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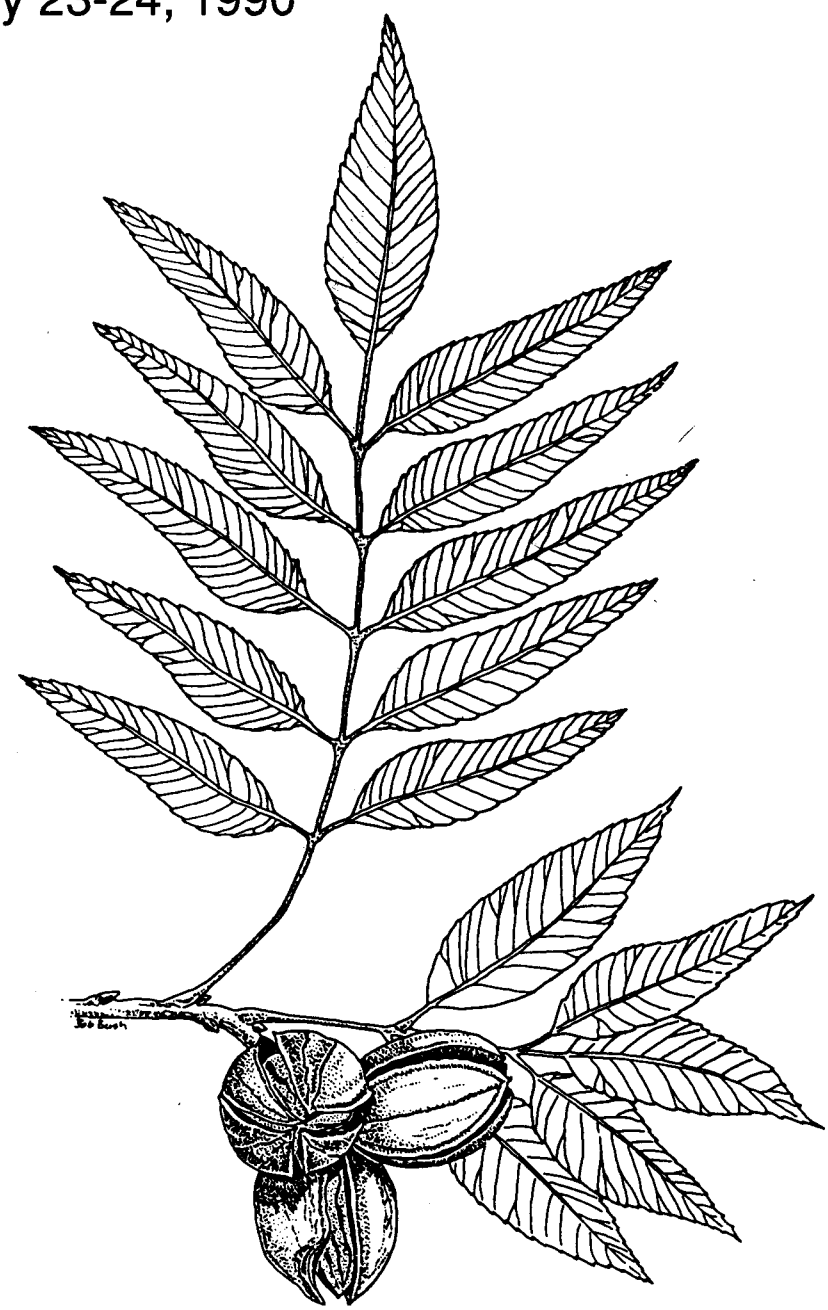

ZONATE LEAF SPOT OF PECAN: A REVIEW AND RESEARCH NEEDED

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ABSTRACT

Defoliation of pecan trees by zonate leaf spot during years of above normal rainfall has often occurred in trees located adjacent to woodlands. Most of our knowledge of this disease is based upon a secondary cycle of infection involving cone-shaped macroconidia produced by *Cristulariella moricola*. Sclerotia collected and overwintered outdoors and in the laboratory have shown development of fruiting structures of the sexual stage, *Grovesinia pyramidalis*. However, the epidemiology of primary infection has not been determined. Thus, our information is inadequate to prescribe fungicides to control this disease.

Cristulariella moricola (Hino) Redhead (=*C. pyramidalis* Waterman & Marshall), the causal agent of zonate leaf spot of pecan, can cause severe defoliation of pecan trees (Latham 1969, Latham 1972). The disease is most severe on pecan foliage in the Southeastern United States during the July through September rainy season, but is absent during dry seasons. Zonate leaf spot has occurred in orchards maintained on a scab prevention schedule using dodine or triphenyltin hydroxide. Benomyl has been recommended for control of zonate leaf spot in Georgia, but the development of resistance by many fungi to benomyl (Littrell 1974, Littrell 1975) suggests that *C. moricola* might also develop resistance to this fungicide.

Evaluations of fungicides for control of zonate leaf spot have been conducted in orchards with a history of the disease, but tests generally have not been successful due to its sporadic occurrence (Latham 1969). In recent greenhouse tests, propiconazole was found to be effective in stopping growth of *C. moricola* in established lesions, thus effecting a cure of zonate leaf spot.

SYMPTOMS

The zonate leaf spots on the dorsal side of pecan leaves were grayish brown in color, with concentric ring formation less distinct than from the ventral view (Latham 1969). Leaf spots viewed from the ventral side appeared light brown to tan in the center, becoming darker brown toward the periphery. Small lesions were typically circular. A series of concentric rings occurred in leaf spots of larger irregular-shaped necrotic tissues, resulting in the zonate appearance. A film of crystalline-like material formed over the leaf spot surfaces, giving them a gray-brown to gray-white appearance depending upon the angle of incident light. The crystalline material on the ventral leaf surface was lumpy near the center of the zonate lesions. Leaves with extensive lesion development appeared dried, and curled upward from the margins, before falling from the trees (Latham 1969). Defoliation of infected foliage was pronounced in mid-September.

CAUSAL ORGANISM

The leaf spot pathogen, *Cristulariella moricola* (Hino) Redhead (Syn. *C. pyramidalis* Waterman & Marshall), is anascomycete: teleomorph *Grovesinia pyramidalis* M. Cline, Crane, S. Cline (Cline 1983). However, little is known about the sexual stage of this pathogen and its ecology.

Black sclerotia, 2-5 mm in diameter, of *C. moricola* have been produced on both naturally infected leaves and on artificial media. Sclerotia are formed within 3 days on media supplemented with yeast extract or V-8 juice and within 4 days on potato dextrose agar. The occurrence of sclerotia and their longevity appear to be correlated with nutrition and moisture composition of the growth substrate (Latham 1969, Latham 1974, Latham 1987).
A discomycete with cup-shaped apothecia 1.5-2.0 mm in diameter has been produced on sclerotia. Mycelial cultures have been developed from ascospores (Cline 1983, Harada et al. 1981).

Examination of *C. moricola*-infected pecan leaves from the orchard may reveal cone- or pyramidal-shaped fruiting structures (macroconidia) attached to the zonate lesions (fruiting structure=pyramidal head *sensu* Waterman and Marshall (Waterman, 1947). Fruiting structures develop from diseased tissues with a

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fertile hyphae 0.5-1.0 mm long topped by a pyramidal head 157-568 μm long and 80-210 μm in diameter (Latham 1969). Macronidia are scarcely detectable macroscopitally, but may be observed with a hand lens or other means of low power magnification. Macroconidia were not observed on small lesions (7-10 mm); however, on large lesions (15-20 mm), erect macroconidia were distributed randomly over the leaf spot.

Macroconidia cultured on greenhouse-grown pecan leaves were used in *in vitro* studies with Czapek-Dox plus yeast extract agar (Latham 1974). Plates were inoculated with macroconidia and incubated at temperatures ranging from 6 to 30°C and at 3°C intervals. The optimal temperature for growth of *C. moricola* was 21°C, with colony diameters approaching 45 mm within 96 hr. Additionally, *C. moricola* has been cultured on agar plates amended with a variety of carbohydrates, vitamins, and natural substrates, but macroconidia did not develop.

The production of microconidia *in vitro* has been reported by several investigators (Latham 1969, Niedbalski et al. 1979, Waterman and Marshall 1947, Yokoyama and Tubaki 1974), but their infectivity has not been demonstrated. Cline et al. (1983) used microconidia to fertilize sclerotia and produce apothecia and ascospores.

Trolinger et al. (1978) reported *C. moricola* occurred on both woody and annual plants, including 73 species in 36 families distributed in the Central and Eastern United States.

DISEASE CYCLE

Until now, many thought sclerotia, formed on naturally infected, defoliated leaves of several hosts, were the overwintering stage for *C. moricola* (Cline 1983, Davis 1962, Harada et al. 1981). Harada et al. (1981) collected sclerotia in November, overwintered them outdoors and observed apothecia on them in May and June, 1981. They were unable to obtain infection with ascospores. However, they did obtain infection of Japanese apricot using hymenial fragments from the apothecium and mycelia from an ascospore-isolated culture. Cline et al. (1983) succeeded in producing apothecia on sclerotia incubated 6 months in the dark at 4°C followed by 4 weeks incubation at 15°C in the light. However, they were unable to collect ascospores in sufficient numbers to conduct pathogenicity studies.

Epiphytotics have been associated with one pyramidal-shaped conidium typically found in the center of all lesions on pecan leaves (Latham 1969, Niedbalski et al. 1979).

Tests were conducted using lesions dried for 16 and 60 days. The lesions were thoroughly rewetted and maintained in a water-saturated atmosphere. After 96 hr, lesions dried 16 and 60 days produced macroconidia over 49 and 35% of the lesions, respectively (Latham 1974).

EPIDEMIOLOGY

Macroconidia were used to study the epidemiology of zonate leaf spot and the development of secondary cycles of infection (Latham 1974). Investigations were made on potted seedling pecans, inoculated with macroconidia of *C. moricola* and incubated at constant temperatures. Maximal lesion diameters and macroconidial numbers occurred at 21°C; largest lesions developed at temperatures between 18 and 21°C. The fungus grew quite rapidly with lesions of 3.2, 6.9, 11.0, and 15.3 mm developing in 48, 72, 96, and 120 hr, respectively, at 21°C.

Relative humidity (RH) was a significant factor in development of lesions and macroconidia production (Latham 1974). At 97 to 100% RH, macroconidia were produced abundantly as long as lesions were wet and enlarging. When RH was reduced to 87%, macroconidia did not develop.

Tests were conducted *in vitro* to develop methods for production of macroconidia for use in epidemiology research. These investigations showed that 360 macroconidia per petri dish were produced on autoclaved pecan leaves in a water-saturated atmosphere. However, when an excess of water was present in the dishes, sclerotia were produced accompanied by reduced numbers of macroconidia (Latham 1974). Also, light was required for production of macroconidia on the sterile leaf substrates (Latham 1987).

CONTROL

Since sclerotia have been found on diseased leaves, a promising method for control of zonate leaf spot might be the raking and burning of leaves.

We do not know when to start the application of fungicides to prevent infections because environmental conditions for maturation of ascospores and their method of dissemination are unknown.

Benomyl fungicide has been recommended for control of zonate leaf spot of pecan (Ellis et al. 1981). Regular spraying with dodine and triphenyltin hydroxide (TPTH) has not controlled *C. moricola*. In fact, zonate leaf spot was discovered in orchards sprayed with dodine and TPTH (Latham 1972).

Propiconazole protected mature pecan leaves in the greenhouse for over 6 weeks. It was also effective in stopping the growth of *C. moricola* in established lesions, thus effecting a cure of zonate leaf spot of pecan (Latham 1987). When rainy weather occurs during midsummer in an orchard with a history of zonate leafspot, applications of Orbit would be advised (Davis 1962, Latham 1972, Latham 1987). When the weather is dry, fungicidal controls would not be needed, since this disease usually has been a problem only in association with abundant rainfall.

None of the presently available varieties of pecan are resistant to zonate leaf spot.

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