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Western Pecan Growers Association Conference

WPGA Pecan Show

Pecan Food Fantasy

And

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Herbicide Resistance: Development and Management

Dr. Jamshid Ashigh
Extension Weed Specialist
New Mexico State University

Worldwide, herbicides remain the most efficient technology for large-scale weed control. Therefore, the widespread evolution of herbicide resistance among weed populations within intensive crop production systems is a major threat to the sustainability and profitability of cropping systems. The introduction of new herbicides and herbicide modes of action to replace those herbicides failing due to resistance is essential for weed management. However, the rate of introduction of new herbicides for world agriculture has slowed dramatically. This is due to the difficulty and high cost involved in discovery of new herbicides/herbicide modes of action with the necessary environmental properties. As a result, new herbicide or herbicide mode of action discovery will occur but not as frequently as required for proactive and reactive resistance management. Therefore, there is a strong imperative to use the currently available herbicide resources in more sustainable ways (Walsh and Powles 2004).

Resistance Definition and Development:

Herbicide resistance is the inherited capacity of a plant to survive and reproduce following selection with a dose of herbicide normally lethal to the wild type. Resistance to a particular herbicide can be a natural property of the plant or a secondarily acquired mechanism (Heap and LeBaron 2001). Mechanisms of herbicide resistance include: altered site of action, site of action over production, enhanced herbicide metabolism, decreased herbicide absorption and translocation and herbicide sequestration. However, in weeds the most common mechanisms that cause herbicide resistance are: altered site of action and enhanced herbicide metabolism. Site of action is the specific process within a plant that a particular herbicide/herbicide family inhibits. Alterations in the site of action that prevent the herbicide from binding are the most common mechanism of resistance (Heap and LeBaron 2001). Enhanced herbicide metabolism is the superior ability of plants to metabolize the herbicide to nontoxic metabolites whereas susceptible species are unable to detoxify the herbicide before plant death occur (Saari et al. 1994).

The development of herbicide resistance in weeds is an evolutionary process. Weed populations are extremely diverse in their genetic background, even though they may be similar in their appearances. In some cases, the genetic variations within weed populations include the inherent abilities to resist some of the herbicides. However, frequency of such variants in a normal weed population is very low. But if a herbicide/herbicide family is applied repeatedly on those populations the entire picture could change as the majority of the susceptible biotypes will be controlled after repeated applications. This provides the few resistant biotypes, which are normally less competitive than the susceptible biotypes, with a unique opportunity to proliferate themselves. Therefore, if a herbicide/herbicide family is used continuously for many years, within the natural weed population, the number of susceptible biotypes decreases drastically and resistant biotypes increases dramatically. For that reason, in response to widespread use of a particular family of herbicide, weed populations change in genetic composition such that the frequency of resistance gene(s) and resistant individuals increases. Thus, weed populations become adapted to the intense selection imposed by herbicides (Jasieniuk et al. 1996).

Major factors influencing the development of herbicide resistance include the intensity of selection by herbicides, the initial frequency of herbicide-resistant individuals in the population and gene flow. (Jasieniuk et al. 1996).

Selection Pressure. Selection pressure has been stated as one of the most important determinants in the resistance phenomenon. Major factors contributing to selection pressure include the efficiency of the herbicide, the frequency of use (Maxwell and Mortimer 1994). Selection intensity in response to herbicide application is a measure of the extent to which a herbicide (selective agent) differentiates between resistant and susceptible individuals within a population. Moreover, depending on the soil and herbicide chemical properties, herbicide residual activity could also be a major factor in the development of herbicide resistance (Jasieniuk et al. 1996; Beyer et al. 1988).

Initial Frequency Resistance Mutations. Precise studies have not been performed on the initial frequency of resistance mutations in weeds. However, mutation frequency, based on cell culture studies have been estimated to be approximately around 2.7×10^{-8} to 1×10^{-9} (Harms and DiMaio 1991).

Gene Flow. Gene flow between and within plant populations occurs through two primary means, pollen and seed movement (Maxwell and Mortimer 1994). Rates of gene flow are generally believed to be higher than rates of mutations (Jasieniuk et al. 1996) and are affected by the mating system of weed species. When resistance is conferred by a single dominant gene, the spread of resistance occurs more rapidly in cross-pollinated species compared to self-pollinated species (Jasieniuk et al. 1996). Therefore, resistance genes most likely arise in an area through mutation and gene flow would facilitate the spread of the resistance genes among individuals within that area (Jasieniuk et al. 1996; Ashigh et al. 2008).

To date, resistance to at least 18 classes of herbicides has been reported in more than 323 biotypes of 187 species (112 dicots and 75 monocots). In New Mexico, only one biotype of kochia (*Kochia scoparia*) has been reported to have resistance to acetohydroxyacid synthase (AHAS, also known as ALS) inhibiting herbicides (Heap 2009). However, recently a population of Palmer amaranth (*Amaranthus palmeri*) has been reported to have survived several applications of glyphosate in Doña Ana County, and current research at NMSU is to confirm and characterize resistance in the suspected glyphosate-resistant population of Palmer amaranth. To date, fourteen prominent weed species have developed resistance to glyphosate worldwide. In the United States, nine weed species including: Palmer amaranth, common waterhemp (*Amaranthus rudis*), common ragweed (*Ambrosia artemisiifolia*), giant ragweed (*Ambrosia trifida*), hairy fleabane (*Conyza bonariensis*), horseweed (*Conyza Canadensis*), italian ryegrass (*Lolium multiflorum*), rigid ryegrass (*Lolium rigidum*), and johnsongrass (*Sorghum halepense*), have developed resistance to glyphosate, in several states (Heap 2009).

Confirmation of Resistance:

Resistant biotypes can be confused with weed escapees as a result of herbicide failures caused by bad weather, type and size of the weeds, and/or improper applications. However, herbicide resistance should not be suspected unless a herbicide failure fits the following traits: (a) the same herbicide was used year after year, (b) one weed, which normally should be controlled, is not controlled although other weeds are controlled, (c) a patch of an uncontrolled weed is spreading, and (d) healthy weeds are mixed with controlled weeds (of the same species). In cases that a control failure exhibits above mentioned traits, seeds of suspected herbicide resistant weed(s) can be sent to our Plant Diagnostic Clinic at NMSU (following addresses) for absolute diagnosis or confirmation of resistance.

Mailing address: New Mexico State University, Attn: Plant Diagnostic Clinic, P.O.Box 30003, MSC 3AE, Las Cruces, NM 88003
Shipping address: (UPS or Fed Ex): New Mexico State University, Attn: Plant Diagnostic Clinic, 945 College Ave., Skeen Hall Room N140, Las Cruces, NM 88003

Prevention and Management of Resistance:

As resistance is generally the consequence of using a single tool repeatedly, any proactive or reactive approach should take an opposite view: use a diversity of methods to avoid repetition as much as possible.

Identification. Most resistant populations do not become apparent to the growers until at least 10-30% of the weed population becomes resistant. Identification of resistant biotypes (by repeated field monitoring) at lower frequencies would enable the grower to contain/manage the resistance problem sooner and employ preventative operational measures to control the spread of resistance.

Prevention. Once a resistance problem is identified, containment of the problem could be implemented with restricted movement of crop and equipment. Biosanitary practices, such as cleaning of equipment, removal and destruction of resistant plants to prevent re-infestation of the field with resistant seed or plant parts can be employed.

Cultural control. Crop rotations with different weed spectra or competitive cover crops, where economically feasible, could be employed. The weed spectra associated with different crops differ due to differences in the competitiveness and life cycles of different crops. Crop rotations or use of competitive cover crops work toward the suppression of certain weeds. Rotations of crops may also permit the use of different herbicides, fertilization and tillage programs.

Mechanical control. Cultivation as a means of weed control would reduce reliance on herbicides, the need for persistent herbicides, and provide a non-selective method of weed control. However, depending on the soil type cultivation could increase the risk of soil erosion.

Chemical control. The use of herbicide rotations and mixtures are frequently advocated for resistance prevention and management. However, herbicide rotations and mixtures should include compounds from different classes with dissimilar modes of action which control similar spectra of weeds. They should possess the same persistence in the environment, and be degraded in different manners. Recent studies have shown that herbicide mixtures present superior resistance prevention/management among weed populations than herbicide rotations. The idea behind the use of herbicide mixtures and/or rotation is to reduce the occurrence of resistant individuals in a weed population to a very low frequency equaling to their initial frequencies of herbicide resistance for each compound used in the mixture or rotation before they were ever used.

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MEXICAN STRAIN PECAN NUT CASEBEARER

Mr. Bill Ree, Extension Program Specialist II - IPM (Pecan)
Texas AgriLife Extension
Bryan, TX

Where it occurs across the pecan belt, the pecan nut casebearer, *Acrobasis nuxvorella* Neunzig, (Lepidoptera: Pyralidae) is considered one of, if not the most important nut feeding insect of pecan. In Texas, management of this insect is the cornerstone of the pecan IPM program.

Successful management of PNC is based on monitoring emergence of first generation adults, monitoring oviposition and applying an insecticide on an as needed basis. In 1996 producers had available to them a monitoring tool for detecting emerging adults which used the recently discovered sex pheromone females use to call males. The use of this pheromone in conjunction with a sticky trap has been used successfully in Texas, New Mexico and Oklahoma to monitor adult activity. However, where the pheromone was used in field trials in Mexico (1995 – 2006) it failed to attract males. This failure to collect adults suggested a possible difference in populations due to being geographically isolated.

In 2003 a trail was set up to investigate the problem in the states of Sonora and Chihuahua, Mexico. Pecan nut casebearer pupate were collected from infested nuts in Hermosillo (Sonora) and Julimes (Chihuahua), Mexico and adults that were reared were positively identified by USDA entomologist as *A. nuxvorella*, the pecan nut casebearer. .

To investigate the problem, field testing utilizing a blend of pheromones during 2004 – 2007 which included the standard pheromone (9E, 11Z)-hexadecadienal (9E,11Z-16:Ald) plus the corresponding acetate, (9E,11Z)-hexadecadien-1-yl acetate in a 1:1 ratio attracted a significant number of male moths. This blend of pheromones always was successful in collecting males in the Mexican states of Chihuahua, Coahuila, Durango and Sonora where previous trials in these states with the standard pheromone rarely resulted in the collection of males. Additional trials during the same time period in the United States with the Mexican pheromone blend has detected populations of what is now referred to as the Mexican strain of PNC in Texas, Oklahoma and New Mexico.

In U.S. tests where the standard pheromone and Mexican strain pheromones were evaluated in the same orchard, the collection of adults of the two strains were almost identical with very little difference in initial collections, rate of increase of adult collections and last collection time.

The discovery of this different strain of PNC has significant implications in IPM programs where pheromones could be used in mating disruption management programs. Additional information on the discovery of the Mexican strain pheromone can be found in;

Harris, Marvin, A.A. Agustin Fu, Humberto Nunez, Enrique Aranda-Herrera, Jardel A. Moreira, J. Steven McElfresh and Jocelyn G. Millar, 2008, "A New Pheromone Race of *Acrobasis nuxvorella* (Lepidoptera:Pyralidae)", J. Econ. Entomol. Vol. 101, Number 3, pp 769-776.

Pecan impPIPE
Belt-Wide

Dr. Marvin Harris
Texas A & M University

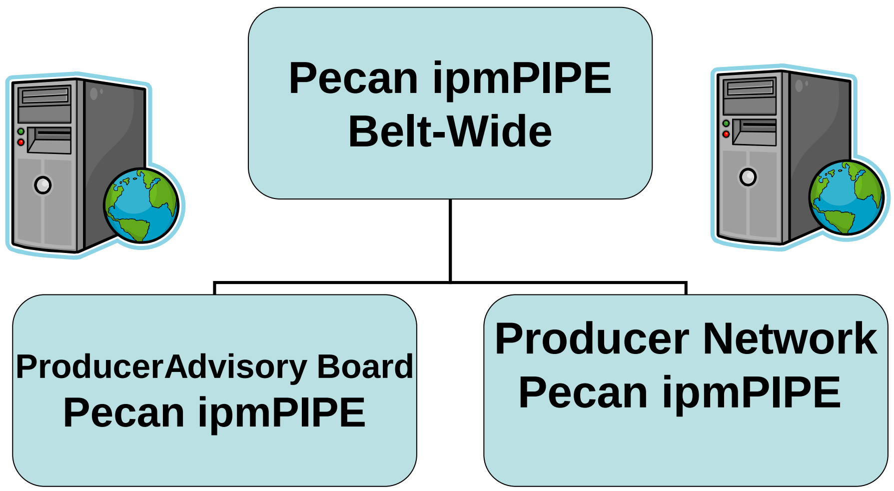
Pecan ipmPIPE: Aiding communications among pecan stakeholders Belt-Wide.

Marvin Harris, Program Director; Monte Nesbitt, AL; Randy Luttrell, AR; Russ Mizell, FL; Jim Dutcher, GA; Mike Hall, LA; Bill Reid, KS & MO; Phil Mulder, OK; Brad Lewis, NM; Bill Ree, TX; Allen Knutson, TX

Technology breakthroughs in communications provide new opportunities to improve how we gather, process, transfer and use information. The amount and type of information that can be gathered, analyzed and integrated with other information for use in near real time decision making is prodigious, and pecan stakeholders (producers, scientists, industry, etc.) are just in the initial stages of learning how to do this well. Pecan scientists in the Southern Regional Project on Pecan Insects (S-1017) and Producer Cooperators are initiating a Pecan Belt-Wide decision support program that will become available on-line in the 2009 growing season. The program is called Pecan ipmPIPE (PIPE=**P**est **I**ntegrated **P**est management **E**xtension and education, a USDA acronym). The public interface is a web-site to be launched on the internet to: 1) provide key real time decision information to pecan producers and advisors (first on pecan nut casebearer, with later efforts on other pests in planning stages) and 2) upgrade our Pecan IPM information system via a Toolbox for problem diagnosis, decision-making aids, and other informational resources. The Pecan ipmPIPE program is the beginning of an interactive near real time informational resource that will provide currently useful information relevant to stakeholder needs that will grow as new technologies become available for use.

The current Pecan ipmPIPE program structure is shown in Figure 1. Note that producer input is a key part of this program.

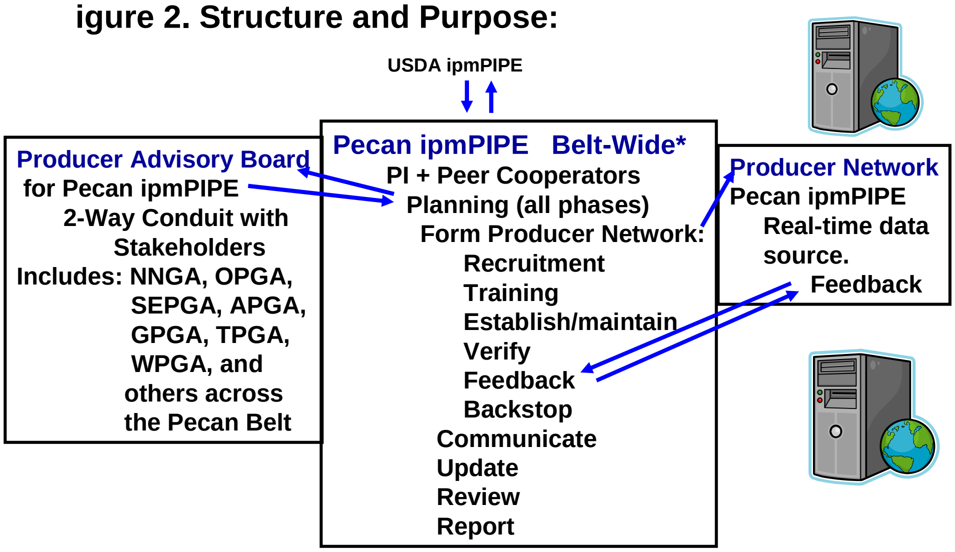
Figure 1. Structure of Pecan ipmPIPE:
ipmPIPE is a Commodity Wide USDA IT* Program
The Pecan Belt-Wide Program is One Component;
Soybean, Legumes, Cucurbits, etc. are also part of the USDA Program



***IT = Information Technology; The ipmPIPE Programs are Designed to Facilitate Communications Among Stakeholders Via the Web.**

A more detailed description of Pecan ipmPIPE is shown in Figure 2.

igure 2. Structure and Purpose:



***<u>The Purpose is to facilitate communications among Pecan Stakeholders using Information Technology via the Web to benefit the pecan industry.</u> Stakeholders include producers, researchers, extension, <u>and all that serve the industry.</u>**

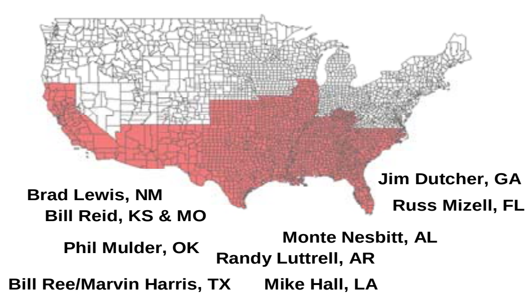
Many key elements are needed to make this effort successful. Belt-Wide activities need to be facilitated and coordinated among key scientists (called Peer Cooperators) and Producer Network Cooperators to gather, synthesize, and report via the web near real-time information on key pest problems (pecan nut casebearer is initial target). These Peer Cooperators are shown in Figure 3. They will recruit and help train the Producer Network Cooperators (we expect 150-200 Belt-Wide) to participate in this program and the PC will also participate in routinely keeping stakeholders informed through local, regional and other meetings as opportunities arise. The PC will also interface with stakeholders to help design the Pecan IPM Toolbox so that it can be tailored to serve needs of the producer at the local level; general theory of IPM principles is needed as background, but putting this theory into practice requires specific information relevant to individual producers needs to be available for decision-making. The Pecan Belt extends over a vast area with pest incidence and severity varying widely through the region, thus the IPM Toolbox must be constructed to allow theory to be put into practice at the local level. These are the major internal elements of the Pecan ipmPIPE Program.

In order to ensure relevance of the Pecan ipmPIPE Program to producer stakeholders and the pecan industry, a mechanism for Belt-Wide producer input to Pecan ipmPIPE is also needed. The Pecan ipmPIPE Producer Advisory Board is established to accomplish this. We are now initiating our plans to conduct this program and will be seeking more input from our stakeholders to ensure that what we can deliver will meet their needs.

We are soliciting your input for producer stakeholder representation, in the Producer Network and on the Pecan Advisory Board, as part of our team that has begun work on the Pecan ipmPIPE program. We want our producers to provide their perspective on how we can best proceed and to provide feedback on program elements as they are developed for use by producers. This will be a great help in keeping our work on track and relevant to producer needs. Officers of our pecan organizations (APGA, OPGA, SEPGA, TPGA, NNGA, WPGA, etc.) have been contacted to obtain views on which producer stakeholders will be best able and willing to participate in this aspect of our work. Producers can also volunteer directly by contacting their regional Peer Cooperator.

Figure 3:

Peer Cooperators in Pecan ipmPIPE Belt-Wide Program



(Peer Cooperators are networked with other regional scientists in this program.)

Cooperating Producer Organizations:

APGA, GPGA, NNGA, OPGA, SEPGA, TPGA, WPGA and others.

Producer Network cooperators will receive training in Pecan IPM and real time decision making on pecan nut casebearer (PNC). They will be provided PNC monitoring kits and be expected to provide real time data three (or more) times/week during the key flight period in the spring via e-mail, as well as other background information relevant to the program. They will also have the opportunity to become involved with pilot trials of new technologies as they become available for testing.

We expect each producer serving on the Pecan ipmPIPE Advisory Board to be able to interface with producer stakeholders from their area and work with producers Belt-Wide to facilitate Pecan ipmPIPE efforts to serve the pecan industry. Most routine communication is expected to be computer based via e-mail and other web resources. The purpose of the Board is to help develop, deliver and improve this Pecan ipmPIPE effort as the program matures.

We anticipate the Pecan ipmPIPE Program will be able to grow beyond current objectives into a new realm of information gathering, synthesis and transfer through the use of new technologies that continue to become available for implementation in production agriculture. We have an opportunity to work together to both make the present program successful and to map our way into the future.

Acknowledgements: Partial funding for this program has been provided by the USDA *ipm*PIPE, Southern Regional IPM Program, and Environmental Protection Agency Region 6, along with producer organizations (see list in text above) and their volunteer members, and CSREES institutions that support the scientists involved. An earlier version of this paper appeared in The Pecan Grower, Sept.-Oct. 2008 issue.

Imidacloprid Concentrations in Pecan Xylem

Bryan Fontes and Brad Lewis
Department of Entomology, Plant Pathology and Weed Science
New Mexico State University

The systemic insecticide imidacloprid is widely used in western United States for controlling black-margined pecan aphid (BMA), *Monellia caryella* (Fitch) in pecans. Recently, soil applications of imidacloprid have resulted in unsatisfactory BMA control in several Arizona, New Mexico, and Texas flood and sprinkler irrigated orchards. Laboratory and field studies were conducted from 2007 – 2008 in an effort to increase the reliability of imidacloprid soil applications directed at BMA control. Imidacloprid was quantified in pecan xylem (sap) to determine uptake rate, canopy distribution, and residual activity in pecan trees following three soil application methods and applied at two labeled application rates.

Two field studies (application and rate) were conducted in commercial pecan orchards during the 2007 and 2008 growing season near Las Cruces, New Mexico. Both orchards were flood irrigated and planted to a Western Schley cultivar. Trees were approximately 20 years in age and grown using standard practices for the area. All treatments were replicated four times with individual plots consisting of five adjacent trees. In each study, terminals were removed from pecan trees, chilled, and transferred to the laboratory where xylem sap was extracted. Imidacloprid concentrations within xylem sap were quantified using an adapted ELISA technique[1,2]. Xylem sap samples were removed and BMA population densities determined after each irrigation.

APPLICATION STUDY

The application study was initiated in August 2007 and was designed to compare the impact of three common imidacloprid soil application methods on imidacloprid concentrations in pecan xylem sap. Imidacloprid was soil applied at 14 oz/acre (4F formulation) using either: 4-shanks set 3 inches below the soil surface; 1-shank set 3 inches below surface; and 1-shank set 5.5 inches below surface. Shanks were positioned on opposing tree sides with the shank closest to the trunk positioned at 3.5 feet from the trunk. The soil type was classified as a sandy-clay-loam.

Results indicate that all three methods of application resulted in similar imidacloprid concentrations in xylem sap (Figure 1). Initial uptake by pecan was quicker in the 4-shanks treatment, which resulted in maximum xylem sap levels 10 days after treatment, compared to the 1-shank at 3 inches deep and 1-shank at 5.5 inches deep treatments, which took 42 and 70 days respectively after application to reach maximum imidacloprid xylem sap concentrations. Imidacloprid xylem sap concentrations remained above 8 parts per billion (imidacloprid to xylem sap) up to the last sampling date of the year. The following year, imidacloprid concentrations were measured at approximately 5 parts per billion in samples from May 8, 2008. Imidacloprid xylem sap concentrations continued to decrease in subsequent sampling dates with the multiple shank application method resulting in generally lower imidacloprid concentrations than either single shank application method. At 15 months after application, imidacloprid xylem sap concentrations were found to be less than 2 parts per billion.

During fall 2007, BMA control was not evident in any imidacloprid treated plot compared to the untreated control (UTC), with maximum non-winged BMA densities measuring greater than 20 aphids per leaf in all treatments on September 28 (Figure 2). In 2008, BMA populations began to build on June 23 with all imidacloprid treatments providing reductions of aphid populations compared to the untreated check until the July 18 evaluation. Following the July 18 evaluation, no imidacloprid treatments provided aphid suppression compared to the UTC.

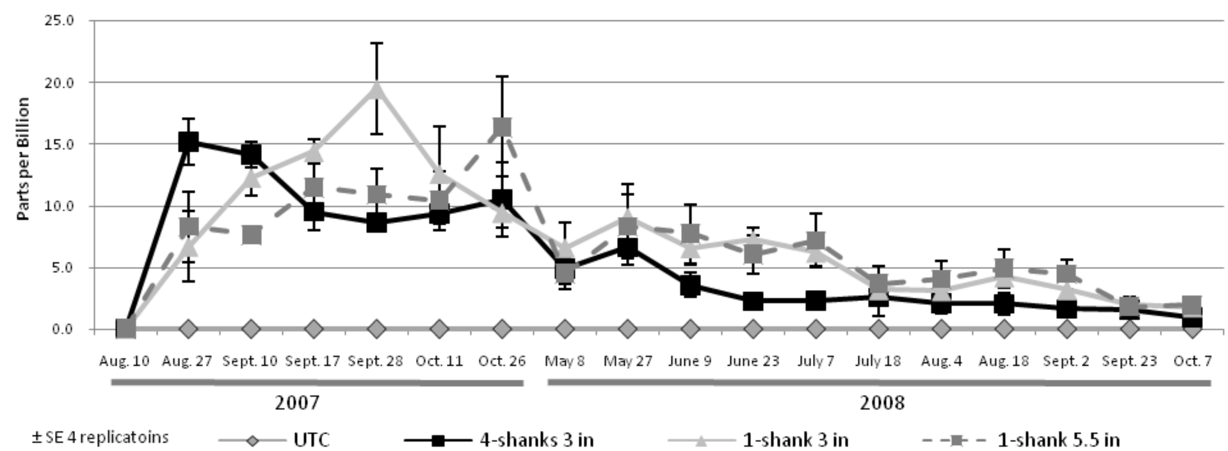


Figure 1. Mean imidacloprid concentrations in pecan xylem sap following soil applications of imidaclorid using 3 methods. 14 oz/acre applied Aug. 17, 2007

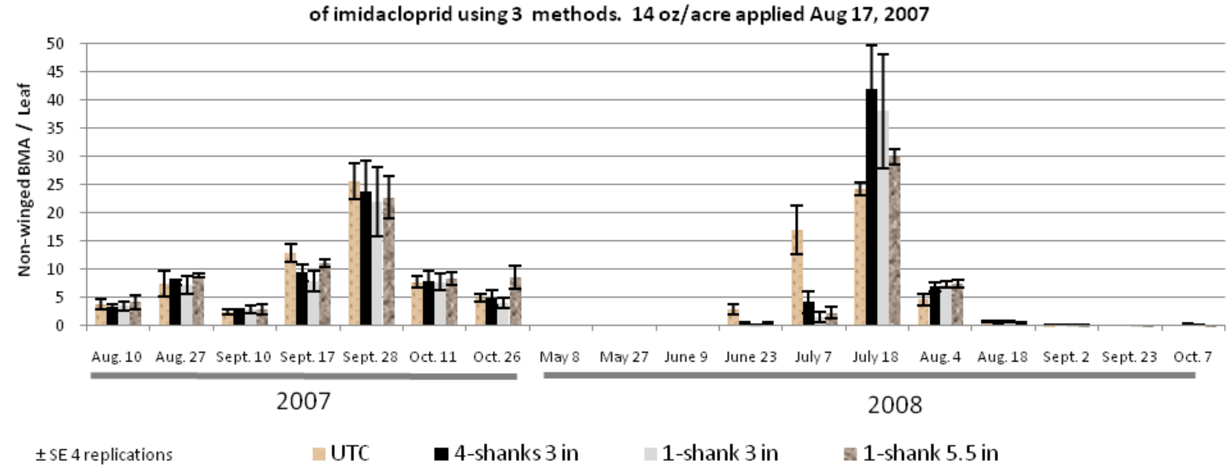


Figure 2. Mean number of non-winged blackmargined aphids per pecan leaf following soil applications of imidacloprid using 3 methods. 14 oz/acre applied Aug 17, 2007

RATE STUDY

The rate study was initiated in May 2008 and designed to compare imidacloprid concentrations in pecan xylem sap following soil applications at either 14 oz or 7 oz/acre (4F formulation). Imidacloprid was applied using 3-shanks at 3 inches below the soil surface level. Soil type was classified as clay.

Doubling the rate of imidacloprid applied to the soil resulted in an approximate doubling of imidacloprid xylem sap concentration throughout the year (Figure 3). At 7 oz/acre, imidacloprid xylem sap concentrations did not exceed 2 parts per billion, while the 14 oz/acre treatment resulting in a maximum of 5 parts per billion. Following applications, imidacloprid xylem sap concentrations continued to increase until both rates peaked on the 20 August sampling date. Imidacloprid xylem sap concentrations were found to be less than 4 parts per billion at the end of the season.

There was no suppression of BMA populations in either rate treatment throughout the year when imidacloprid treated plots were compared to the untreated control (UTC) (Figure 4). Non-winged BMA populations in all treatments were measured greater than 20 aphids per leaf on the 20 July evaluation date. Aphid population densities were not present in the field when imidacloprid sap concentrations peaked on 20 August.

Figure 3. Mean imidacloprid concentrations in pecan xylem following application of imidacloprid at 2 labeled rates. Applied with 3 shanks (3 in. depth) on May 16, 2008

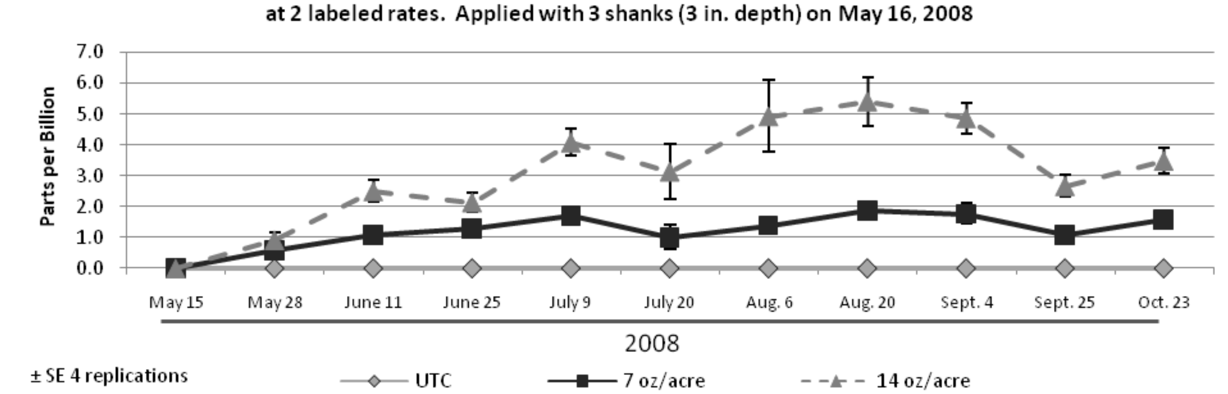
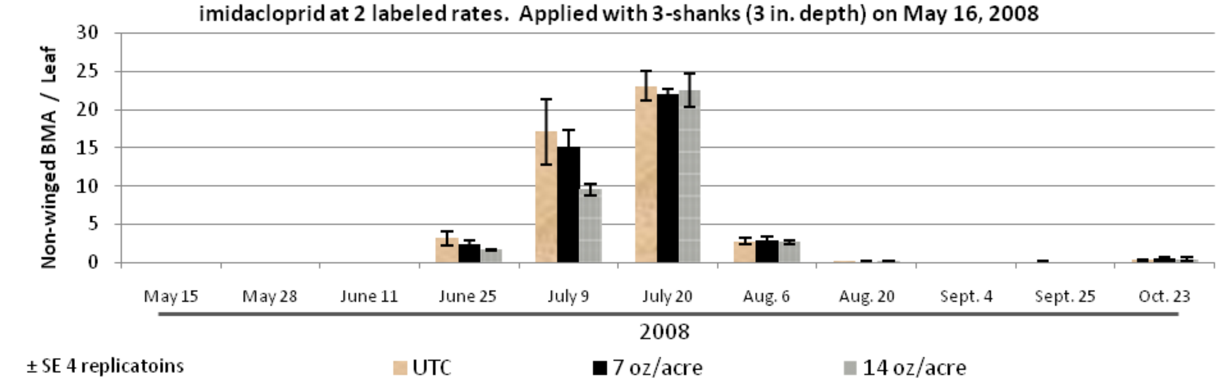


Figure 4. Mean number of non-wingedl blackmargined aphid per leaf following soil applications of imidacloprid at 2 labeled rates. Applied with 3-shanks (3 in. depth) on May 16, 2008



SUMMARY:

This research determined that ELISA could be used to measure imidacloprid in pecan xylem sap and leaf tissue (not presented) when samples were properly prepared. The use of this technique will provide a relatively easy method to help establish baseline information for future resistance management research.

Results from the application study determined that a single shank application method resulted in similar imidacloprid xylem sap concentrations as the commonly used multiple shank application method. Although the multiple shank method resulted in a faster rate of imidacloprid uptake, application efficiency could be improved by using a single shank method.

There was a direct relationship between application rate of imidacloprid and uptake into the xylem sap of pecan trees. Results show that lower labeled rates of imidacloprid applied to an orchard will result in lower uptake rates by the tree.

Although the two studies were not designed to directly compare the impact of soil texture on imidacloprid uptake, imidacloprid sap concentrations did not exceed 5 parts per billion when applied to a clay soil (rate study), compared to 15 parts per billion when applied to a sandy-clay-loam soil (application study). The increased uptake of imidacloprid in trees of the application study was likely due to half the amounts of clay and organic matter content compared to the rate study orchard. The results emphasize the importance soil texture may have with respect to imidacloprid uptake and BMA control[3,4]. Orchards with more clay and organic matter may reduce uptake and result in lower concentrations of imidacloprid in pecan trees.

Data collected (not presented in this paper) to determine if imidacloprid distribution within the tree canopy was uniform resulted in no significant differences between the top and bottom of the tree and no significant differences around the canopy. Imidacloprid applications on two opposing sides of a tree are considered adequate.

Under the conditions specified in the two studies, soil applications of imidacloprid did not result in acceptable suppression of BMA population densities when compared to the untreated control. Lack of BMA control in these studies indicates either: imidacloprid xylem sap concentrations did not result in efficacious imidacloprid leaf concentrations; imidacloprid concentrations in pecan xylem sap may not be a good indicator of efficacy with respect to BMA; or BMA populations are exhibiting isolated instances of tolerance to imidacloprid.

There is no doubt that imidacloprid has and will continue to play an important role in the management of western pecan BMA populations. Current research is attempting to correlate imidacloprid xylem sap concentrations with leaf tissue concentrations in an effort to establish baseline information for use in resistance management.

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Herbicides for Weed Management In Pecans[1]

Dr. William B. McCloskey,
Extension Weed Specialist, Department of Plant Sciences
University of Arizona.

Introduction

Weeds are undesirable competitors with pecan trees and require the constant attention of orchard managers. Orchard floor management systems that maintain a vegetation free zone of 6 to 8 feet around the trees provide optimum pecan growth and nut yield (Faircloth et al., 2007). Common management systems in Arizona maintain a vegetation free strip on each side of the tree row and mow the resident vegetation in the remaining area between tree rows or maintain a completely vegetation free orchard floor or a do both depending on the time of year. Designing a weed management program for a pecan orchard begins with questions regarding the use of tillage, the irrigation method (e.g., drip, micro-sprinkler, solid set sprinklers, and furrow or flood irrigation), the soil type and texture in the orchard, the weed species currently present in the orchard and the current weed management program. Generally, tillage is not routinely used in southwestern pecan orchards as a method of weed control but some tillage is often done in winter months and is associated with harvest. Although some newly planted orchards are micro-sprinkler irrigated, most orchards in the southwest are flood irrigated or irrigated in a manner that results in most of the orchard floor receiving moisture. By far, the most commonly used weed management tactic in southwestern pecan orchards is the use of a postemergence herbicide, usually glyphosate, multiple times a year to spray weeds on an as-needed basis.

Preemergence Herbicides

There are several advantages to using a preemergence herbicide in irrigated pecan orchards. The use of preemergence herbicides reduces the densities of many weed species (number of plants per acre) and usually reduces the number of postemergence herbicide applications needed per year, especially after two or more years of preemergence herbicide use. In addition, the weeds that do emerge grow slower due to root growth inhibition providing a longer "window of opportunity" in which small weeds can be sprayed with postemergence herbicides. Preemergence herbicides should be applied to bare soil for maximum effectiveness because they bind almost irreversibly to organic debris such as leaf litter on the orchard floor and these bound herbicide molecules do not provide weed control. A logical time to apply preemergence herbicides is after harvest in the winter or in early spring before bud break. Research and grower experience has found that one of the best foundation preemergence herbicides for pecans is pendimethalin at rates of 2 to 4 quarts/acre (1.9 to 3.8 lb a.i./A). The lower rate is used in tank-mixtures with herbicides such as Chateau (flumioxazin) or Goal Tender (oxyfluorfen) while 3 to 4 quarts/acre is applied when pendimethalin is used alone. These herbicides must be incorporated with

[1] *This information is intended to summarize suggestions for chemical control of weeds in Arizona nut crops. Herbicide labels are subject to frequent change; always consult the product label before using any herbicide. The user must assume responsibility for proper application of herbicides and for residues on crops as well as for damage or injury caused by herbicides referred to in this article, whether to crop, person or property.* ***Any products, services or organizations that are mentioned, shown or indirectly implied in this publication do not imply endorsement by the University of Arizona.***

irrigation or rainfall shortly after application. A good alternative to pendimethalin is trifluralin if it can be mechanically incorporated with a field cultivator, finishing disk or similar implement. Chateau or Goal Tender should not be mechanically incorporated. Other preemergence herbicide can have a fit in pecan orchards depending on soil type (e.g. loam, clay loams or clay soils) and the weeds present. Solicam (norflurazon) can be a good choice in orchards with perennial weed problems such as nutsedges. The preemergence herbicides oryzalin, pendimethalin and trifluralin are members of the dinitroaniline class of herbicides. In orchards with heavier soil textures (e.g., clays) or drainage problems where irrigation water ponds or soils remain water logged after irrigation or rainfall, the dinitroaniline herbicides breakdown rapidly under anaerobic conditions and quickly become ineffective. In these situations, orchard managers can use higher rates of Goal Tender or Chateau. Patience is required when beginning to use preemergence herbicides in orchards where a significant weed seed bank is present in the soil; it may take 2 to 3 years of preemergence herbicide use to realize the maximum amount of weed suppression and reduced numbers of postemergence herbicide applications. An additional benefit of using preemergence herbicides is that they add diversity to weed management programs and reduce the risk of developing herbicide resistant weeds.

Table 1. Selected **preemergence herbicide** options for Southwestern pecan orchards (check state labels). These herbicides should be applied to a clean soil surface and will not control emerged plants **except as noted**. These herbicides can be moved into the soil using irrigation water (or rainfall) unless otherwise noted. The herbicides diuron and norflurazon are somewhat mobile in soils and can be moved into the root zone of trees by irrigation causing tree injury especially in coarse textured soils (e.g., sandy loams, etc.). Preemergence herbicides with postemergence activity (i.e., diruon, flumioxazin and oxyfluorfen) should be applied with a non-ionic surfactant or crop oil concentrate to obtain burn-down activity.

Common name	**Trade name(s)**	**Pecans**	**Weeds controlled**
norflurazon	Solicam DF	X	Grasses & broadleaves, suppresses perennials such as nutsedge and bermudagrass
oryzalin	Surflan, Oryzalin	X	Grasses & small-seeded broadleaves
pendimethalin	Prowl H_20, Prowl 3.3	X	Grasses & small-seeded broadleaves
trifluralin	Treflan, Trifluralin, Triap	X	Grasses & small-seeded broadleaves; must be mechanically incorporated into the soil (e.g., by disking).
Diuron	Karmex, Diuron	X	Grasses and some broadleaves; do not use on trees established less than 3 years. Has postemergence activity.

flumioxazin	Chateau	X	Broadleaves (weaker on grasses); do not use on trees established less than 1 year. Postemergence contact activity similar to carfentrazone and oxyfluorfen.
oxyfluorfen	Goal, GoalTender	X	Broadleaves (weaker on grasses); postemergence contact activity similar to carfentrazone and flumioxazin.
rimsulfuron	Matrix	X	Some broadleaves & grasses; should be used in a tank mixture with one of the above.

Herbicide labels can be viewed at the following websites: www.cdms.net or www.greenbook.net.

Postemergence Herbicide Recommendations for Pecan

Weeds that emerge after the application of preemergence herbicides should be sprayed with post-emergence herbicides. Systemic herbicides are translocated or moved in plants and are superior choices when attempting to control perennial weeds. Glyphosate is the most commonly used postemergence herbicide in southwestern pecan orchards and is available in numerous formulations many of which contain differing amounts of the active herbicide molecule, glyphosate acid, combined with various positive ions to form stable salts in an aqueous suspension (e.g., K, Na, ammonia, isopropylamine and trimethysulfonium salts). Glyphosate is best applied in low carrier volumes (e.g., 10 gallons per acre or less) and should be applied with ammonium sulfate. In orchards where glyphosate has been used repeatedly, some weeds tolerant of glyphosate (e.g., little mallow and spurred anoda) may increase in number and become more difficult to control. Control of many of these broadleaf weeds can be improved by tank mixing a contact herbicide with burndown activity such as carfentrazone (Aim), flumioxazin (Chateau) or oxyfluorfen (Goal) with glyphosate. Contact herbicides are not translocated in plants so only the sprayed portion of the weed is killed. When using contact, burndown herbicides, the spray parameters must be changed to apply smaller droplets and greater carrier volume (e.g., 20 gallons per acre) to obtain uniform coverage of the target weeds. This is best accomplished by increasing the nozzle orifice size and increasing spray pressure. The rates of flumioxazin or oxyfluorfen tank-mixed with glyphosate are lower than when these herbicide are applied for preemergence weed control (see herbicide labels for rates). All postemergence herbicides must be applied with adjuvants (e.g., ammonium sulfate, non-ionic surfactant, crop oil concentrate or methylated seed oil) to obtain acceptable weed control.

Table 2. Selected **postemergence herbicide** options for southwestern pecan orchards; read herbicide labels for rates and specific application directions (labels can be obtained at the following websites: www.cdms.net or www.greenbook.net). Most postemergence herbicides perform well at carrier volumes of 10 to 25 gallons per acre (GPA) using flat-fan nozzles at pressures of 20 to 30 PSI at the nozzle tip.

Common name	Trade name(s)	Pecan	Application Notes	Type, Weeds controlled
clethodim	Select Max, Select	NB	1, 2, 3	Systemic, selective; controls only grass weeds
fluazifop-p-butyl	Fusilade DX	X	1, 2, 3	
Sethoxydim	Poast, Poast Plus	X	1, 2, 3	
Halosulfuron	Sandea	X	4, 5	Systemic, selective; controls nutsedge and some broadleaf weeds
Glyphosate	Roundup, Credit, Touchdown, Honcho, Glyphosate, others	X	5, 6, 7	Systemic, non-selective; controls green herbaceous plants
glufosinate-ammonium	Rely 200	X	8	Contact, non-selective; controls green herbaceous plants
paraquat *(restricted use pesticide)*	Gramoxone Inteon	X	2, 4, 8	
Carfentrazone	Aim	X	2, 8	Contact, selective; controls only broadleaf weeds, should be applied with a shielded sprayer.

Notes:
[1]Should be applied at higher pressure (e.g., 30 to 60 psi) to obtain small spray droplets in a carrier volume of 10 to 20 gallons per acre (GPA).
[2]Greatest efficacy is obtained with methylated seed oil or crop oil concentrate.
[3]Efficacy may be improved by adding liquid fertilizer (10-43-0, 28%N or 32%N) or spray grade ammonium sulfate (AMS) at the labeled rate.
[4]Use with 0.25 to 0.5% v/v non-ionic surfactant.
[5]Performance on nutsedge species is enhanced by using a tank-mixture of glyphosate and halosulfuron and by spraying in mid to late summer; two applications are generally required for nutsedge control.
[6]Should be applied with spray grade ammonium sulfate (AMS) as described below.
[7]Some glyphosate formulations do not include a surfactant; read label and add surfactant if necessary.
[8]For contact herbicides use a minimum of 15 GPA to obtain good spray coverage; use 20 to 40 GPA on dense weed canopies.

Herbicide Spray Adjuvants

Non-ionic Surfactants (NIS) reduce surface tension and allow droplets to spread resulting in better contact between the spray solution and plant surfaces. Rates typically range from 0.25 to 0.5% v/v of the total spray volume with 0.5% v/v (2 qt/100 gal) being recommended in the hot arid climate of Arizona. Best results are obtained using a non-ionic surfactant that contains at least 80% active ingredient.

Crop oil Concentrates (COC) also reduce surface tension and usually contain between 17 to 20% surfactant mixed with light petroleum, vegetable oil, or methylated vegetable oil. The surfactants in these adjuvants contain emulsifiers that allow them to mix with water generally producing a milky-looking solution. Certain herbicides such as sethoxydim, carfentrazone, flumioxazin and oxyfluorfen consistently have more foliar activity when mixed with a methylated seed oil or crop oil concentrate than when mixed with a non-ionic surfactant. Crop oil concentrates are typically used at a rate of 1% v/v (1 q/25 gallons or 4 qt/100 gal) but some labels recommend 1 quart per acre.

Ammonium sulfate (AMS) effectively protects glyphosate from chelation or binding with monovalent (e.g., Na^+ and K^+) and divalent cations (Ca^{+2}, Mg^{+2} and Mn^{+2}) in the spray tank water (which renders glyphosate inactive) and should be added to the water before adding glyphosate. Ammonium sulfate also enhances the uptake or absorption of many postemergence, systemic herbicides and is particularly effective in enhancing glyphosate activity in hot, arid climates. For glyphosate herbicides, add 8.5 to 17 lb of spray grade AMS to 100 gallons of water; for other postemergence herbicides, consult the product label for the recommended AMS rate. Ammonium sulfate is also available in liquid form. Ammonium sulfate cannot protect glyphosate from chelation with trivalent cations (e.g., Fe^{+3} and Al^{+3}) but some new commercial water conditioners are available that may protect glyphosate from chelation with these cations.

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Light Management in Pecan Orchards

Dr. Leonardo Lombardini
Associate Professor, Department of Horticultural Sciences
Texas A&M University

Orchard crops such as pecan typically intercept 65% to 70% of the available sunlight (Wood, 1996) with up to 95% light interception in overcrowded, unpruned orchards (Lombardini, 2006). Orchard profitability depends on efficient absorption and use of light, since sunlight is the source of energy that leads the biological production of dry mass (Garriz et al., 1998). Therefore, many training and pruning techniques are designed to maximize total light interception as well as keep a good light penetration into the canopy (Li and Lakso, 2004).

Tree crowding is a phenomenon that pecan growers have to face during the production cycle. The onset of tree crowding depends mainly on tree spacing, but soil depth, growth rate and tree architecture/cultivar play a role as well. In a commercial orchard with trees planted at the common spacing of 35 × 35 feet, growers should start canopy management practices when trees are in their 12^{th} to 15^{th} season.

A decline in tree productivity and health associated with crowding should not be attributed to natural tree senescence, as there is no known upper age limit for pecan production (Worley, 1990). Pecan trees begin to bear fruits within six to ten years from planting and continue to produce for decades. Records indicate that native trees over 150-year-old can produce an average annual crop of over 400 lb/tree (Brison, 1974). Competition for nutrients, water and light are likely the prevalent cause of the progressive weakening of crowded cultivated trees.

Crowding induces reduction in number of flowers, productivity, percent kernel and it has been indicated as one of the possible causes for increase in alternate bearing (McEachern and Stein, 2003; Wood, 1990). Moreover, when trees are crowded lower limbs begin to die, the bearing surface is reduced in volume, and the fruit is born higher in the canopy and becomes more difficult to manage. Crowding also reduces the amount of light intercepted per unit of leaf area, thus decreasing the efficiency of carbon assimilation, and decreases air movement, which in humid areas such the southeastern United States may result in a greater probability of scab or other diseases (Brison, 1974; Latham and Goff, 1990).

The beneficial effects of pruning pecan trees have been proved by several studies. When height of ‘Stuart’ trees was gradually reduced by removing one to three limbs per year, tree vigor, terminal shoot growth and nut size were improved, although the yield was reduced (Worley and Mullinix, 1997). Malstrom et al. (1982) tested mechanical hedge-pruning on mature ‘Western’ pecan trees in the lower El Paso valley in Texas, and found that pruning increased the amount of light penetration between trees but not within individual tree canopies which may explain why production and nut quality were not affected (Malstrom et al., 1982). Results from a 20-year hedging program conducted in Australia on ‘Western’ and ‘Wichita’ trees indicated that mechanized hedge-pruning and topping returned better nut yield than treatments that reduced crowding by removing selected trees (Wood and Stahmann, 2004).

Despite the known benefits and the several approaches to choose from, pruning as a cultural practice has been widely adopted only in pecan orchards in areas characterized by dry environments, such as New Mexico and western Texas. In more humid areas, such as the southeastern United States, the tendency has been to allow trees to grow until canopies begin to touch and then remove trees. However, removal of mature, bearing, healthy trees at the peak of their productivity is a difficult option for pecan producers, who have invested years of resources to culture the trees. The tendency to delay tree thinning has also resulted in many orchards with trees that exceed 40-50 feet in height and show typical symptoms of tree crowding. Due to the high costs associated with hedging, selective pruning is an option that some growers choose to open up crowded orchards. Such an approach is typically less expensive than mechanical canopy hedging, especially in those regions where hedging equipment is less readily available, but it is not as effective in removing tree canopy and can be also very labor-intensive and dangerous for the operators. The results of a pruning study that we conducted a few years ago in east Texas showed that one-time mechanical hedge-pruning of non-irrigated, 'Cape Fear', 'Desirable', and 'Kiowa' pecans initially reduced intercanopy crowding and increased light penetration but did not necessarily increase orchard productivity, nut yield, nut quality or reduced alternated bearing (Lombardini, 2006). Hedging programs have not been very successful in more humid regions probably because of the overall lower seasonal solar radiation which may prohibit sun leaves from performing photosynthesis at full capacity (Wood, 2009). Recently, we investigated the photosynthetic response of sun and shade leaves of field-grown pecan trees to changes in light intensity in order to quantify the effects on the leaf morphological and physiological characteristics. The results revealed that in both cultivars investigated (Pawnee and Stuart), maximum carbon assimilation rate in shade leaves was about half of that measured in sun leaves in June-August. These results may explain why pecan trees can tolerate severe hedge-pruning and still maintain high productivity in areas characterized by relatively high light regions, such as the southwestern United States and east-central Australia, but not in more humid regions. The reduction of canopy size caused by hedging likely allows for increasing the ratio between sun-exposed leaves and shaded leaves. The presence of a greater number of sun leaves could explain why productivity of hedged trees is maintained in high-light environments.

Investigations like the ones reported here may in the future reveal which pecan cultivars are more suitable to maintain high photosynthetic rates even at lower light levels and possibly tolerate pruning or hedging program in the southeastern United States.

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ReTain® Can Increase Early Season Fruit Retention by Pecan

Dr. Bruce W. Wood[1] and Dr. Richard Heerema[2]

[1]*U. S. D. A., Agricultural Research Service, Southeastern Fruit and Tree Nut Research Laboratory, Byron, GA;* [2]*New Mexico State University, Las Cruces, NM*

Excessive fruit-drop limits profitability of certain pecan cultivars. We report on a series of studies examining the efficacy of ReTain®, a natural ethylene inhibitor, for reducing fruit-drop. Four years of field studies on 'Desirable' pecan trees found that ReTain® can substantially reduce fruit-drop; thus, increasing crop-load over non-treated trees by as much as 16-38%, with the percentage retention being greatest in trees with a relatively heavy crop load and minimal in trees with a light crop load. The efficacy of ReTain® for reducing fruit-drop increases with crop load. Efficacy is also greatest when applied soon after the termination of stigma receptivity. Two post-bloom applications of ReTain® increased fruit-set in an "on-phase" commercial orchard with a moderately heavy crop by 38%, while not reducing in-shell yield or kernel quality the following year when ReTain® was not used, and the orchard possessed a light to moderate crop-load. Proper usage of ReTain® appears to offer commercial producers of 'Desirable' nutmeats a practical tool for reducing fruit-drop and managing crop-load. Although not evaluated, the product is likely to be similiarly beneficial for other cultivars that drop a lot of fruit during the early season –e.g., 'Stuart'. Usage of ReTain on Western Schley in New Mexico did not appear to influence fruit-drop enough to detect an effect on crop-load. It appears that ReTain can be used successful in the southwestern U.S. on cultivars that exhibit a substantial early-season fruit-drop; however, this needs to be better studied.

Costs of Growing Pecans in the West

Dr. Richard Heerema
Extension Pecan Specialist
New Mexico State University

2008 was the most expensive season in history to grow pecans. On September 21, 2008 Dr. Lenny Wells, University of Georgia Pecan Specialist, and I presented "Costs of Growing Pecans" to the National Pecan Shellers Association at their conference held in San Francisco, CA. Dr. Wells addressed the production costs for eastern pecan producers, while I addressed the costs for the growers of west Texas, New Mexico, Arizona and California. We made our estimates based on conversations with growers and chemical salesman throughout our respective regions, as well as with agricultural economists at University of Georgia and New Mexico State University.
The following is a summary of my findings for the western region.

Labor Costs.
Farm labor has become scarcer and significantly more expensive in recent years. A number of factors are behind this, including tighter immigration regulation of the U.S.-Mexico border. In some western pecan growing areas, the high wages that may be found in the oil fields have attracted laborers out of agriculture. We estimated that most western pecan operations require about 20-30 hours of labor per acre and hourly wages are about $9.50 plus 25-35% overhead.

Diesel Fuel.
The equipment necessary for most orchard operations runs on diesel. Annually, about 15-20 gallons of diesel are used per acre and the average price for diesel was about $4.35 per gallon. According to the Energy Information Administration (http://tonto.eia.doe.gov), this is a 60% price increase since 2007 and a 200% increase in price since 2003.

Irrigation Water.
Pecan growers in the arid west usually need about 5-6 acre-feet to meet the crop consumptive water use (evapotranspiration) demand. In nearly all western pecan growing areas, at least a portion of the irrigation water must be pumped from wells. In some areas part of the water may also come from irrigation districts ("river water").
For a shallow (~100 foot deep) well, the annual pumping cost (5½ acre-feet of irrigation water) was estimated at about $400 per acre with a diesel pump, $190 per acre for a natural gas pump or $130 per acre for an electric pump. In areas where the water must be pumped from deeper aquifers (in some areas it may be deeper than 1000 feet!), pumping costs are higher, and, in areas where relatively inexpensive irrigation district water is available, growers may be able to reduce irrigation water costs a little.

Fertilizers.
Western pecan growers must apply a number of macronutrient and micronutrient fertilizers to maintain adequate leaf nutrient levels. The material costs of the primary macronutrient fertilizers, nitrogen, phosphorus and potassium, were $140-325 per acre (depending on nitrogen application rates and whether phosphorus and potassium applications were made). This was a

cost increase of 90% since 2007 and 160% since 2003. Micronutrients, particularly zinc, are applied foliarly in most western pecan orchard each springtime. The material costs of micronutrient fertilizers were at least $50 per acre, a 30% increase since 2007 and a 75% increase since 2003.

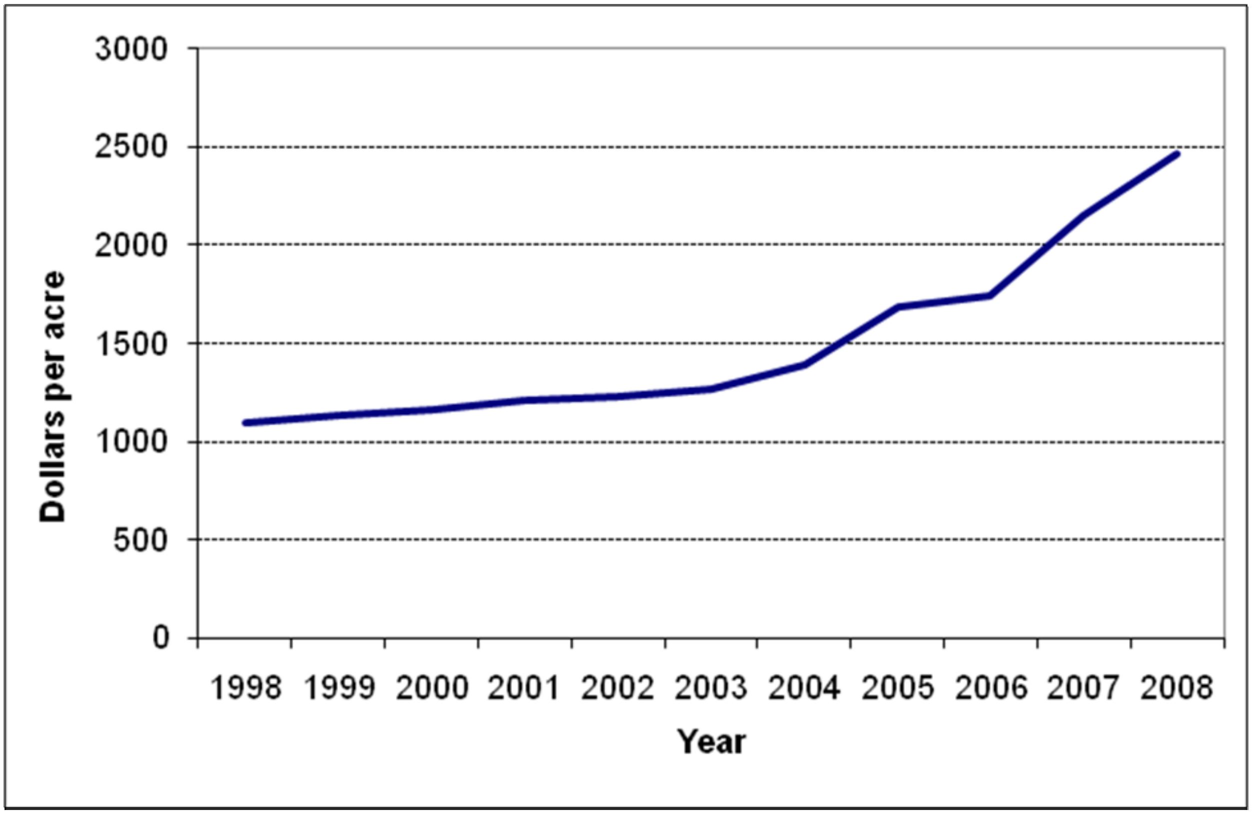
Pest Management.
Pecan aphid control cost approximately $100 per acre (material costs) in 2008. Other pecan pests, including the pecan nut casebearer and the hickory shuckworm, are not found throughout the entire western pecan growing region, but each had material costs of only about $25 per acre for control. Material costs for weed control (clean orchard floor; 5 applications of glyphosate) was about $200 per acre in 2008, an approximately 200-300% increase in cost over the 2007 season.

Harvest and Cleaning
Some western pecan growers own their own harvest and cleaning equipment; others hire custom harvest and cleaning companies for these operations. For simplicity, prices of custom harvest and cleaning were used to calculate the cost of producing pecans in 2008. Custom harvest was $420 per acre and custom cleaning was $160 per acre.

Pruning and Brush Removal
Most western pecan growers have adopted a mechanical pruning program. The costs of custom mechanical pruning (most growers hire a custom pruning company to do the work) are approximately $75 per acre. Historically, pecan growers pushed brush from the orchard floor out of the orchard and burned it. Today, an increasing number of growers are chipping or shredding the brush and leaving it on the orchard floor. The cost of custom brush shredding is also about $75 per acre.

Total Production Costs
Using “middle-of-the-road” cost estimates, total variable production costs were calculated to be around $1800 per acre for the west in 2008. Dr. Jerry Hawkes calculated total pecan production costs (variable plus fixed costs) to be about $2,500 per acre (for the Mesilla Valley, NM). See the trend in total production cost for pecans in Figure 1.

Figure 1. Total production costs (variable costs plus fixed costs) for pecans in the Mesilla Valley, 1998-2008. Source: Dr. Jerry Hawkes, NMSU agricultural economist



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Safe Use of Organic Matter as Fertilizer

Organic Matter as Fertilizer

Dr. William C. Lindemann
Professor, Soils
New Mexico State University

Soil organic matter (SOM) content is viewed as a critical soil quality/soil health/crop yield indicator because SOM affects many physical, chemical, and biological properties. Heavy textured soils have more SOM than light textured soils, orchard soils have more SOM than row cropped soils and permanent pasture soils have the highest SOM. Organic amendment and reduced tillage are strategies used to increase SOM. Either or both are used by conventional and organic farmers in Southwest pecan orchards. In general, as the amount and frequency of organic amendment increases and the tillage intensity decreases, the SOM increases. A management goal should be to increase SOM where feasible.

Organic amendment has many benefits including the improvement of soil structure, water stable aggregates, aeration, water holding capacity, nutrient retention, buffering capacity, microbial activity, and many other properties. Most of these properties are intimately tied to plant productivity, and a strong correlation exists between yield and SOM content. Crop residues and manure are the most common organic matter amendments in the US. Biosolids amendment is now common in areas near cities because many of the detrimental properties of biosolids have been lessened or eliminated. Composted residues (plant and animal) are also sources.

Manure and biosolids amendment is certainly beneficial with respect to adding organic matter, nutrients, and overall increasing soil tilth, but these amendments have detrimental aspects related to their use, and particularly their repeated use. Pathogens (*E. coli*, *Listeria*, *Salmonella*, etc.) are commonly present, contamination of food and water is well documented, excessive application can result in phosphorus accumulation in the soil profile and nitrate leaching to the ground water, and total salt and sodium accumulation are concerns in the Southwest.

Pathogens in manure are reduced by composting but not totally eliminated. Ultra-violet light (sunshine) is very effective at sanitation. Other factors that reduce pathogens in manure amended soils include desiccation, extreme temperatures, extreme pH, starvation (lack of a readily available carbon source), and predation by indigenous soil microorganisms. Because most pathogens in manure are not indigenous to the soil and are accustomed to an optimum environment in the gut, they do not survive long. Most pathogen numbers decline rapidly in a few weeks or months to undetectable levels. In general, soil incorporation of manure early in the season poses no contamination problems for a fall harvest. The National Organic Program rules require at least 120 days between the incorporation of manure and harvest. For a conservative estimate, manure should not be incorporated after July 1 in the Southwest for the start of harvest on November 1. If contamination of food occurs as the result of manure application, it is the result of surface contamination and sanitation after harvest, not the uptake of the pathogen from the soil or growth of the pathogen in the edible part.

The rate of manure application will depend on the yield goal and a variety of other factors. In most instances, the rate of application will depend on the nitrogen requirement of the crop. Under certain circumstances, the phosphorus requirement for crop may be the rate limiting factor, but currently this is not the case in most production areas in the Southwest. A demonstration of how to calculate a manure amendment rate will be given.

Manure and biosolid amendment to soil requires careful monitoring, more so than with synthetic fertilizers, because of the salt and sodium content. Annual soil sampling and manure analysis is critical to determine the levels of nutrients, total salt, and sodium. Yearly application of manure is necessary to significantly increase SOM, but yearly applications of manure can result in accumulation of salts. Deep samples (2-5 feet) should be taken ever few years to monitor nutrient and salt accumulation below the zone of application and intense rooting zone. A soil analysis should always include a measurement of total salts (electrical conductivity-EC) and sodium adsorption ratio (SAR). Depending on soil texture, irrigation method, amount of irrigation water applied, and other factors, the EC should not exceed 3.0 mmhos/cm and the SAR should not exceed 5 of the rooting zone for pecans.

Training Young Pecan Trees

Robert E. Call
Horticulture Agent, University of Arizona
Cooperative Extension

The first five years of growth are very important in developing a central leader and scaffold branch framework of the pecan tree. Structural developments in the trees during these years will be evident 30 or 40 years later. Few cultural practices will be effective longer than those exercised in developing the framework of a young pecan tree. This development should be done carefully, with a minimum amount of pruning. Considerable planning is required to properly train and prune young trees. Mechanical equipment used for orchard management will influence the training program chosen. Keep in mind the ideally structured tree and always try to shape each tree to this pattern. No two trees are alike and only a few will conform exactly to your picture, but it will serve as a standard.

The type and amount of training and pruning that should be used can be determined, to a considerable extent, by the ultimate use of the tree. Early nut production is directly related to the amount of pruning, with the earliest production being on trees subjected to the least pruning. Backyard growers may be willing to sacrifice some early production in order to have an aesthetically well-shaped tree. However, commercial growers with a large number of pecan trees are more likely to compromise some structural development and form to obtain early production from their trees.

There are several pruning methods commonly used for training young pecan trees. Heading back, branch selection, tip pruning, and pinching are all good methods. They need to be practiced during the first few growing years of new pecan trees. Proper training is critical.

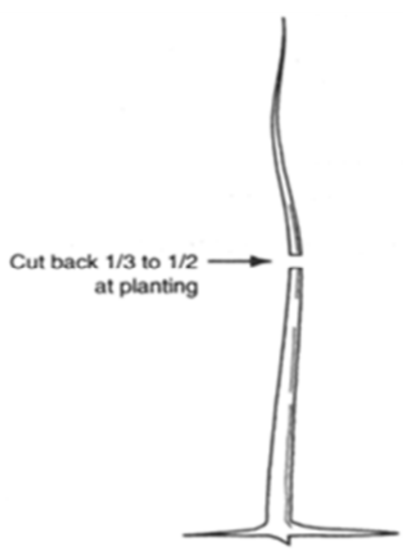

Fig. 1. Pruning at Planting

Heading Back

To develop a medium-size, strong, wind-resistant tree, use a central leader or modified central leader system. At planting time, prune the top one-third to one-half of the tree (Fig. 1). This usually results in a whip 36-42" tall. Head-back pruning encourages strong central leader re-growth. Frequently two or three new shoots develop adjacent to the cut-back point in the early spring. However, newly planted trees usually grow slowly during the first season. If growth has not started by July, cut the tree back to twelve inches above the bud union to force growth. During winter (dormant season), the strongest and most vigorous shoot should be selected and headed back one-third to one-half (Fig. 2). The second strongest shoot should be removed. The remaining shoot needs to be tip-pruned to reduce growth and encourage short laterals. Lateral shoots will also develop below the cut back point. These lateral shoots can develop into small permanent scaffold limbs. They can be pinched during the summer and usually tip-pruned in the winter. The previous year's growth of the central leader should be cut back about one-third during the first through fourth (or fifth depending on development), dormant seasons. Continue to force one strong shoot to grow at the top of the tree (Figs. 2, 3, 4, and 5).

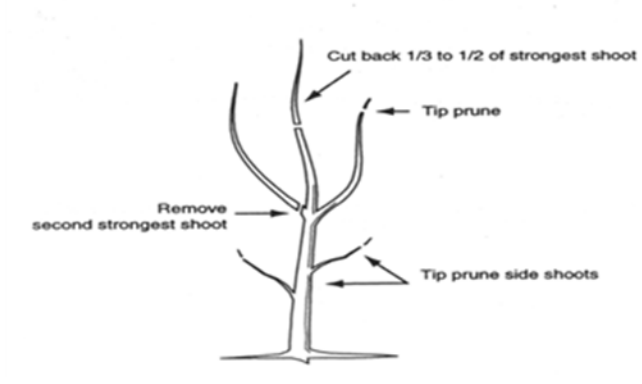

Fig. 2 First-year dormant pruning

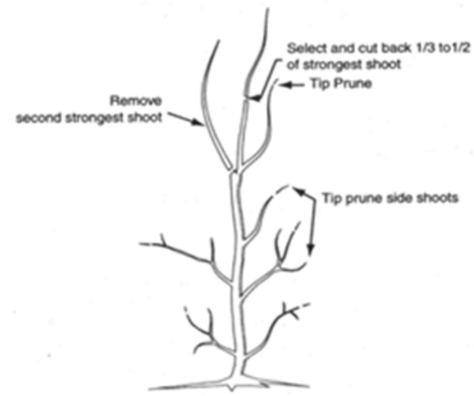

Fig. 3 Second-year dormant pruning

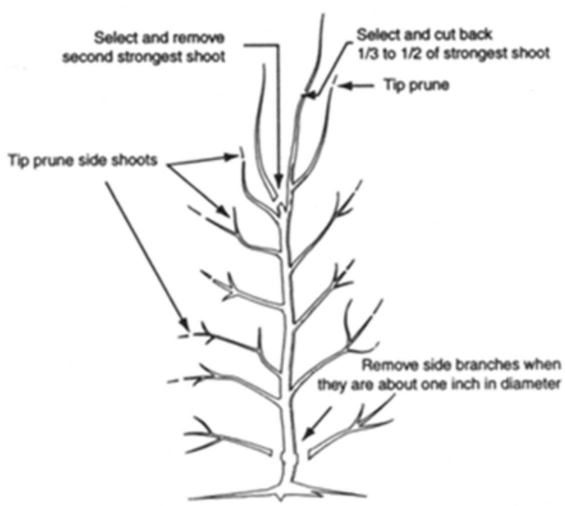

Fig. 4 Third-year dormant pruning

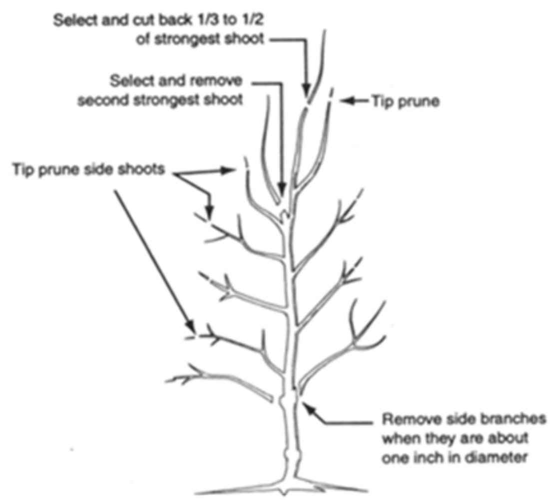

Fig. 5 Fourth & fifth-year dormant pruning

Branch Selection

When selecting branches that will become permanent scaffold limbs, choose only the branches that form wide angles with the central leader. The selection of the main lateral scaffold branches should be delayed until the dormant period after the first year of growth. It is important to note that at each node (growing point) primary, secondary, and tertiary buds occur.

Scaffold branches from the main central leader trunk may be formed from primary, secondary, or tertiary buds. Those formed from primary buds usually produce narrow crotch angles, and are weaker than scaffolds formed from secondary or tertiary buds. The primary bud should not be used in developing the major scaffold branches of the framework. The shoot from the primary bud may be pruned or pinched out to force the development of a shoot from the secondary bud. The same procedure, pruning or pinching both primary and secondary buds, may be used if a scaffold branch is desired from a tertiary bud.

The main trunk or central leader from which the scaffold branches are formed is more easily developed from a primary bud with its natural tendency for upright growth so the center of the tree will be erect.

When training a young pecan tree arrange six to ten side branches in a spiral around the central leader. These are selected and spaced eight to fourteen inches apart. Having several small scaffold branches can be harvested more easily with a mechanical shaker than those having only two or three large branches. The lowest scaffold branch should not be higher than necessary to attach the shaking machine head. About four or five feet should suffice. The exact height will be determined by the type of harvesting equipment used.

All side shoots developing below four feet, which will not be selected for permanent scaffold limbs, should not be removed until they are one inch in diameter. Research has shown that a "trashy trunk," one where no trunk limbs are removed for the first three years, will increase trunk girth and root development. Their purpose is to manufacture food for central leader extension, sun protection, trunk girth growth and root development. In addition, these lower branches will produce nuts until weakened by excess shade.

Lateral branches frequently grow in clusters instead of the ideal spiral arrangement. When this happens, select the most ideally located one, prune it in the dormant season and shorten the others to a few inches to reduce vigor. Trunks with two central leaders should be pruned because splitting may occur at the junction. If two upright trunks of equal size develop, one must be removed. This should be done as early in the life of the tree as possible. This reduces the probability of "V" trunk development which has included bark causing the trunks to be weakly attached to each other.

A "crow's foot" is the development of four to six shoots from the end of a young limb. Thin out the limbs so that only two or three remain. Tip-pruning significantly reduces the crow's foot problem. All pruning should be done during the dormant season.

Tip-Pruning

Most cultivars produce extremely vigorous growth in the third, fourth, and fifth seasons. Tipping these vigorous shoots will produce many lateral branches. The most desirable can be selected for further training. Tip-pruning is practiced on permanent limbs by removing about two inches of terminal growth during the dormant season. Shoots are tip-pruned only when they are 32" or longer (Figs. 2, 3, 4, and 5). This practice stimulates the development of numerous small lateral shoots. Heading back (removal of one-third to one-half of the shoot length) instead of tip-pruning will usually result in the development of three or four strong shoots directly below the pruning cut.

Tip-pruning will bring pecan trees into commercial bearing at an earlier age and encourage central leader development. It also reduces tree size during the first ten years. It has been recommended to tip-prune trees until the sixth or seventh year. It is not needed on larger bearing trees.

Pinching

Pinching is accomplished on trees less than four years old. As small scaffold limbs develop along the trunk, pinching is performed by removing the soft, light green growing points. The growing point can be easily broken off with the fingers. Lateral shoots should grow twelve to eighteen inches before the growing point is removed during the first season, and 12-32" during the second, third, and fourth growing seasons (Figs. 2, 3, and 4). Pinching results in larger leaves on the lateral shoots. It also inhibits development of large scaffold limbs during the first four years of the tree's life and encourages strong leader development.

Shaping Takes Time

Almost all pruning necessary on young trees can be done during the growing season, if done as soon as needed. Trees trained and pruned in this manner will seldom require the use of a pruning saw.

At least five years are needed to complete the selection of scaffold branches and train the tree to the proper form. Each tree will be different although you attempted to make them appear uniform. It is impossible to select branches on a tree that conform exactly to your ideal. If you continue to compare each tree with your mental picture of an ideal pecan tree, your orchard will produce maximum yields of high quality nuts.

Source: http://cahe.nmsu.edu/pubs/_h/h-605.html

Diagnosing and Correcting Common Micronutrient Disorders in Pecan Orchards

Dr. Richard Heerema
Extension Pecan Specialist
New Mexico State University

The essential plant nutrients are usually categorized as either macronutrients or micronutrients. The macronutrients (nitrogen, phosphorus, potassium, sulfur, calcium and magnesium) are those nutrients required by plants in relatively large amounts and are measured in leaf tissues in percent by weight. The micronutrients (zinc, iron, manganese, copper, chlorine, boron, molybdenum and nickel) are required by plants in much smaller amounts and are usually measured in plant tissues in parts per million (ppm; sometimes expressed as mg/kg). Nevertheless, in pecan orchards the micronutrients are no less important than the macronutrients for maintaining an orchard's productivity—**a shortage or excess of <u>any one</u> of the fourteen essential nutrients negatively affects tree performance**.

Most of the pecan orchards in the western pecan growing region have relatively high soil pH (typically 7.8-8.1). Furthermore, most western pecan orchard soils are calcareous and are thus highly buffered (i.e., it is very difficult to significantly reduce the soil pH). This is significant for pecan growers mainly because the metal micronutrients, zinc, iron, manganese, copper and nickel are poorly available for uptake by the roots in high pH soils. That is, even when these nutrients are abundant in the soil, high soil pH causes these nutrients to convert to less available forms or to bind to the soil so that they cannot be accessed by the pecan tree roots.

Zinc (Zn).

Pecan trees are more likely to be deficient in Zn than any other micronutrient. Because Zn demand by the tree is relatively high for a micronutrient, Zn shortages often occur even in the acid soils of eastern growing areas. Zinc has a number of physiological roles in the plant, including involvement in the biosynthesis of the plant hormone IBA. IBA is critical to normal shoot and leaf growth; so it is not surprising that Zn deficiency should result in the well-known "rosette" (shortened and telescoped shoots) and "little leaf" symptoms. Other symptoms of Zn deficiency include wavy or crinkly leaf margins, leaf chlorosis (yellowing), shoot apex death, fewer fruit per shoot, smaller fruit, lower percent kernel and delayed shuck split.

Zinc concentration in leaflets sampled in July or August provides the best indicator of tree Zn status. University recommendations for an optimal pecan leaf Zn concentration range vary: New Mexico State University (NMSU) recommends 50-100 ppm Zn, Texas A&M (TAMU) recommends 80-500 ppm and the University of Arizona (UA) recommends 48-257 ppm.

The most popular Zn fertilizer is zinc sulfate. Other available Zn fertilizers include zinc nitrate, zinc oxide, NZN and various chelated Zn fertilizers. Thus far, correcting Zn deficiencies through soil application of these fertilizers in calcareous western soils has in most cases been unsuccessful or impractical. Nevertheless, there are anecdotal accounts of pecan growers maintaining adequate leaf Zn levels in their orchards through a program of regular soil Zn application (generally through injection into micro-irrigation systems). The current university (NMSU, TAMU and UA) recommendation for maintaining adequate levels of Zn in pecan orchards is to make multiple (at least 3) foliar zinc applications at approximately 2 week intervals each springtime while the leaves continue to expand. Excessive Zn levels in the plant may interfere with uptake of other micronutrients, most notably nickel. So, if a foliar Zn program brings the July- or August-sampled leaflet concentrations in a pecan orchard to or above the recommended concentration range, it may be prudent to reduce Zn application rates (either number of sprays applied or fertilizer concentration in the spray tank) in the subsequent spring.

Iron (Fe).

Among other functions, Fe is necessary for biosynthesis of chlorophyll, the green-colored molecule in leaves that collects light energy for photosynthesis. The leaves of iron deficient trees are a very light yellow (sometimes almost white) color in the area between the leaf veins with some green color on and near the veins. Over time iron deficient trees show signs of shoot dieback, presumably in part because photosynthesis is reduced to the point that shoots become energy starved.

NMSU recommends 50-250 ppm Fe, TAMU recommends 50-300 ppm and the UA recommends 43-81 ppm. However, pecan trees exhibiting clear Fe deficiency symptoms often have leaf Fe concentrations within the adequate range. Thus, the situation with Fe appears to be more complicated and confusing than for some of the other nutrients.

Iron deficiency often appears on scattered trees throughout an affected pecan block. Application of foliar Fe fertilizers (particularly Fe chelate fertilizers) can help to green up trees to some degree even after Fe deficiency symptoms have appeared. Nevertheless, fully correcting Fe deficiency is usually very difficult.

Iron deficiency is most often associated with waterlogging of orchard soil. Thus, careful irrigation management and/or soil physical modifications in orchards with poorly drained soils is often the most effective way to prevent Fe deficiency symptoms from appearing.

Manganese (Mn).

Manganese deficiency and toxicity have both been reported in southwestern pecan trees—Mn deficiency is, however, far more common than toxicity. In plants, Mn activates numerous important enzymes and is essential for photosynthesis. Manganese deficiency symptoms in pecan were first described by Smith et al, 2001: "…shoot growth was short, with pale green foliage. There was no discernible pattern in leaf chlorosis or necrosis, other than a general pale color." Pecan trees with severe Mn toxicity exhibit delayed budbreak, "rosetting" similar to Zn deficiency (but with normal sized leaves), and shoot dieback.

NMSU recommends 100-600 ppm Mn, TAMU recommends 40-300 ppm, and UA recommends 104-674 ppm. As with Zn, springtime foliar applications of Mn fertilizer (e.g., manganese sulfate), can correct Mn deficiencies. Where Mn toxicity has been reported, soil pH was abnormally low (i.e., acid) for the western U.S. (Nuñez, personal communication) and the imbalance could be corrected by increasing soil pH.

Nickel (Ni)

Nickel is required by plants in miniscule amounts—only a tiny fraction of the amounts of the other micronutrients (with the exception of molybdenum). This is why it was surprising to many when Ni deficiency was documented in the field for the first time (in pecan of all plants!). Nickel is required for activation of numerous enzymes, most notably some enzymes important for nitrogen metabolism. Nickel deficiency symptoms in pecan include brittle branches and roundish, small ("mouse-eared") leaflets. Currently, NMSU and TAMU do not have published recommended Ni levels for pecan. UA recommends 8.5-14.3 ppm for July- or August-sampled leaves. Nickel deficiency may be corrected through either spring or fall applications of chelated nickel.

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Evaluation Of Soil Zinc Fertilization In Alkaline Soil On Pecan Orchards In Southern Arizona

Humberto Núñez[1], James Walworth[1], Andrew Pond[1], Bruce Wood[2], and Mike Kilby[3]

Department of Soil, Water and Environmental Science, University of Arizona, Tucson, AZ[1]
USDA Southeastern Fruit and Tree Nut Research Laboratory, Byron, GA[2]
Department of Plant Sciences, University of Arizona, Tucson, AZ[3]

Two field studies and one with potted trees were conducted to evaluate the effect of soil zinc fertilization on pecan orchards with alkaline soil. Field studies were done on 7 year old flood irrigated 'Wichita' pecan trees. Treatments in one study included soil application of $ZnSO_4$ and zinc EDTA at 74 and 19 kg $Zn{\cdot}ha^{-1}$, respectively. Treatments were applied once in 2005. Treatment applications in the second study started in 2006. They were manure 1X (10 ton ha^{-1}); manure 1X plus zinc 1X (10 ton ha^{-1} plus 75 kg of zinc ha^{-1} as $ZnSO_4$); manure 2X; manure 2X plus zinc 2X; and control. Treatments were applied annually. In both studies, a randomized block design with four replications was used. Potted one year old 'Wichita' trees in 40 L containers were treated with manure and various zinc sources. A foliar Zn treatment was included. Data collected in field studies were yield, nut quality, and leaflet zinc concentration during the season. Yield and quality differences between treatments in field studies were not significant. All yields in 2008 were above 2850 kg ha^{-1} and nut filling was greater than 62 %. Zinc EDTA and zinc sulfate did not significantly affect zinc leaflet concentration in four years of study. Manure 2X plus zinc 2X had elevated levels of zinc in leaflets (66 ± 13 ppm) during the second year of evaluation, whereas leaves in the control treatment had 45 ± 2 ppm. In potted trees, Zn EDTA increased Zn leaflet concentration (244 ± 158 ppm). Application of zinc to calcareous soils can be effective, but chemical form and placement are critical, and trees may take several years to respond to treatments.

QuickBooks a Financial Management Tool for Agriculture

Dr. Jerry M. Hawkes
Associate Professor
New Mexico State University

Financial recording keeping in an agricultural business is a vital part of the success of many small or large margin operations producing agricultural commodities in a competitive business environment today. These records are essential in gaining a full understanding of the financial condition of the firm. With this understanding decision making is made more accurate and may have more beneficial impacts on the liquidity and solvency of the agribusiness than without the decision making capabilities that are provided with the assistance of software programs today. A basic but very employable software package that is available for producers today is QuickBooks Pro. This program is comprehensive but user friendly at the same time which will allow a broad range of users to begin compiling better records leading to better financial decision making in the future.

QuickBooks Pro 2007 has the ability to provide a small business with a practical financial software package that can be beneficial in a wide variety of agribusiness and production agriculture settings. QuickBooks Pro 2007 has the ability to easily organize sales receipts, pay bills, create estimates and invoices, track vendors and customers, and write checks, as well as generate financial statements, organize payroll records as well as assist in the completion of state and federal tax returns.

The employment of a software package that will facilitate an owner's ability to make informed financial decisions in a competitive business environment is essential for long-term financial success. The ability to make informed financial decisions will be valuable in the generation of greater net returns on an investment which is primary for any business today. There are other programs which are available but the user may find that these are more complicated to use in an agricultural firm and may provide similar data needed for decision making with much greater effort.

Almond, Walnut, Pistachio, and Pecan Production in California

Brent A. Holtz
University of California Cooperative Extension
Madera CA

Abstract
California's almond industry has experienced tremendous growth. California's bearing almond acreage has gone from 550,000 to 660,000 acres in the last two years, averaging more than 50,000 acres of new plantings per year. Bearing acreage is expected to reach 800,000 acres in the next two years. In 2008, California produced a record 1.5 billion pounds of almond meats, averaging 2,270 lbs per acre. The almond industry used to be concentrated in the Sacramento Valley of California, but now 85 percent of the state's acreage is in the San Joaquin Valley of California, and most of the new planting has occurred in Madera, Fresno, and Kern Counties as cotton fields were converted to almond orchards.

In the last two years California's walnut industry has grown from 216,000 acres to 218,000 acres, averaging 1,000 acres per year. In 2008, California produced 277 million pounds of walnut meats, averaging 1,270 lbs per acre. In the last two years California's pistachio industry has grown from 110,000 bearing acres to 118,000 acres, averaging 4,000 acres of pistachio plantings per year. In 2007, California produced a record 415 million pounds of pistachio in shell, averaging 3,615 lbs per acre. In 2008, the industry produced 278 million pounds, demonstrating the alternate bearing pattern of pistachio in California. In the last two years California's pecan acreage has not increased, holding at 3,100 acres. In 2008 California produced 4 million pounds of pecan meats.

Many of California's older almond and walnut orchards are being replanted to second generation orchards. Replant disease is a concern when orchards are replanted using the same or related rootstock that was previously grown. Increasing regulatory restrictions associated with soil fumigation to control replant disease and plant parasitic nematodes in replant situations are industry concerns. Senate bill 700 will restrict the open field burning of agricultural wastes in 2010, and California's tree fruit industries have responded by shredding or chipping their tree prunings, and grinding or tilling their trees during orchard removal. As many as 200,000 almond acres may be adversely affected in 2009 by the current drought in California as water allotments in the Westland's irrigation district has been reduced to zero. In a state with 40 million people and over 2 million acres of irrigated land, water allocation will always be a contentious issue.

When to Go Into Cold Storage

Kyle Brookshier
Brookshier Pecan Farm J.V.
Van Horn, TX

I. Necessity

1. Carry – In of previous year crop necessitates storing crop until next crop year.
    a. Income tax – to not have two crop years income in the same year.
2. Lack of capacity on farm to hold full production of one year.
3. Flexibility to sell when you want, at a time when you have more ability to concentrate on the pecan market.
4. Freezers- preserves quality much better than open barn.
    a. Quality is better preserved if transferred from field to freezer within one week of harvest.
    b. Flow of shipper taking two loads per day to cold storage.
    c. Harvesting, processing, and shipping end very close together.

II. Price

1. The best time to sell is **not** when there is a glut on the market.
2. Statistical Data
    A. When one is considering holding for a better price **he must** keep informed as to what the current crip production is, the previous crop year productions was, and the long range forecast of the coming crop year.
    B. U.S.D.A. is the final word on crop size.
        1. Predictions – during crop year
            a. Final Prediction – Previous years final crop figures are given at Texas meeting in July.
            b. Sheller Crop Prediction
                1. Michael Maros did a long range study and found the shellers prediction is wrong 90% of the time.
                2. The sheller's are usually high on both on and off year.
                3. Sometimes they are right on.
                4. Dynamics of shellers prediction are they get crop size reports from shellers in different areas of the country. Predictions are at best an educated guess.
    C. Grower Predictions
        1. First crop prediction is made in Louisiana in mid – June.
        2. Second prediction is made in Texas in July.
        3. Grower predictions are also an educated guess, but historically much closer on an average.
    D. Who to believe and make your decision.
        1. Find that one person in whom you have the most trust to tell you what they
           think the crop is, has been ,and is going to be.
        2. Your decision to hold in cold storage is based on your belief through your

study of the crop predictions.

3. Rule of Thumb
   a. Hold only going in to an off-year.
   b. I have held going into an **on** year with some success.
   c. This rule does not account for a situation where there may have been less made on the off-year than was thought, or a sheller thinks that the price was too high in the off year and realized he would not have enough to fill his contracts and is willing to pay more because of his need. This has happened and it happened in 2007.

C. Cost of Cold Storage

1. Two main cold storage facilities in the El Paso area are Millard's Refrigerated Services and Southwest Cold Storage.
   a. Southwest Cold Storage charges for totes or super sacks $14.00/month for 30 days. Their in/out fee is $13.50/super sack or bin. If your super sacks are not on pallets they charge .18/hundred weight to unload.
   b. Millard's charges $11.51 per month per super sack or bin for 30 days. Their charges are based on no more than 1500 lbs per super sack. In and out charges are $60.00 per load.
   c. Store with a Sheller
      1. Good option if you have a clear understanding with sheller. This may involve a first option to buy agreement.

Conclusion:

One should always consider cold storage as an option. Depending upon the conditions you can make as much as 10-20 cents more per pound above your cold storage costs. If you are willing and able to take the risks, the reward can be there. The one thing that is rarely mentioned is when the grower stores his own nuts it actually helps the sheller. The sheller does not have capital tied up or the storage costs and it helps stabilize the market by not flooding it with product.

43rd ANNUAL WESTERN PECAN GROWERS ASSOCIATION CONFERENCE SPEAKERS

March 1-3, 2009

Dr. Jamshid Ashigh
Extension Weed Specialist
New Mexico State University
MSC 3AE – P.O. Box 30003
Las Cruces, NM 88003
(575) 646-2888
jashigh@nmsu.edu

Kyle Brookshier
Brookshier Pecan Farm J.V.
P.O. Box 216
Van Horn, TX
(432) 283-2975
kb@telstar1.com

Rob Call
Extension Agriculture Agent
Cochise County Extension
University of Arizona
450 S. Haskill
Willcox, AZ 85643
(520) 384-3594
recall@ag.arizona.edu

Dr. Lowell Catlett
Dean/Regents Professor
New Mexico State University
College of Agricultural, Consumer and
& Environmental Sciences
MSC 3AG - P.O. Box 30003
Las Cruces, NM 88003

Brian Fontes
Graduate Student
New Mexico State University
MSC 3BA, Box 30005
Las Cruces, NM 88003
(575) 646-3207
Fontes22@nmsu.edu

Dr. Marvin Harris
Professor of Entomology
Texas A & M University
College Station, TX 77843
(979) 845-9757
m-harris@tamu.edu

Dr. Jerry Hawkes
Associate Professor
Ag Economics & Ag Business
New Mexico State University
MSC 3169, P.O. Box 30003
Las Cruces, NM 88003
(575) 646-2322
jhawkes@nmsu.edu

Dr. Richard J. Heerema
Extension Pecan Specialist
New Mexico State University
Box 30003, MSC 3AE
Las Cruces, NM 88003
(575) 646-2921
rjheerem@nmsu.edu

Dr. Brent Holtz
Pomology Farm Advisor
University of California
Cooperative Extension
328 South Madera Avenue
Madera, CA 93637
(559) 675-7879, Ext. #205
baholtz@ucdavis.edu

Dr. Jim Libbin
Interim Associate Dean &
Director of Academic Programs
New Mexico State University
MSC 3AG, P.O. Box 30003
Las Cruces, NM 88003
(575) 646-2915
jlibbin@nmsu.edu

Dr. Bill Lindemann
Professor, Soils
New Mexico State University
Plant & Environmental Sciences
MSC 3Q, P.O. Box 30003
Las Cruces, NM 88003
(575) 646-1907
wlindema@nmsu.edu

Dr. Leonardo Lombardini
Plant Physiologist/Horticulturist
Texas A & M University
College Station, TX 77843-2133
(979) 458-8079
l-lombardini@tamu.edu

Dr. William B. McCloskey
Associate Specialist
University of Arizona
Plant Sciences Department
Marley Building, Rm. 541B
P.O. Box 210036
Tucson, AZ 85721-0036
(520) 621-7613
wmcclosk@ag.arizona.edu

Humberto Nuñez
Research Associate
Dept. Soil, Water, &
Environmental Sciences
1177 E. Fourth Street
Shantz Bldg. #38, Rm. 429
Tucson, AZ 85721-0038
(520) 626-3364
hnunezm@email.arizona.edu

Bill Ree
Pecan IPM Agent
Texas A & M University
P.O. Box 2150
Bryan, TX 77806-2150
(979) 845-6800
w-ree@tamu.edu

Dr. Rolston St. Hilaire
Associate Professor
New Mexico State University
Plant & Environmental Sciences
MSC 3Q, P.O. Box 30003
Las Cruces, NM 88003
(575) 646-3638
rsthilai@nmsu.edu

Dr. Bruce W. Wood
Research Leader
USDA-ARS SEFTNRL, 21 Dunbar Road
Byron, GA 31008
(478) 956-6421
bwwood@saa.ars.usda.gov

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John Harris
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Mesilla, NM 88046

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Steven Benavidez
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Todd Edwards
P.O. Box 750
Clearfield, UT 87089

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6000 Uptown Blvd. NE #400
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Julie Dingus
2001 E Lohman ,Ste. 110
Las Cruces, NM 88011

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Ron Gillison
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Houston, TX 77082

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Yuba City, CA 95993

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Fresno, CA 93727

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P.O. Box 5611
Valdosta, GA 31603

Nogal Santa Rita
Ing. Daniel Fernandez
Dr. Jose Eleuterio Gonzalez
808 Col. Gil De Leyva
Montemorelos, N.L. Mexico 67560

Orchard Machinery Corp
Don Mayo
2700 Colusa Hwy
Yuba City, CA 95993

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Hans Bollerud
5724 E Whitmore Avenue
Hughson, CA 95326

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Joe Cook
P.O. Box 714
Comanche, TX 76442

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Henderson, TX 75654

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Mark Hendrixson
P.O. Box 282
Orange Cove, CA 93646

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P.O. Box 4490
Modesto, CA 95352

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Ron Kaiser
P.O. Box 8
Valley Springs, CA 95252

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Albuquerque, NM 87105

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Clay Savage
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102 Barton St
St. Louis, MO 63104-4729

SNT/PPI
Dewayne McCasland
324 Hwy 16S
Goldthwaite, TX 76844

South Plains Implement, LTD
Chuck Griffith
P.O. Box 609
Mesquite, NM 88048

South Valley Structures, LLC
Tom Conlee or Eric Norris
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Roswell, NM 88201

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Robert Waller
P.O. Drawer 300
Mesquite, NM 88048

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Kevin Conley
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Terra Bella, CA 93270

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Brad Achen
P.O. Box 540
Hatch, NM 87937

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Brent Besler
1302 E. Broadway
Brownfield, TX 79316

The J. C. Smith Co.
Donny Smith
471 S. Hwy. 16
San Saba, TX 76877

USDA/NASS/NM Field Office
Jim Brueggen
2507 N. Telshor Blvd. #4
Las Cruces, NM 88011

Valley Equipment
Chris Enriquez
P.O. Box 1026
Las Cruces, NM 88004

Weiss McNair Ramacher
Fred Corona
531 Country Drive
Chico, CA 95928

Weldcraft Industries, Inc.
Jerry Micke
P.O. Box 11104
Terra Bella, CA 93270

Western Blend, Inc.
Louie Salopek
P.O. Box 705
Doña Ana, NM 88032

Wizard Manufacturing Inc.
Alan Reiff
2244 Ivy Street
Chico, CA 95928

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