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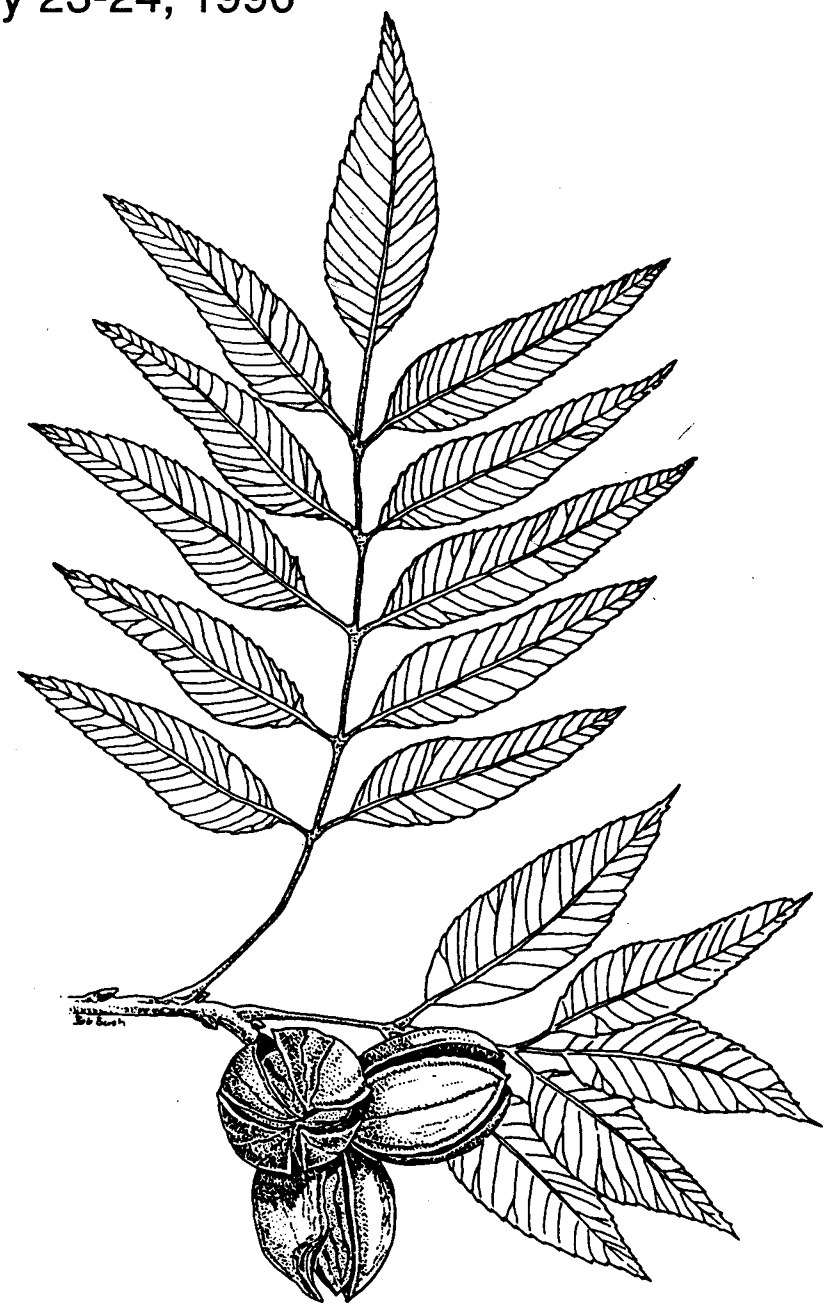

DEVELOPING LOW-INPUT MANAGEMENT STRATEGIES FOR NATIVE PECAN ORCHARDS

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ABSTRACT

Low-input strategies offer the only avenue for native pecan producers to increase profitability. The native pecan agro-ecosystem in NE Oklahoma, SE Kansas, and SW Missouri is ideally suited for low input management. Limited insect and disease pressure and a short growing season should enable growers in the three state area to make significant reductions in pesticide inputs. Development of improved crop and pest monitoring techniques can lead to methods for the biological control of overproduction. A total systems approach to crop management is required for future development of low-input management strategies.

INTRODUCTION

Ninety million pounds of pecans are produced annually from seedling trees growing in natural stands throughout Kansas, Louisiana, Missouri, Oklahoma, and Texas (USDA/ERS 1988). Pecans produced from "native" trees represent more than one third of the total U.S. production. In Kansas, Oklahoma, and Missouri, native pecans account for over 90% of the pecan acreage (Figure 1) (Thompson 1984).

Several economic factors are leading to a steady decrease in profits earned from managing native pecans. Over the past 20 years, the price growers receive for native pecans has remained almost constant, while the price of improved pecans (nuts from large, thin-shelled cultivars) has increased slightly (USDA/ERS 1989a) (Figure 2). Adjusted for inflation, grower prices for both native and improved nuts have actually decreased (USDA/ERS 1989b) (Figure 3). In sharp contrast, costs of production inputs have risen dramatically over the same time period (Table 1). With input costs out-pacing increases in nut prices, native pecan producers have three avenues for maintaining profitability: increasing yields per acre, adopting new technologies, and reducing production costs.

Yield of Native Pecans

On a industry wide basis, pecan yield per acre has increased over the last 20 years, as orchards of improved cultivars have taken a larger share of the U.S. production. Limited by the genetic potential of a seedling population, native pecan yield per acre peaks at around 1000 lbs./acre (Reid and Olcott-Reid 1985). Currently, this yield is obtained with an intensive management program that requires large investments in fossil fuels, fertilizer, and pesticides.

Adopting New Technology

The labor and equipment needed for harvesting and cleaning pecans account for 25% of the total production cost (Pena 1987). In the mid 60's, several mechanical harvesters were introduced for use in native pecan groves. These machines have enabled producers to harvest large acreages, while reducing labor costs. Harvesting technology has been refined since that time, but significant changes to allow additional reductions in harvesting costs have not occurred since the mid 70's.

Reducing Production Costs. The leading variable costs associated with the production of native pecans include fuel, fertilizer, pesticides, equipment maintenance, and labor (Pena 1987). Pest control alone accounts for as much as 50% of all variable costs.

In the absence of yield increases or technological breakthroughs, reducing the cost of production remains the only viable approach native pecan producers have to improve profitability. Reducing production costs by substituting biological and managerial inputs for chemical and fossil fuel inputs has been the focus of 'Low Input' agricultural research. Much of the biological information needed to develop a low-input approach to native pecan management is available. Integrating that information into low-input management systems tailored to specific bio-regions offers an exciting challenge for pecan researchers in the 1990's.

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LOW-INPUT AGRICULTURE AND NATIVE PECANS

The expressions, 'low-input agriculture' and 'low-input sustainable agriculture' are among the current buzz words heard in the halls of agricultural academia. But what do these phrases mean? Most commonly, low-input sustainable agriculture is used as a verbose synonym for organic farming. Low-input sustainable agriculture has been defined as a philosophy and system of farming based on a set of values that reflect heightened levels of ecological awareness (MacRae et al. 1989). In practice, low-input sustainable systems avoid the use of synthetically manufactured fertilizers, pesticides, and growth regulators (Pimentel et al. 1989). Crop rotation, green manures, animal manures, cultivation, and mineral-bearing rocks are used to maintain soil fertility. Cultural and biological control measures are employed to check insects, diseases, and weeds. What sets low-input sustainable agriculture apart from low input agriculture is that management decisions in the 'sustainable' system are made within the narrow confines of what is philosophically defined as 'organic'.

Low-input agricultural systems employ many of the same biological and cultural techniques used in 'sustainable' systems but are not limited to purely 'organic' methods. Management decisions in low-input systems are economically based rather than philosophically based. The principles that govern low-input agricultural systems are: (1) adapting crop production techniques to the environment of the bio-region; (2) preserving and enhancing naturally available biological and soil resources; and (3) substituting management skill for prophylactic cultural practices.

Northern Native Pecans: Ideal for the Low-Input Approach. Native pecans thrive in the riparian environments of NE Oklahoma, SE Kansas, and SW Missouri. Commercial orchards, carved from riverbottom forests in this area, are located on the northern edge of the native pecan belt. The growing season in this region is relatively short for pecan, ranging from 190 to 210 days. Heavy, loamy-clay soils dominate most pecan sites in the three state area. Soils are deep, fertile, sub-acid (pH 6.0-6.7), and subject to seasonal flooding. Production problems and practices are quite similar throughout this area, where native pecans dominate the industry (Figure 1).

The native pecan agro-ecosystem in NE Oklahoma, SE Kansas, and SW Missouri is ideally suited for the low-input management approach. Five factors contribute to this ideal suitability:

1. Low economic returns for native pecans provide financial incentive for growers to avoid making expenditures for production inputs of questionable value.

2. Lepidopterous insects that attack pecan fruit and foliage have fewer generations per year in the north. Thus, control measures can be applied less frequently or not at all.

3. Northern native pecans grow under conditions of limited disease pressure. Routine fungicide applications are unnecessary in the area.

4. A permanent ground cover, high soil organic matter content, and optimum soil pH ensure an adequate supply of zinc in northern native orchards. Foliar zinc applications, commonly recommended for Texas native pecans (Johnson et al. 1987), are unnecessary in the three state area.

5. Pecans adapted to fruiting in regions of a short growing season produce seeds that grow, fill, and dehisce in fewer than 150 days from pollination (Reid 1985). This rapid nut development shrinks windows of opportunity through which nut feeding insects attack or injure the nuts.

Keeping these five factors in mind, a low-input management system for northern native pecans can be devised by using current knowledge of pecan tree physiology, integrated pest management, and agricultural economics.

The Native Pecan Agro-ecosystem: A Review

Pecan [*Carya illinoensis* (Wang.) K. Koch] is the largest of the North American hickories. This tree is native throughout much of the central United States, thriving in the flood plains of major rivers in the Mississippi river drainage system (Little 1971). In areas where pecan is endemic, it is often the dominate forest species comprising more than 50% of the native forest biomass (Spencer et al. 1981). Many landowners have taken advantage of this natural resource by developing pecan orchards from the native trees.

Converting a bottomland forest into a productive native pecan grove is a five-step process (Reid and Olcott-Reid 1985). First, all species of trees other than pecan are removed, and the understory is cleared. A permanent ground cover is then established under the trees to facilitate harvest and to prevent soil erosion. After the initial forest thinning process, most native pecan areas are often too crowded for optimum nut production. Old, weak, or diseased trees are removed to allow adequate space for younger, more productive trees. Nut production in the native grove is further stimulated by the annual application of nitrogen fertilizer. And finally, an insect management program is initiated to prevent serious yield losses from nut feeding insects.

All cultural practices applied to native pecan groves are to promote high annual nut production. Even with superior management, native pecan orchards have a strong tendency towards irregular bearing (Figure 4). The unreliable annual supply of seedling pecans inhibits food processors from developing additional products that utilize seedling pecans. This absence of new product development contributes to depressed grower prices for native pecans.

Several internal and external factors influence seed production in pecan. An understanding of how these factors interrelate is needed before new cultural practices, including low input strategies, can be developed to reduce irregular bearing and improve grower profitability.

Internal Factors: The Cropping Cycle

Pistillate flowers of pecan trees are borne on terminals of the current season's new growth (Brison 1974). Although no morphological evidence of pistillate flower initiation can be found until after growth commences in the spring (Wetzstein and Sparks 1984), flowering intensity is determined during the previous growing season through the influence of seed production on tree physiology (Smith et al. 1986) (Figure 5). During growth and development, pecan seeds pull large amounts of carbohydrates from surrounding plant tissues (Davis and Sparks 1974). This carbohydrate drain limits the amount of energy available for pistillate flower initiation in the following year.

External Factors Affecting Pecan Yield

Native pecan yield is influenced by weather, tree spacing, weed competition, soil fertility, diseases, and insects. These factors influence pecan yield at two points in the cropping cycle (Figure 6). Drought and early-season, nut-feeding insects can cause significant nut abortion, thus influencing yield directly. Tree overcrowding, weed competition, low soil fertility, foliar diseases, and foliage-feeding insects influence yield indirectly by reducing tree vigor and photosynthetic efficiency.

As discussed earlier, the primary focus of native pecan management has been to minimize the impact of all external crop-reducing factors. This approach has been only moderately successful in reducing alternate bearing (Sparks 1983). Further advances in pecan yield regulation will be made only after cost effective methods for thinning heavy crop loads are developed.

Nut-Feeding Insects

Pest control efforts in native pecan groves are aimed at three major nut-feeding insects; pecan nut casebearer (*Acrobasis nuxvorella* Neunzig), hickory shuckworm [*Cydia caryana* (Fitch)], and pecan weevil [*Curculio caryae* (Horn)]. Although pecan weevil is the most serious pest native pecan producers face (Payne et al. 1979), this insect attacks nuts after seed development is largely completed (Harris 1985) and has little impact on the pecan cropping cycle. Pecan nut casebearer and hickory shuckworm cause nuts to abort before seed development is complete (Payne et al. 1979). This nut thinning directly affects the pecan cropping cycle and may offer a possible biological solution to overproduction problems.

MAKING A LOW-INPUT PROGRAM WORK

In developing a low-input management program for northern native pecan orchards, an analysis of current inputs is necessary in order to identify potential areas for input reductions. Production costs for the typical northern pecan grower include nut harvest, nitrogen fertilization, and insect control.

As mentioned previously, nut harvest consumes 25% of all variable costs. In the absence of new technologies, harvest costs must increase with increases in costs for machinery, fuel, and labor. Reductions in harvests costs are not on the horizon for any management system.

Nitrogen Fertilization

Native pecan orchards respond to nitrogen fertilization with considerable yield increases (Reid 1990a). Trees in well spaced groves will respond within 2 years of the initial nitrogen application. Nitrogen application may be the most profitable cultural practice used to increase native pecan yield. If the cost of urea (45% N) is $170.00/ton (1990 price) and a grower applies 225 lbs. urea/acre (100 lbs.N/Acre), he will spend $19.13/acre on fertilization. The application of 100 lbs. N/acre to native pecans increases yield by an average of 200 lbs./acre. If native pecans are sold for $0.45/lb., fertilization will return $90.00/acre in increased nut production and $70.87/acre in profit.

As long as the price for manufactured nitrogen remains relatively low, there is little incentive to develop alternative soil-fertility management systems. Increasing prices for fossil fuel used in the manufacture of chemical nitrogen and growing public concern for nitrogen contamination of ground water resources may alter this situation. If future events precipitate large increases in the cost for applying chemical nitrogen, native pecan growers will be among the first to turn to nitrogen-fixing cover crops as a low input alternative. The nitrogen-fixing capacity of forage legume crops is well known (Brady 1974). The ability of orchard-grown legumes to provide all the nitrogen needed to sustain high yields is a question that needs further study.

The incorporation of legume cover crops in the pecan agro-ecosystem also has important pest management ramifications. Legumes provide a nursery for the *in situ* proliferation of beneficial insects that can be manipulated for the control of pecan aphids (Tedders 1983). Successful aphid biological control programs using legume cover crops have been employed in south Georgia (Bugg and Dutcher 1989, Tedders 1983). In the north, pecan aphids are only an occasional pest and are rarely the target of chemical control measures. Naturally occurring beneficial insects keep aphids in check during most years in Kansas (Dinkins and Reid 1985). For legumes to become part of a soil fertility program for northern low-input orchards, the influence of this cover crop on insect populations (both harmful and beneficial) must be studied carefully to ensure that total inputs for nitrogen fertilization and insect control are reduced.

Insect Control

With pesticide prices increasing fourfold from 1970 to 1990 (Table 1), limiting their use on native pecans could significantly reduce production costs. The primary targets of the insecticides applied to native pecans in the north are pecan nut casebearer, hickory shuckworm, and pecan weevil. Because these insects have tremendous destructive potential, insecticides are applied 4 to 5 times a year under the assumption that economically damaging populations occur every year (Gallott et al. 1988, Morrison et al. 1982). For native pecan orchards that have had a high level of management for many years, this assumption may be invalid. During years of overproduction, pecan nut casebearer and hickory shuckworm may actually play the much needed role of nut thinning agents. Late in the late season, pecan weevil populations may be driven so low by years of pesticide application that further applications are not economically justified.

Scouting procedures have been developed for all the major insect pests of pecan (Reid 1988). Unfortunately, too many native pecan managers still apply prophylactic sprays without prior information on pest population levels. Low input strategies can work only after growers learn to substitute investments in management effort for investments in routine pesticide applications of questionable benefit. Intelligent decision making about pest management requires an intimate knowledge of insect and host plant biology and accurate scouting methods for determining economic injury levels.

Insect and Crop Load Monitoring

The success of a low-input, pecan-management program hinges on our ability to weigh insect control costs (both economic and biological) against potential income loss. In spite of recent advances in pecan pest management, native pecan growers are often faced with making pest control decisions without the benefit of accurate economic injury information. A brief look at the management of two nut feeding insects points out weaknesses in current IPM practices.

Pecan Nut Casebearer

A growing-degree day model (Ring et al. 1983) and sequential sampling plan (Ring et al. 1989) have been proposed for pecan nut casebearer. The growing-degree day model has had some success in estimating a best 'spray date' for control of this insect, whereas the sequential sampling plan attempts to determine the need for control. Both techniques are based on determinations of percent nut clusters infested with pecan nut casebearer. The expression of damage in percent infested clusters may accurately reflect insect behavior but is not easily converted to nut loss estimates. The discrepancy between percent infested clusters and percent nut loss can be seen in Table 2. Regardless of how percent damage is expressed, lack of accurate estimates for nut load renders percent damage information useless for determining economic injury levels. Percent nut loss to pecan nut casebearer was similar in 1986 and 1987 (16.7% and 16.9% respectively), yet nut yield per acre was three times greater in 1987 than in 1986 (Reid 1990a). In 1987, 16% nut loss would have provided a beneficial level of nut thinning to reduce overproduction. In a low crop year such as 1986, 16% nut removal by casebearer represents a significant economic loss.

Accurate estimation of pecan yield potential will be crucial to the future of biological control of seed overproduction (i.e., allowing pecan nut casebearer to thin pecan fruit). A recent attempt to estimate yield (Wright et al. 1990) has limited application to native pecan systems. The authors found significant differences between yield estimation models for different cultivars, years, and sites. Because of the immense genetic diversity in a native pecan grove, yield estimation models must be developed from large scale data bases. The management decisions native pecan managers make are for large acreages (100 to 1000 acres). Methods to estimate the yield potential of a 100-acre native pecan grove would be sufficient to determine economic thresholds and make pest control decisions.

Hickory Shuckworm

The current pest management approach to controlling hickory shuckworm can best be described as the "also" approach. Native pecan producers rarely apply a pesticide with the exclusive objective of controlling shuckworm. In Kansas and Oklahoma, native pecan growers often make a prophylactic insecticide application in early July to control insect pests such as walnut caterpillar, fall webworm, hickory nut curculio, and "also" hickory shuckworm (Gallot et al. 1988, Morrison et al. 1982). In August, insecticides applied to control pecan weevil "also" control hickory shuckworm.

As low-input strategies are adopted and pesticide applications are reduced, will hickory shuckworm become a more prominent pest? In the north, the hickory shuckworm has three generations per season (Dinkins and Reid 1988). The overwintering generation emerges before nut set and does not injure pecan. The first summer generation is usually so small that nut drop caused by this insect is negligible. Larvae from the second summer generation mine nut shucks and have been shown to inhibit nut fill. In a survey of 146 native pecan trees from a single orchard in SE Kansas, I found 25% of all nut shucks infested with shuckworm larvae (Reid 1990b). However, infestation rate could not be related to decreases in nut fill (Figure 7) or number of indehiscent nuts. Shuckworm larvae may not pose a significant threat to kernel fill in the north, where pecans are adapted to a short season climate. Northern natives fill their kernels before shuckworm larvae grow large enough to reduce the flow of carbohydrates to the seed.

The apparent differences in potential damage from hickory shuckworm between northern and southern pecan regions point out the importance of developing management strategies for specific bio-regions. Collection of basic biological information on all agro-ecosystem components is necessary for the development of site-specific, low-input strategies.

FUTURE RESEARCH NEEDS

Implementation of low-input management systems is dependent on total agro-ecosytem research programs. History provides painful evidence of how narrowly focused research can lead to economic disasters for growers who rely on university research for production guidelines. The pecan aphid problem that currently plagues southeastern pecan growers was created by the overuse of pesticides. After nearly 20 years of attempts at chemical quick fixes, scientists have adopted the total agro-ecosystem approach as the only sustainable solution to aphid management (Tedders 1986). Research opportunities abound for pecan scientists wishing to develop low-input pecan-management systems. An integrated approach to crop load estimation and pest monitoring techniques should become a research priority across the pecan belt.

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Table 1. 1970 and 1990 producer price indexes for selected equipment and supplies used in native pecan production. Source: U.S. Dept. of Labor, Bureau of Statistics. 1967=100.

Commodity	1970	1990
Farm Implements	115.3	331.0
Oil Products	103.1	413.1
Nitrogen Fertilizer	65.1	163.4
Pesticides	108.5	435.4

Table 2. Pecan nut casebearer damage expressed as percent infested clusters and percent of nuts lost. Data collected from 200 nut clusters on 10 native pecan trees growing in SE Kansas in the years 1981 through 1987.

Year	Percent Infested Nut Clusters	Percent of Nuts Damaged
1981	11.5	9.1
1982	28.5	19.8
1983	7.0	3.3
1984	32.5	22.0
1985	34.0	26.4
1986	25.5	16.7
1987	27.5	16.9

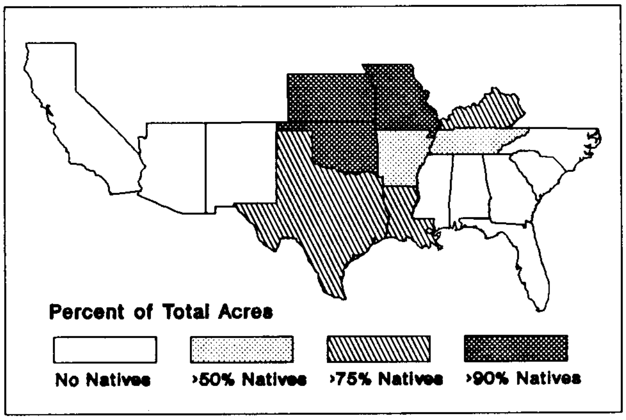

Figure 1. The importance of native pecans in pecan producing states.

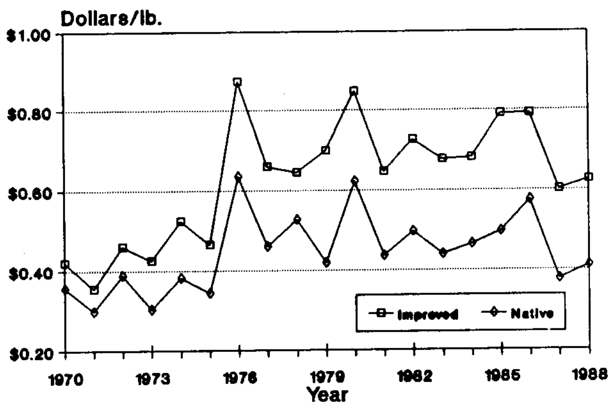

Figure 2. Prices paid to growers of native and improved pecans in the U.S. for the years 1970 through 1988.

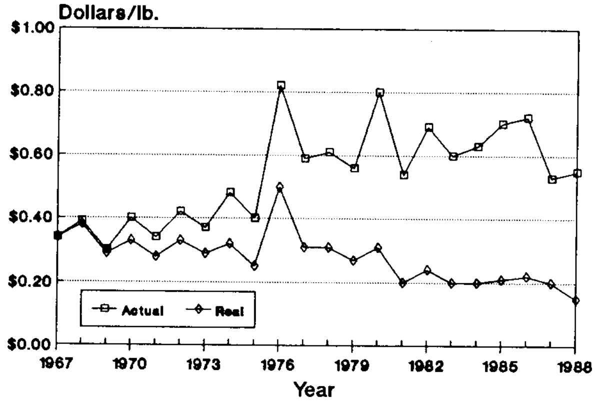

Figure 3. Grower prices for all pecans in actual and real dollars. The price paid to growers are expressed in actual dollars. The price paid to growers after adjustment for inflation are shown in real dollars.

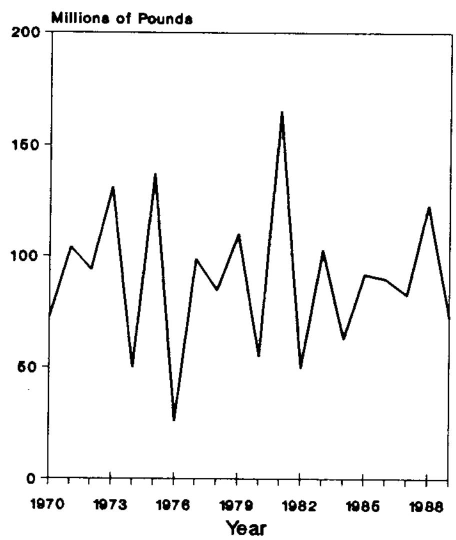

Figure 4. Total U.S. native pecan production for the year 1970 through 1989.

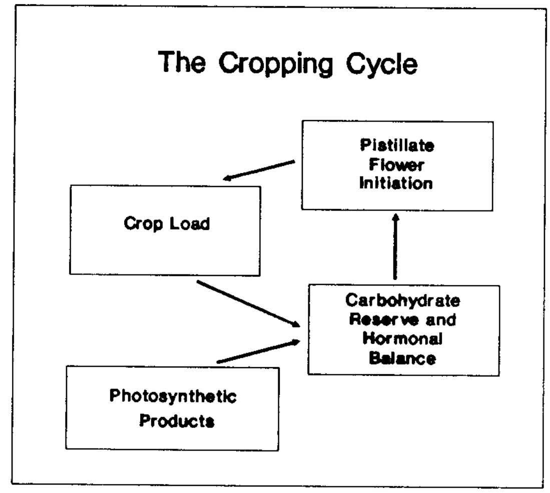

Figure 5. A schematic representation of the pecan cropping cycle.

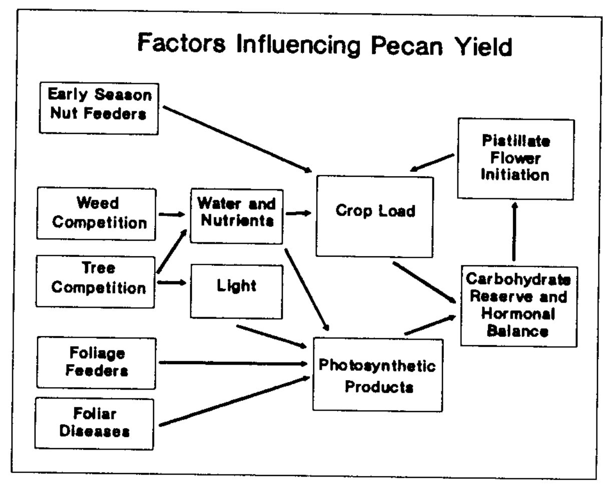

Figure 6. The external factors that affect the pecan cropping cycle.

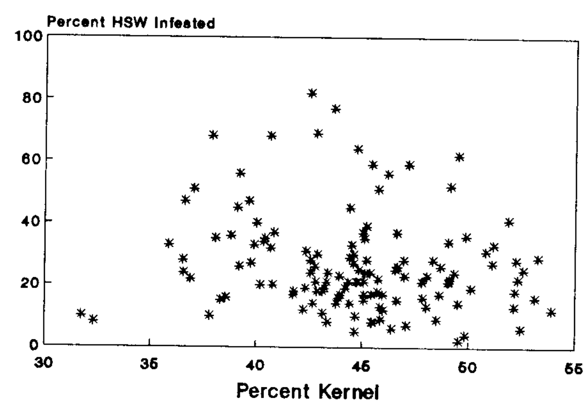

Figure 7. The relationship between hickory shuckworm infestation and kernel quality for 147 native pecan trees growing in SE Kansas in 1988.