on pecan production and pecan pest management.

Also at New Mexico State University:

Controlling the Pecan Nut Casebearer by Applying Insecticide Based on Heat Units
New Mexico State University
http://weather.nmsu.edu/nmcrops/pecans/
/pecan_nut_casebearer.html

Oklahoma Pecan Management
Oklahoma State University
http://www.hortla.okstate.edu/pecan/

The Oklahoma Pecan Scab Model
http://blaze.ocs.ou.edu/~nassar/scab/

The Oklahoma Pecan Nut Casebearer Model
http://blaze.ocs.ou.edu/agwx/models/pecan/
/pnc/

Oklahoma Cooperative Extension Service Pecan Publications
http://agweb.okstate.edu/pearl/hort/fruits/
/index.html

The OSU website hosts about 17 different fact sheets on pecan production and pecan pest management.

Also at Oklahoma State University:

F-7642 - Pecan Diseases: Prevention and Control
http://agweb.okstate.edu/pearl/plantdisease/
/f-7642.pdf

Texas A&M University Aggie Horticulture
http://aggie-horticulture.tamu.edu/

Texas Nut Culture 418
Texas A&M online Horticulture Course
http://aggie-horticulture.tamu.edu/
/syllabi/418/schedule.htm

Managing Insect and Mite Pests of Commercial Pecans in Texas
Texas Agricultural Extension Service, B-1238
http://entowww.tamu.edu/extension/
/bulletins/b-1238.html

Controlling the Pecan Nut Casebearer
Texas Agricultural Extension Service, L-5134
http://entowww.tamu.edu/extension/
/bulletins/l-5134.html

Pecan Pest Management CD-ROM

Developed at Texas A&M University, the **Pecan Pest Management CD-ROM** features:

General Information — pecan tree overview, pecan phenology, calendar checklist, chemicals, cover crops, diagnostic key.

IPM Information — key pests, natural enemies, diseases, casebearer and pecan weevil management.

Tutorial — pecan tree, pest management graphics by region, early-, mid-, and late-season pests.

With 166 color photos and the ability to search by keyword. Available for $60 through The Olde Pecan Bookstore.

Field Guide to the Insects and Mites Associated with Pecan, B-6055
http://entowww.tamu.edu/extension/forsale/
/b-6055.html

Texas A&M's entomological field guide to important pests and beneficial insects found in pecan orchards, with color photos and descriptions; available for $12.95 per copy (includes postage and handling). Make checks or purchase orders payable to: Texas Agricultural Extension Service Account #233206

Publication and Supply Distribution
Texas Agricultural Extension Service
P.O. Box 1209
Bryan. TX 77806-1209

Texas Pecan Pest Management Newsletter
Entomology at Texas A&M University
http://entowww.tamu.edu/extension/
/newsletters/

Published 8–10 times during the growing season between March and September. Back issues to 1998 are located online, as well as the current growing season.

Texas Pecan IPM Articles in The Pecan Press
http://pecankernel.tamu.edu/newsletters/

Pecan Kernel (Texas)
http://pecankernel.tamu.edu/

A pecan pest management site from Texas A&M entomology. It provides a convenient link to all the current and back issues of ***Texas Pecan Pest Management Newsletter*** and ***Texas IPM for Pecan Press*** articles**.** Here, you can also find a list of pecan specialists working at 19 land-grant universities and research and extension centers.

UC Pest Management Guidelines: Pecans
University of California
http://www.ipm.ucdavis.edu/PMG/
/selectnewpest.pecans.html

1998 Sample Costs to Establish a Pecan Orchard and Produce Pecans (San Joaquin Valley, Flood Irrigated)
University of California
http://www.agecon.ucdavis.edu/outreach/crops/
/cost-studies/98pecans.pdf

Routing Pecan Scab — Protecting a Popular Nut
USDA Agricultural Research Service
http://www.ars.usda.gov/is/AR/archive/aug98/
/scab0898.htm

Crop Profile for Pecans in North Carolina
USDA Office of Pest Management Policy & Pesticide Impact Assessment Program
http://pestdata.ncsu.edu/cropprofiles/
/Detail.CFM?FactSheets__RecordID=205

Crop Profile for Pecans in Texas
USDA Office of Pest Management Policy & Pesticide Impact Assessment Program
http://pestdata.ncsu.edu/cropprofiles/Detail.CFM?FactSheets__RecordID=291

The USDA Office of Pest Management Policy & Pesticide Impact Assessment Program website provides a state-by-state assessment of pesticide use in crop production. Reports provide crop status, key pests, and typical pesticide recommendations. Currently North Carolina and Texas are the only two states that have completed reports on pecans. These crop profiles are valuable because they summarize the important pests and what pesticides are used to control them. Where least-toxic or cultural controls are available, these are also included.

Northern Nut Growers Association, Inc.
Articles & Books on Pecans
http://www.icserv.com/nnga/pecan.htm

Texas Pecan Growers Association
http://www.texaspecan.com/

Darrell Sparks' Pecan Page
University of Georgia–Horticulture
http://www.geocities.com/CollegePark/Campus/
/3370/

IPM Pest Management Supplies

BioQuip Entomology Products
17803 LaSalle Ave.
Gardena, CA 90248-3602
310-324-0620
310-324-7931 Fax
bioquip@aol.com
Supplier of entomology books and supplies: handlens, catch nets, blacklights, pheromones traps, etc.

Gemplers IPM Products
P.O. Box 270
Belleville, WI 53508
1-800-332-6744 (Customer Service)
1-800-382-8473 (Phone orders)
http://www.gemplers.com
Supplier of IPM books and manuals; IPM field products, & pesticide safety gear.

Trece
1143 Madison Lane
Salinas, CA 93907
831-758-0204
831-758-2625 Fax
http://www.trece.com
Supplier of pheromone traps & lures.

The electronic version of **Sustainable Pecan Production** is located at:
http://www.attra.org/attra-pub/pecan.html

By Steve Diver and Guy Ames
NCAT Agriculture Specialists

Revised November 2000

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APPENDIX: **Pecan Cultivars Resistant to Pecan Scab***

Cultivar	Average rating[1]
Apache	5.0
Wichita	5.0
Burkett	5.0
Western Schley	5.0
Tejas	4.0
Cherokee	4.0
Cherokee	4.0
Cheyenne	3.5
Mahan	3.3
Shawnee	3.0
Sioux	2.7
Pawnee	2.5
Shoshoni	2.5
Mohawk	2.5
Maramec	2.5
Forkert	2.3
Osage	2.2
Colby	2.0
Barton	1.7
Peruque	1.7
Kiowa	1.7
Cape Fear	1.7
Podsednick	1.7
Choctaw	1.7
Chickasaw	1.5
Curtis	1.5
Desirable	1.5
Stuart	1.5
Caddo	1.2
Moreland	1.2
Sumner	1.2
Jackson	1.0
Success	1.0
Starking Hardy Giant	1.0
Gloria Grande	1.0
Melrose	1.0

[1]No scab lesions = 1; Lesions on over half of nut surface area = 5

From: Thompson, Tommy E. and L.J. Grauke. 1994. Genetic Resistance to Scab Disease in Pecan. HortScience. September. p. 1078–1080.