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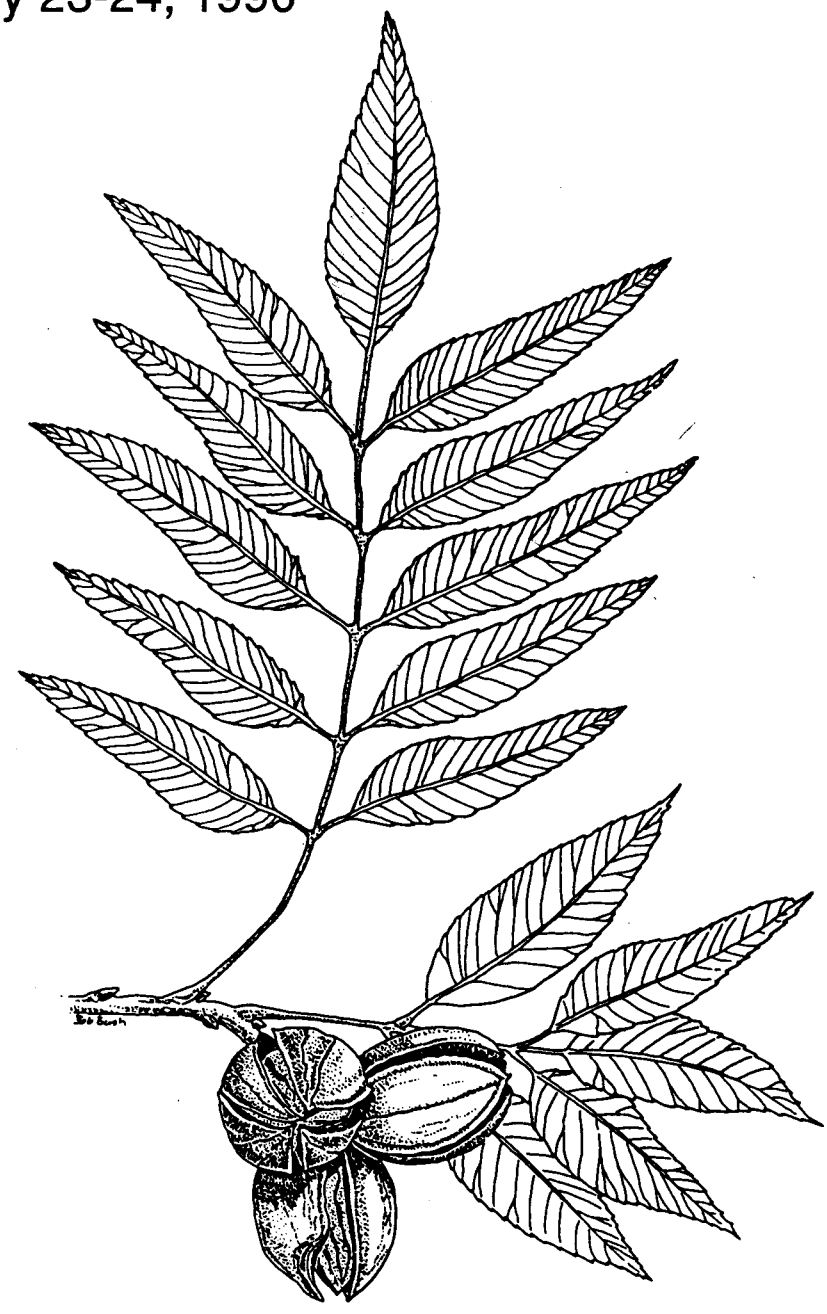

INSECT-PLANT INTERACTIONS WITHIN THE PECAN ECOSYSTEM

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INTRODUCTION

The generalized food web is composed of at least three trophic levels; the plant, herbivore and natural enemies. Each trophic level may influence another, thereby resulting in what is termed 'interactions'. The plant, which is basically a 'chemical factory', is attempting to defend itself from herbivores, while the herbivore is concerned with the extraction of the necessary constituents from the plant for growth and reproduction.

The mechanisms that mediate insect-plant interactions are at least three fold: (1) physically mediated interactions (plant structural and architectural features; i.e., plant hairs or trichomes which function in plant defense against herbivores, or herbivore protection from their enemies, etc.); (2) chemically mediated interactions (plant nutritional and resistance factors; i.e., plant chemistry which provides nutrients to herbivores and natural enemies, or which function in herbivore defense against their enemies, etc.); (3) semiochemically mediated interactions (plant allelochemicals which provide chemical cues for searching herbivores and natural enemies, or which function in plant defense, etc.).

The coevolutionary processes which result in the reciprocal development of chemical defenses by plants and the counter-adaptation to these plant defenses by the herbivore are considered to be the basis for much of the insect-plant specialization seen in nature. Therefore, insect-plant interactions are concerned with the ecological and evolutionary relationships between plants and insects (Spencer 1988).

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CURRENT STATUS OF KNOWLEDGE

Investigations of insect-plant interactions within the pecan ecosystem have been limited in number and generally superficial per se. However, the wealth of knowledge, particularly the observational and survey information associated with selected developmental, behavioral and host selection processes of key pecan pest species (i.e., insect-host plant specificity; insect-host plant synchronicity; host/plant susceptibility; host plant attractancy), forms an invaluable basis for the formulation of questions, the avenues of pursuit, and the ultimate direction for utilization and/or implementation of insect-plant interactions research into pecan management and culture. Following is a synopsis of the pertinent literature which forms such a basis, discussed in relation to the mechanisms which mediate insect-plant interactions.

Physical Features of Pecan. Manning (1950) and Stone (1962) reported that glandular trichome features (i.e., anatomical, chemical, and color) have considerable taxonomic potential within *Carya* species, and therefore might aid in understanding certain insect-plant interactions. Hardin and Stone (1984), in an investigation of foliar surface features of *Carya* species of North America, found that foliar surface features (i.e., trichome type and micro-relief formed by cell contours, cuticular patterns and epicuticular wax) were variable within, as well as among species. Therefore, physical examination of the cuticular or epicuticular wax features, or trichome types (with the exception of the multiradiate type) was not sufficiently or consistently restricted to be reasonably diagnostic and useful in identification of *Carya* species. Therefore, it is doubtful that foliar surface physical features would be useful in determining certain insect-plant interactions within *Carya* spp. However, differences in foliar surface chemistry, not discernible by physical examination, have not been evaluated.

Chemical Features of Pecan. Chemical composition of pecan in relation to tree growth, development and physiology has been reported, with an emphasis on carbohydrate, fatty acid, polypeptide, protein, amino acid, nitrogen, hormonal and oil content of selected pecan tissues (i.e., leaves, fruit, root, shoot etc.) and their association to selected physiological processes (i.e., photosynthesis, senescence, shuck dehiscence, kernel development, shoot growth and alternate bearing). These chemistries, if important in insect-plant interactions, are likely

to exert their primary impact on pecan insect pest species by influencing their growth and reproduction. Therefore, these chemistries would likely be associated with the host suitability component of host selection.

Mody et al. (1976) reported 38 volatile constituents of leaves and immature pecan nuts, including various mono- and sesquiterpene-hydrocarbons, -alcohols, -aldehydes, and -ketones, and other aldehydes, ketones, alcohols and esters. Their studies were initiated to identify those constituents that could conceivably attract pecan weevil to the leaves and nuts. The constituents could also be precursors of the pecan weevil sex pheromone.

Although inconclusive, selected pecan plant constituents have been investigated in regard to their allelochemic nature and function in: (1) phylloxera-pecan interaction related primarily to gall formation (Calcote and Hedger 1980, Hedin et al. 1985); (2) pecan aphid-pecan host plant interactions (Carpenter et al. 1979a, 1979b; Neel et al. 1980, 1982); (3) pecan weevil attraction to pecan fruit (Raney and Eikenbary 1967; Mody et al. 1973); (4) hickory shuckworm attraction to, and feeding stimulation by, pecan shuck extracts (Howell and Maxwell 1969); (5) pecan nut casebearer attraction to exposed stigmatic surfaces (Maden 1972); and (6) pecan aphid attraction to new young pecan foliage (Tedders 1978). Additionally, alleopathy has been reported in pathogen-pecan host plant interactions (Hedin et al. 1979, 1980).

Histological investigations of pecan aphid feeding was reported by Tedders and Thompson (1981) and Wood et al. (1985). Largely qualitative in nature, the impact of pecan aphid feeding on pecan growth and development, and on selected plant chemical constituents (i.e., carbohydrates, etc.) has also been reported.

CURRENT INVESTIGATIONS

The insect-plant interactions investigations currently in progress are focused on: (1) the spatial and temporal dynamics of pecan plant chemistry; particularly those chemistries most likely to function in the host selection processes of the key pecan pest species (Smith et al. 1990a, 1990b, 1990c); (2) the development of sensitive and reliable bioassay techniques and procedures for utilization in substantiating the biological activity or function of the identified pecan plant chemistries (or natural plant products); (3) the role of pecan plant chemistry dynamics in the seasonal population dynamics of the pecan aphid species; (4) the host acceptance and suitability of North American species of Juglandaceae family of nut trees (hickories, walnuts, hicans), as well as a wide range of pecan cultivars, by the pecan aphid species. The primary emphasis of these investigations is centered around the identification of what phytochemical characteristics of pecan influence the selection, allocation and utilization of this host plant by its complex of insect pest species. Secondarily. but equally as valuable, is the identification of natural plant products from both distantly or closely associated plant species which might alter disrupt these insect-plant interactions processes.

ADDITIONAL RESEARCH QUESTIONS AND CHALLENGES

In addition to these current investigations in progress, some of the obvious research questions associated with insect-plant interactions in pecan of more immediate concern are: (1) what role does pecan nut chemistry play in host finding and ovipositional behavior among the key nut infesting pest species (i.e., pecan weevil, hickory shuckworm, pecan nut casebearer, stink bugs); (2) what role does pecan plant chemistry play in the synchronicity of pecan weevil emergence and pecan nut development, or are both factors merely indirectly associated by their regulation by key environmental factors (i.e., temperature, rainfall, etc.); (3) what role does the temporal dynamics of pecan leaf chemistry play in the mid-season population crash and late-season sexual cycle induction among the pecan aphid species (i.e., primarily related to food quality or host suitability for growth and reproduction); (4) what pecan plant and/or aphid characteristics govern the leaf conditioning process; (5) what abiotic (i.e., water stress) and biotic factors (i.e., pathogens) affect aphid-pecan plant interactions; (6) what role does pecan and associated cover crop plant species play in the host selection processes (habitat finding, host finding, host recognition) of the key beneficial insect species (i.e., lacewings, ladybeetles, etc.).

Although these are but a few of the more obvious concerns associated with insect-plant interactions in the pecan ecosystems, the future challenges are many. Natural product analytical chemistry has advanced tremendously in the past 10-15 years. However, continued development of techniques which provide an accurate depiction of the 'intact plant' is vital. Therefore, an understanding of plant biochemistry is critical.

An area of research with major deficiencies and which has failed to keep pace with advances in analytical chemistry is that of bioassay technology. Bioassay is essential for substantiation of the biological activity of the natural products (of plant or insect origin) involved in insect-plant interactions. The identification of the natural product and its function, as well as its ultimate successful utilization in pecan management hinges on the sensitive and reliable bioassay.

Following the development of an understanding of the insect-plant interaction system (both its structures and functions), identification of the more vulnerable links within the system should allow the manipulation, exploitation, and/or interruption of system function. For example, identification of a chemical cue emanating from the pecan nut and used by the pecan weevil in host finding or host recognition might be utilized as a monitoring tool or in combination with an insecticide as a control strategy; for the pecan aphid species, identification of a chemical cue which functions as a feeding deterrent might be utilized to prevent aphid acceptance of, or feeding on, pecan foliage. Although identification of the components of the pecan ecosystem is essential (i.e., what insect pest species are associated with pecan, pecan cultivar, pecan tissue, etc.), expansion beyond the 'what' questions of system structure to the 'how' and 'why' questions of system function is imperative if solutions are to be discovered which work within the system or which are compatible with other pecan management components (i.e., biological control, cultural control, disease management, etc.).

Because nature knows no disciplinary boundaries, multidisciplinary team research is essential; particularly for mission-oriented research where utilization and implementation are considered of paramount importance. Furthermore, insect-plant interactions research must proceed beyond the two-trophic level system and consider more multi-trophic level interactions. For example, pecan and/or its associated plant species may function in a biological control program where they provide searching cues for beneficial insect species. Finally, research should avoid preconceived notions and too narrow a view of natural system interactions. Such a view has more times than not resulted in our inability to transfer new technologies from controlled laboratory test conditions to cropping systems in the field.

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