



United States
Department of
Agriculture

**Agricultural
Research
Service**

1995-3

July 1995

Sustaining Pecan Productivity Into the 21st Century

Second National Pecan Workshop Proceedings

**Wagoner, Oklahoma
July 23–26, 1994**

PECAN SCAB MANAGEMENT IN HUMID REGIONS

A.J. Latham¹

ABSTRACT

In areas of frequent rainfall, i.e., highly humid environments, management of pecan scab may be centered around four basic premises. First, to develop quality pecan kernels during the production year, pecan leaves must be maintained in healthy, disease-free conditions to manufacture the nutrients needed by the growing nuts. Second, to develop carbohydrate reserves and set a crop of pecans the following year, pecan leaves must be maintained on their trees until at least 1 November. Third, to obtain maximum crop production, green nuts must be maintained disease-free. Fourth, applications of fungicides must be made in relation to frequent rainfall to effectively protect foliage and green nuts from the development of scab.

Scab caused by *Cladosporium caryigenum* (Ell. et Lang.) Gottwald (= *Fusicladium effusum*) (Gottwald 1982) is the most important disease of pecans (*Carya illinoensis* (Wang.) C. Koch) in humid areas such as the southeastern United States (Gottwald and Bertrand 1983, Latham 1982). To effectively manage pecan scab, researchers and growers must have a clear understanding of how *C. caryigenum* develops in pecan tissues, how it is influenced by environmental factors, and how effective are the control methods.

ETIOLOGY OF SCAB ON LEAVES

Cladosporium caryigenum overwinters in lesions, i.e., stromata on shucks, leaf petioles, and twigs infected the previous season (Demaree 1924, Gottwald and Bertrand 1982). In the spring, the conidiogenous stroma produce conidia that function as primary inoculum (Gottwald and Bertrand 1982, Latham 1982). As temperatures and wind increase in the morning, humidity decreases below the usual night-time condition of 100% RH, and conidiophores responding to drying conditions release their conidia. Populations of conidia disseminated into the atmosphere increase to a peak at 1200 hr, according to aeobiology data (Gottwald and Bertrand 1982, Latham 1982). When a conidium falls onto a juvenile leaf moistened by free water, the conidium germinates and pecan tissues may become infected within 2-3 hr (Gottwald 1985, Latham and Rushing 1988). Infection of the leaf is by direct penetration. The pathogen colonizes leaf tissues subcuticularly and after 7 to 9 days

incubation, breaks through the plant's cuticle to resume conidiation (Demaree 1928, Latham 1988). Continued discharge of conidia, and frequent rains may lead to successive infection periods that cause newly emerging leaves to become partially to totally covered by coalescing lesions of *C. caryigenum* (Gottwald and Bertrand 1988, Latham 1982). Scab on the foliage is especially important early in the season before nut set, since it serves as the inoculum base to infect the developing nutlets (Gottwald and Bertrand 1988). As pathogenesis continues, and the lesions mature, internal leaf cells collapse, leaflets become non-functional, and abscise from their rachis (Latham 1982, Latham and Rushing 1988). As a result, during unusually rainy years, trees may become defoliated by mid-to late summer (Latham 1982).

Pecan leaves are susceptible to infection when they are young and actively growing (Gottwald 1985, Latham 1982, Latham and Rushing 1988, Payne et al. 1979). The susceptibility period of leaflets to *C. caryigenum*, lasts for approximately 7-21 days after bud break (Gottwald 1985). New compound leaf emergence along the elongating shoot and maturity of leaflets along the leaf rachis prolongs the time and number of susceptible leaves available for scab development (Latham 1979, Latham 1982). Therefore, during tree foliation, the over-all period of susceptibility to *C. caryigenum* may extend to 90 or more days (Latham 1979).

Thus, our first major concern relative to managing pecan scab:

1. To develop quality pecan kernels, during the production year, pecan leaves must be maintained in a healthy condition with an appropriate disease control program.

According to Worley (1979), pecan trees stressed by defoliation sustained reduced kernel percentages as the defoliation date became later from 1 August through 15 September. Nuts produced from trees defoliated during late summer were small and of poor quality (Gottwald and Bertrand 1988, Worley 1979). As a result of total defoliation in 1969, no yield of pecan nuts occurred during 1970 and 1971 (Worley 1979). Additional research by Worley (1979) showed that defoliation in the fall depleted carbohydrate reserves and reduced or prevented nut growth if defoliation occurred prior to 1 November. Thus, our next major concern relative to managing pecan scab:

2. To develop carbohydrates for a crop of pecans the following year, pecan leaves must be maintained on trees until 1 November.

¹Department of Plant Pathology, Alabama Agricultural Experiment Station, Auburn University, AL 36849

ETIOLOGY OF SCAB ON NUTS

Pecan nut-shucks are only moderately susceptible for the first 2-3 weeks after nut set (Gottwald and Bertrand 1983). Gottwald and Bertrand (1988) reported that as soon as the nuts entered a rapid expansion or growth stage, susceptibility to scab increased. Accordingly, rates of scab increase appeared to accelerate in response to the increased susceptibility of the tissues (Gottwald and Bertrand 1988). They (Gottwald and Bertrand 1983 and 1988) concluded that during mid-to late-season, nut-shuck tissues again decreased in susceptibility as nuts ceased to expand and started to fill. The effects of *C. caryigenum* infection on nut quality were reported as the result of infection that occurred prior to mid-June, coincident with the time of shell (endocarp) differentiation (Gottwald and Bertrand 1983).

According to Shuhart (1932), who reviewed the morphology and anatomy of the fruit of *Carya illinoensis* Koch, the shuck is that portion of the fruit which dehisces from the nut at maturity and separates into four sections. Each section contains an outer ring of vascular bundles which provide for the flow of nutrients from the peduncle to near the distal end of the fruit. Subsequently, the course of the bundles crosses to the inner side of the shuck, and the direction of nutrient flow is reversed to proceed to the nut base then pass through a septum into the ovary. Calcote et al (1984) traced the vascular system of the shuck with acid fuchsin dye translocated through live tissues. This technique was used to study the effect of feeding and tunneling by hickory shuckworm larvae on the vascular bundles. Damage of shucks at the base of the fruit caused the nuts and kernels to weigh less than insect-free green nuts. They found a large portion of the vascular bundles leading into the ovary on the inside of green shucks had been severed near the base of the nut. These nuts were usually "pops"; i.e., shells devoid of edible kernels that resulted from tissues infested with larvae. In a similar manner, the pathological effects of *C. caryigenum* may damage vascular bundles and cut off the flow of nutrients to the developing ovary.

Preliminary investigations in our laboratory (Campbell and Latham 1993) have discovered mycelium of *C. caryigenum* occurred between sub-epidermal cells of Schley pecan shucks 24 days after inoculations. At 36 days, epidermal cells had collapsed and mycelia had penetrated 6-8 cells or more deep and toward the vascular system. We are continuing these host-parasite investigations to evaluate how scab affects the shuck tissue systems to reduce or stop nut maturation.

Thus, our next major concern relative to managing pecan scab:

3. To obtain maximum crop production, shucks of growing nuts must be maintained free of disease with appropriate disease controls.

EFFECT OF MOISTURE

Moisture in the form of rain, fog, or dew is required for successful infection of pecan tissues (Demaree 1924, Gottwald and Bertrand 1982, Latham 1982). The environmental factor driving the whole problem of scab on pecans is water.

Conidia (of *C. caryigenum*) + pecan tissue (susceptible) + H₂O → SCAB

In Oklahoma, Barnes (1974) demonstrated that three sprays of benomyl per season at 8-week intervals were sufficient to control scab on the cultivar Western during the dry 1972 growing season. During the more humid 1973 growing season, sprays at 4- and 6-week intervals provided commercial control of scab. Subsequently, Wells et al (1976) conducted scab control evaluations in the more humid growing area of central Georgia using the cultivars Schley and Stuart. During the severe scab year 1975, they found that benomyl at 0.1 lb and fentin hydroxide at 0.1 lb applied in 10 sprays gave commercial control on both cultivars. However, when the trees were sprayed only three times during the season, control of scab was not significantly different from unsprayed trees even though the fungicide rate was increased 50%.

During 1974 and 1975, Latham (1982 a,b) studied scab development in unsprayed pecan orchards near Auburn for a 15-week period from April to mid-July. Rainfall, humidity, temperature, wind speed, and leaf wetness were monitored. Conidia trapped with Kramer-Collins spore samplers during the 15-week periods of 1974 and 1975 totaled 23,406 and 63,349, respectively; rainfall recorded during these same periods was 20.4 cm and 44.3 cm, respectively. These comparisons of conidia and rainfall totals showed 270.7% more conidia and 217.2% more rainfall in 1975 than 1974. The peak number of conidia at the end of May 1975 was associated with an average of 300 lesions per compound leaf, which was a conservative count on leaves that were almost completely covered with lesions. Disease incidence became so high that trees defoliated from mid-July through August during the scab epidemic of 1975. Lesions produced on nuts were also recorded from 60 nutlets from 1 June through 12 July. Coalescence of lesions during the second week of July 1975 made accurate counts difficult. Nutlets shriveled, dried, and fell from trees until only 7 of the 60 nuts monitored for disease development were found on July 25.

Additionally, to directly study the effects of rainfall, Latham (1982a,b) used scab-free Schley pecan trees growing in individual plastic bags as "trap crop" or test trees. Six trees were inoculated with a calculated dilution of *C. caryigenum* and six were left uninoculated. The bagged trees were suspended from limbs under scabby foliage and at heights ranging from 6 to 18 ft. After exposure for 1 week, the test

trees were returned to the greenhouse and 12 new replacement trees were installed. Inoculated and uninoculated trees failed to develop scab on leaves during three periods when no rain fell, i.e. during the periods 29 May through 9 June, 9 June through 16, and July 7 through 14. All inoculated and uninoculated trees exposed for periods beginning 16, 23 and 30 June, a time when there was rain, developed scab. The amount of rain did not appear to be critical for infection and lesion development. The important criterion was hours of leaf wetness following rainfall. Scab developed on the test trees 7-9 days after a rainy day when leaves remained wet 12 to 16 hours.

Therefore, another major concern relative to managing pecan scab:

4. Fungicide applications must be made in relation to frequent rainfall to effectively protect foliage and nuts from infections by *C. caryigenum*.

CONTROL

In the humid Southeastern States, pecan nuts may become black from the coalescence of scab lesions on trees not protected with season-long fungicide applications; nuts fall prematurely, and a total loss of the crop occurs (Demaree 1924, Latham 1982). The basic, standard fungicide for control of pecan diseases has been fentin hydroxide (triphenyltin hydroxide, TPTH, Super Tin). Other fungicides used irregularly or in special situations are benomyl, dodine, and propiconazole. The Alabama Cooperative Extension Service scab control recommendations (Sikora and Goff 1994) advise a first spray application at budbreak. This is followed by three applications at 14-day intervals for: prepollination, pollination, and first cover. Subsequently, applications of fungicides are made at 21-day intervals until the end of August. During frequent rainy weather or in orchards containing cultivars that are quite scab-susceptible, the schedule may need to be closed-up to 10-14 day intervals. The full, recommended rates of TPTH should always be used throughout the spray period to prevent scab from becoming established. Also, thorough coverage of all of the tree by the fungicide spray is essential to keep both foliage and developing nuts healthy.

ADDITIONAL CONSIDERATIONS

Recommendations for establishing a new pecan orchard that were listed for the First National Pecan Workshop (Latham and Goff 1991) are still effective and should be reviewed before planting. Also, when selecting pecan cultivars, some consideration should be given to scab resistant selections. Although strains of *C. caryigenum* may develop and attack a previously resistant cultivar, most cultivars retain a degree of resistance that is of practical value to growers. For instance, at the Gulf Coast Substation, Ala. Agric. Exp. Stn.,

during the 1993 season, 23 pecan cultivars were maintained on the recommended scab control program with excellent results except for the highly scab-susceptible cultivars Cherokee and Cheyenne.

Maintain orchard sanitation, i.e., remove limbs, shucks, and other debris that may provide an inoculum base for fungi to grow and propagate diseases.

Keep the areas between tree rows known as "middles" mowed to reduce humidity, promote air flow through the orchard, and to enhance drying of foliage and fruit.

Information regarding the growth habit of a particular cultivar may also facilitate scab management. The Schley cultivar normally has one major and one or two subsequently less vigorous growth flushes per year (Gottwald and Bertrand 1988). As mentioned earlier, *C. caryigenum* only colonizes juvenile tissues, on which it produces conidia; however, as the leaves mature, they become resistant to infection. By comparison, Gottwald and Bertrand (1988), found the Wichita cultivar, tended to have numerous flushes of foliage throughout the season. These flushes of foliage provided a nearly continuous supply of susceptible tissue for infection, colonization, conidiation, and resulted in a steady increase of scab. Of course, associated with this would be increased difficulty in controlling the disease.

LITERATURE CITED

- Barnes, G.L. 1974. Effectiveness of benomyl and thiophanate methyl for long-term control of pecan scab. Plant Dis. Rep. 58:687-690.
- Calcote, V.R., R.E. Hunter and T.E. Thompson. 1984. Nutrient flow through the pecan shuck into the nut and disruption of this flow by hickory shuckworm larvae. Proc. S.E. Pecan Growers Assoc. 77:61-69.
- Campbell, H.L. and A.J. Latham. 1993. Histological studies of *Cladosporium caryigenum* infection of pecan shuck tissues. (Abstr.) Phytopathology 83:1343.
- Demaree, J.B. 1924. Pecan scab with special reference to sources of the early spring infection. J. Agr. Res. 28:321-330.
- Demaree, J.B. 1928. Morphology and taxonomy of the pecan-scab fungus, *Cladosporium effusum* (Wint.) Comb. Nov. J. Agric. Res. 37:181-187.
- Gottwald, T.R. 1982. Taxonomy of the pecan scab fungus *Cladosporium caryigenum*. Mycologia 74:382-390.

- Gottwald, T.R. 1985. Influence of temperature, leaf wetness period, leaf age, and spore concentration on infection of pecan leaves by conidia of *Cladosporium caryigenum*. *Phytopathology* 75:190-194.
- Gottwald, T.R. and P.R. Bertrand. 1982. Patterns of diurnal and seasonal airborne spore concentrations of *Fusicladium effusum* and its impact on a pecan scab epidemic. *Phytopathology* 72:330-335.
- Gottwald, T.R. and P.R. Bertrand. 1983. Effect of time of inoculation with *Cladosporium caryigenum* on pecan scab development and nut quality. *Phytopathology* 73:714-718.
- Gottwald, T.R. and P.R. Bertrand. 1988. Effects of an abbreviated pecan disease control program on pecan scab disease increase and crop yield. *Plant Dis.* 72:27-32.
- Latham, A.J. 1979. Some factors influencing pecan scab development. Highlights of Agric. Res., Auburn Univ., Ala. Agric. Exp. Stn. 26(1):7.
- Latham, A.J. 1982. Effect of some weather factors and *Fusicladium effusum* conidium dispersal on pecan scab occurrence. *Phytopathology* 72:1339-1345.
- Latham, A.J. 1982. Frequency of rain and hours of leaf wetness influence intensity of pecan scab. Highlights of Agric. Res., Auburn Univ., Ala. Agric. Exp. Stn. 29(2):3.
- Latham, A.J. and W.D. Goff. 1991. Pecan scab: a review and control strategies, pp. 89-93. In: B.W. Wood and J.A. Payne (eds.) Pecan Husbandry: Challenges and Opportunities, First National Pecan Workshop Proceedings. USDA, ARS-96.
- Latham, A.J. and J.M. Hammond. 1983. Control of *Cladosporium caryigenum* on pecan leaves and nut shucks with propiconazole (CGA-64250). *Plant Dis.* 67:1136-1139.
- Latham, A.J. and A.E. Rushing. 1988. Development of *Cladosporium caryigenum* in pecan leaves. *Phytopathology* 78:1104-1108.
- Payne, J.A., H.L. Malstrom and G.E. KenKnight. 1979. Insect pests and diseases of the pecan. USDA, SEA, ARM-S-5.
- Schuhart, D.V. 1932. Morphology and anatomy of the fruit of *Hicoria pecan*. *Bot. Gaz.* 93:1-20.
- Sikora, E.J. and W.D. Goff. 1994. Commercial pecan disease recommendations. Ala. Coop. Ext. Ser. 94IPM-27.
- Wells, J.M., J.A. Payne and N.E. McGlohon. 1976. Abbreviated spray programs for control of pecan scab in Georgia. *Plant Dis. Rep.* 60:953-956.
- Worley, R.E. 1979. Pecan yeild, quality, nutlet set, and spring growth as a response to time of fall defoliation. *J. Amer. Soc. Hort. Sci.* 104:192-194.
- Worley, R.E. 1979. Fall defoliation date and seasonal carbohydrate concentration of pecan wood tissue. *J. Amer. Soc. Hort. Sci.* 104:195-199.