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HICKORY SHUCKWORM IPM: PAST, PRESENT, AND FUTURE

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ABSTRACT

Control of the hickory shuckworm, *Cydia caryana* (Fitch), has been approached in various ways since the widespread adoption of sprayer usage in commercial pecans. Methods have ranged from ignoring the pest to multiple applications of preventative insecticides. The inception of organized IPM efforts in the late 1970's directed more attention to the pest as an individual entity. Monitoring efforts have made application timing more precise and preventative sprays have become artifacts in most producing states. IPM efforts have been somewhat hampered by the required use of broad-spectrum insecticides which affected beneficial insect populations, often requiring follow-up sprays for secondary pests. The advent of target-specific pesticides that are less damaging to beneficial organisms and less disruptive to the orchard ecosystem bode well for the future of Pecan IPM and hickory shuckworm control.

INTRODUCTION

The hickory shuckworm, *Cydia caryana* (Fitch), is a key pest of pecan throughout the production areas of the United States (Osburn et al. 1963, Payne et al. 1979) and has been reported to rank as the most important pest in six southeastern states (McQueen, 1973). Damage assessment is difficult but losses due to damage and control costs have been estimated as high as $11.3 million annually in Georgia (Suber and Todd 1980). A multivoltine lepidopterous pest, there are four or five generations per year in most of the principal production regions. IPM efforts have been developed over the past 30 years with varying results.

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PRE-IPM CONTROL EFFORTS

Following the widespread adoption of orchard sprayer use by producers in the early 1960's, control of the hickory shuckworm along with other arthropod pests was achieved by the addition of broad-spectrum insecticides to calendar driven spray schedules. These spray schedules were keyed to the crop development phenology and called for chemical applications on a regular basis, normally a three week schedule (Phillips et al. 1960, Polles and Payne 1974). This approach to control was effective until the mid-1970's. During that time period, it became apparent that, although control of major direct pests such as the shuckworm was obtained, the effects of such liberal applications of broad-spectrum material on the orchard ecosystem was detrimental to naturally occurring arthropods that exerted control influence on secondary and occasional pests such as aphids, mites, leafminers and others. The result was large population increases of many of those pests, elevating them to primary importance.

This method of saturating the orchard with insecticides at regular intervals, with a variety of compounds, was effective in controlling generation two and three of the hickory shuckworm but was less so for the most damaging generation four. This stems from reliance upon Carbaryl, applied for control of the pecan weevil, for a suppressive effect on shuckworm populations during the critical fourth generation. Accordingly, less control of shuckworm was achieved and producers were forced to believe that an infestation rate of shucks at harvest was not of economical importance unless it was greater than twenty-five percent.

CONTROL UNDER IPM SYSTEMS; 1976 TO THE PRESENT

Organized efforts to implement Pecan IPM programs began in Alabama in 1976, followed immediately by Georgia and Texas (McVay et al. 1978, McVay and Ellis 1979). These programs were driven by systems of arthropod monitoring developed for each specific major pest and some secondary pests. Due to the difficulty of post-ovipositional control of immature forms, most programs have encouraged the monitoring of adult populations of the shuckworm. Monitoring procedures were based primarily on the use of blacklight traps suspended in the tree canopy and control applications were triggered by the numbers of adult moths of either sex captured during specific time periods (Smith and Tedders 1978, Tedders and Edwards 1970).

This approach could be and was effective, especially in orchards with large endemic populations of the shuckworm in which treatments applied at peak activity periods throughout the season substantially reduced those populations over time. The major drawback of this system was a reluctance on the part of the producer to regularly monitor the traps, sorting through the large numbers of insects attracted to the traps and picking out the relatively small moths of the shuckworm. The most effective means of operating the trap was on alternating current which required an electric outlet in or near the orchard and constant maintenance. Attempts to control the shuckworm by placing traps in the orchard at the rate of two per acre were effective but were abandoned for the same reasons. Still, many producers did adopt this survey method and became proficient at identifying the moth and making control decisions based on captures.

In recent years, some Extension program specialists have established blacklight monitoring sites in orchards throughout their state's production region and provide producers with regular updates on shuckworm activity via toll-free telephone "hotlines" which the producers can call at any time. The positive aspect of this method is that producers have ready access to moth flight activity information but a negative is that unless their orchard is one that is equipped with a regularly monitored blacklight trap, they don't really know the activity level for their particular case and usually proceed on the basis of orchard history and crop load for the particular year.

In the mid-1980's, Smith et al, developed and released a synthesized sex pheromone of the hickory shuckworm. This type of attractant combined with easy to use traps has historically provided great benefit to various IPM programs. While initially very promising as a tool for directly monitoring shuckworm populations and activity patterns, the results of actual use have been mixed and particularly disappointing in the southeastern production region. Pheromone trap usage in the western production regions and in Mexico appears to allow producers to make control decisions on a timely and accurate basis. However, in the Southeast, only the first and last moth flights of the season appear to be monitored with any degree of accuracy with this tool (McVay et al. 1995).

The reason(s) for this difference in efficacy are presently unknown but some theories have been proposed. It is possible, but not extremely likely, that the pheromone was developed through research on a western strain of the species that produces a sex attractant slightly dissimilar to an eastern strain common to the southeast. However, this is somewhat discounted by the extremely high numbers of adult males attracted to the pheromone during the first and last flights of the season.

Possibly, a more plausible explanation lies in the habits of the insect itself and the occurrence of alternate hosts in the respective areas of production. In the Southeast, the moths of the first generation are known to move primarily to hickory which sets fruit earlier than pecan, which is not a particularly good host at the time of spring emergence. Therefore, it is likely that damage in pecan orchards due to generations 2, 3, and 4, is caused primarily by progeny of previously-mated migrants entering from nearby foci in native hickories. It has been shown that the majority of adult moths captured in blacklight traps during the time of the season in which these generations are active are gravid females and the majority of both sexes captured had been previously mated (Tedders and Edwards 1972). As wild hickory hosts are common in the vicinity of most shuckworm infested orchards in the Southeast and much less so in the far-western and Mexican production areas, a great deal of the difference in pheromone trap performance might be explained in this manner.

This is supported by the slight increase in activity detection by pheromone traps commonly found with each succeeding generation in the Southeast. As the second generation occurs, in the orchard, pheromone traps indicate very little activity. The damage to the crop at this time consists of larval feeding on very small, immature fruit, causing them to drop from the tree. Due to the fruit size, it is commonly accepted that only a small percentage of larvae are able to obtain enough nutrition to survive to adulthood, the so-called suicide generation. The damage caused by generation 3 in mid-July is similar to that of generation 2, but fruit size is considerably larger, allowing a larger percentage of larvae to complete development. Therefore a few more unmated males manage to develop within the orchard from this generation. Larvae of the critical fourth generation, which occurs during kernel fill and development can, in theory, all complete development to adulthood. The development of a large number of adults within the orchard by this generation would explain the sudden increase in pheromone trap capture efficacy during the flight of fifth generation moths. Additionally, it is the progeny of the fifth generation that overwinters in the orchard , providing the moths of generation 1 that are readily attracted to the sex pheromone the following spring.

The net result is two methods of adult shuckworm monitoring, neither of which is close to a perfect solution for a well defined IPM program, but both of which have their uses in some areas of production. In the far-western production areas, the sex pheromone trap can be extremely useful, while in the Southeast, the blacklight trap has proven to be most efficient, despite its more cumbersome maintenance requirements.

Possibly the greatest impediment to the overall IPM effort in pecans as related to the hickory shuckworm has been the necessity of making control applications with broad- or, at best, relatively broad-spectrum insecticides and the resulting negative effects on the orchard ecosystem itself. All of the currently registered insecticides effective against and widely used for shuckworm control are deleterious to the large complex of beneficial arthropods commonly present in the orchard to some degree. The use of these materials to combat the destructiveness of shuckworm populations is necessary but often results in the elimination of or drastic reduction of natural control for secondary and occasional pests in the orchard. Primary among these are two yellow aphid species, *Monellia caryella* (Fitch) and *Monelliopsis pecanis* Bissell; the black pecan aphid, *Melanocallis caryaefoliae* (Davis); and the pecan leaf scorch mite, *Eotetranychus hicoriae* (McGregor).

It is common for populations of any or all of these secondary pest species to expand to destructive levels following applications of broad-spectrum organophosphate materials or synthetic pyrethroids for shuckworm control. This results in the producer making additional applications of various insecticides to control foliage feeding secondary pests that would quite likely have been controlled or at least suppressed below treatable population levels by natural enemies. This approach naturally results in somewhat of a continuation, although to a lesser extent than a calendar spray schedule, of the pesticide application merry-go-round that IPM programs are inherently designed to avoid.

FUTURE IPM POSSIBILITIES INCLUDING RESEARCH NEEDS

Despite the problems already discussed, management of the hickory shuckworm in an IPM context, has already progressed greatly from its point of origin. Recent developments in the agri-chemical industry and the aggressive research of scientists already at work in the pecan IPM area can only strengthen and improve the present situation. The agri-chemical industry has made great strides in identifying and developing new classes of reduced-risk pesticides that fit IPM strategies and hold great promise for future programs that can result in better crops produced in a more environmentally friendly manner. Although pecan production needs have historically been afforded a lesser degree of attention in the development of new chemistries and registrations than such widely grown high-value crops as cotton, the registration process for these new reduced-risk materials is being streamlined and they should come on line much more quickly for pecan IPM use.

These new reduced-risk or biorational pesticides have many qualities heretofore lacking in the pecan IPM arsenal. To varying degrees, they are less toxic to mammals and birds, are much safer to apply and most are target specific to certain insect or mite groups, whether affecting species of the same insect order or different taxonomic groups with similar feeding habits. At the time of this writing, one of the insecticides that is considered to have these qualities has been registered for use in commercial pecan orchards. That material is imidacloprid, sold under the trade names of Provado® and Admire®. This material is not active against hickory shuckworm but is simply the first of the new chemistries to be approved for pecan use.

Hickory shuckworm IPM will rely heavily on the reduced-risk materials in the future. Tebufenozide, marketed as Confirm®, is the first of several materials with similar properties currently being researched, to near registration. Tebufenozide is an IPM friendly material with low toxicity and has proven excellent for control of several lepidopterous pests in the pecan orchard. A mimic of the natural insect molting hormone, 20-hydroxyecdysone, this material induces premature construction of a new cuticle below the old, and the larvae starve to death due to an inability to shed the old cuticle. The effects f this material ppears to be confine primarily to lepidopterous species and no effect has been shown on the complex of beneficial arthropods found in the pecan orchard ecosystem. Recent research has indicated that the use of tebufenozide for control of hickory shuckworm will produce excellent results without affecting the beneficial arthropod complex (author's unpublished data). This will allow chemical control to be applied for shuckworm populations without the necessity of follow-up insecticide applications aimed at secondary foliage feeders. The novel mode of action of this material also will make it an important tool in resistance management, due to little chance of cross resistance with other insecticides. The imminent registration of Confirm® and several other candidate, reduced-risk materials with similar properties will greatly enhance pecan IPM efforts. As these new control tools come on line to hopefully solve part of the shuckworm IPM equation, it is imperative that research be continued on the basic biology of this insect pest in an effort to optimize monitoring methodology. The author submits that it should be possible to develop an effective shuckworm lure based on insect attractant technology combined with pheromone-type traps to effectively monitor populations of the shuckworm in order to allow control decisions to be made based on insect activity and threat to the crop.

Although the sex pheromone lure has not proven to be the optimal monitoring tool it was hoped to be, its use in research has shed some light on the shuckworm's reaction to natural attractants. It has been observed that the placement of a trap charged with a sex pheromone lure into the canopy of a pecan tree will not simply begin to attract adult males to the trap. If there is little or no crop present in the tree, few shuckworm adults will be captured; conversely, if a good crop is present more adults will be present and will be caught in the trap (author's unpublished data). It is obvious to anyone who has noticed the above trend, that there is a karimone attractant associated with the presence of fruit much more powerful than that of the sex attractant. The moths are attracted first to a pecan tree with a crop load, and once within the canopy of the tree, to the less powerful sex pheromone. Accordingly, a biochemical assay of volatiles associated with the immature pecan fruit could possibly yield an attractant that could be synthesized and used with pheromone-type traps to effectively monitor both populations and damage potential of the hickory shuckworm.

Much progress has been made in development of IPM methods for dealing with the hickory shuckworm as part of the overall pecan management effort over the previous twenty years. However, the author feels that we are only now on the threshold of the technology that will allow development of a true Pecan IPM program.

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