PITCH CANKER IN SEED ORCHARDS

L. D. Dwinell and Jane Barrows-Broaddus [1/]

Abstract.--Pitch canker, caused by Fusarium moniliforme var. subglutinans, is a serious disease of pines in southern seed orchards. The disease has been confirmed in over 30 seed orchards from North Carolina to east Texas on a wide range of economically important pine species. Symptoms include branch and bole cankers, and shoot dieback. Wounds are readily infected by the pitch canker fungus. Within pine species, individual clones vary markedly in their susceptibility to infection and incidence of disease is frequently related to the geographic source of seed. This fungus also causes conelet abortion, mortality of maturing cones, and seed deterioration. Control strategies and current research initiatives are presented.

Additional keywords: Fusarium lateritium f. sp. pini, tree shakers, Arthrobacter sp., biological control, systemic fungicides.

As management of commerical forests in the Southern United States becomes more intensive, greater reliance will be placed on seed orchards to supply genetically improved seed for regenerating cut-over lands. Pitch canker, caused by Fusarium moniliforme Sheld. var. subglutinans Wr. & Reink. (Dwinell 1978; Kuhlman et al. 1978), is one of the diseases that is rapidly increasing in importance in seed orchards across the Southeast. Disease impacts are increasing in spite of and sometimes because of the specialized maintenance practices used to force seed production and to harvest the crop. Shoot dieback, known by seed orchard managers for at least 20 years, waxed and waned, and attempts to determine the causal agent were limited. However, in 1975 the disease suddenly became severe in two loblolly seed orchards in separate regions of the South (Dwinell et al. 1977). Since then, pitch canker has been confirmed in over 30 seed orchards.

SYMPTOMS

Two types of symptoms are associated with this disease. The classic symptom as described by Hepting and Roth (1946) is the resinous cankers on the trunks and larger branches which commonly develop at injuries. These cankers are usually sunken, and the underlying wood is soaked with pitch, often to the center of the stem. These cankers are perennial, and frequently girdle the tree (Blakeslee et al. 1980; Dwinell and Phelps 1977).

[1/] Principal Plant Pathologist and Plant Pathologist, USDA Forest Service, Southeastern Forest Experiment Station, Athens, GA 30602.

A second type of symptom is shoot or crown dieback, which occurs when cankers form on the current year's shoot, girdling them before the next growing season. In the fall, needles on recently killed shoots turn yellow to reddish brown; they later turn greyish brown to dark grey. The summer growth flushes appear to be the most frequently attacked, with the terminal usually showing symptoms first. Infected twigs and branches are often soaked with resin. Shoot dieback markedly thins the crcwn, and cankers often kill shoots soon after they develop the following spring. Intensification of shoot dieback symptoms may result in the loss of a year's crop because cone-bearing branches in the crown are killed to the tip. In succeeding years, however, the trees may recover and resume full production (Blakeslee et al. 1980; Dwinell and Phelps 1977; Phelps and Chellman 1976).

DISTRIBUTION AND HOSTS

Disease surveys conducted in the past 5 years have confirmed pitch canker incidence in approximately 30 seed orchards in North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, and east Texas. Shoot dieback is most severe on slash (Pinus elliottii Engelm. var. elliottii) pine in Florida, and loblolly (P. taeda L.) and shortleaf (P. echinata Mill.) pines elsewhere in the South. Bole and branch cankers are common on slash, shortleaf, longleaf (P. palustris Mill.), and Virginia (P. virginiana Mill.) pines. The incidence and symptoms of pitch canker are highly variable and depend on the inherent susceptibility of the pine species and the environment in which the trees are growing.

TREE SHAKER WOUNDS

Most canker-producing organisms, including F. moniliforme var. subglutinans, require a wound as an infection court. In slash pine seed orchards, bole cankers often develop through injuries caused by mechanical shakers used in cone collection. The most obvious damage caused by tree shakers is the actual removal of bark at the point where the pads grasp the bole. However, cankers may develop at grasp sites where there is no obvious bark removal. Furthermore, pitch cankers frequently develop on the upper portion of the bole where the vibration (or whiplash) of the main stem is most vigorous.

A study conducted during 1980 in two Georgia Forestry Commission seed orchards determined the location of bole cankers on slash pines in relation to areas of tree shaker contact. The 80 trees sampled at the Arrowhead and Horseshoe Seed Orchards averaged two cankers per tree (Table 1). Approximately three-fourths of the trees had cankers at the point of tree shaker contact (near breast height). Some two-thirds of the trees had cankers on the middle third of the stem (15-30 ft). Dissection of 10 slash pines at the Arrowhead Seed Orchard revealed that many of these cankers were initiated by infection through branch stubs and fusiform rust galls on the bole. These cankers were commonly the site of breakage during severe weather.

Table 1.--Location of bole cankers on slash pines in two Georgia Forestry Commission seed orchards that have been mechanically shaken for several years

Seed orchard	Tree age (years)	No. trees sampled	Tree DBH (mean)	Tree height (mean)	Shaker. wound	Position of cankers on bolea: Lower third	Middle third	Upper third	Canker/tree (mean)
Arrowhead	23	30	12 in.	42 ft.	80%	63%[b]	53%	13%	2.1
Horseshoe	18	50	13 in.	51 ft.	66%	26%	82%	16%	1.9

[a] % trees with cankers

b The % trees with cankers above or below the point where the trees are grasped by the tree shaker

In 1978 and 1979, tree shaker pads were sampled during regular slash pine cone harvesting operations at the Arrowhead Seed Orchard to determine if the pitch canker fungus and other related fusaria were being spread from tree to tree on the pads. The pads were sampled after every five trees were shaken. The sampling procedure consisted of dispensing 20 ml sterile deionized water at the center top of the pad and collecting the water at the bottom of the pad in a sterile glass bottle. The shaker pads were cleaned with 70% ETOH before and between samples. In 1978, a total of 10 samples representing 50 trees was collected, and in 1979, a total of 20 samples representing 100 was collected. The samples were diluted and a 1-ml aliquot was spread evenly on petri plates containing a medium selective for fusaria (Agrawal et al. 1973). Although eight species of Fusarium were isolated; F. moniliforme var. subglutinans occurred infrequently (3-4%) (Table 2). Also, pathogenicity tests of these isolates indicated that only 50% of them were virulent, qualifying them as the pitch canker strain. Both sampling dates occurred during an extended drought, and under these environmental conditions, it appeared that the risk of spreading the causal fungus on shaker pads was low. The population levels of F. moniliforme var. subglutinans may increase significantly during periods of rainy weather, and given these environmental conditions, the spread on tree shaker pads may be markedly increased. Sporodochia, commonly observed in slash pine plantations in Florida (Blakeslee et al. 1978b) were not observed on active bole cankers in the seed orchards.

Table 2.--Isolations of fusaria from tree shaker pads during slash pine cone harvest at the Arrowhead Seed Orchard. September 1978 and 1979

Year	No. Samples	No. per sample	Fusarium species (%)b							
			Fms	Fm	Fre	Frs	Fl	Fo	Ft	Fs
1978	10	38	4	7	4	80	0	1	4	0
1979	20	45	3	21	0	42	2	30	1	1

[a] Each sample represents a sequence of 5 trees

[b]
Fms = F. moniliforme var. subglutinans
Fm = F. moniliforme
Fre = F. roseum 'equiseti'
Frs = F. roseum 'semitectum'
Fl = F. lateritium
Fo = F. oxysporum
Ft = F. tricinctum
Fs = F. solani

OTHER WOUNDS

Any wound, regardless of cause or location, provides an infection court for the pathogen. Routine seed orchard management practices such as branch pruning, mowing, and, in the case of loblolly pine, tearing cones from the branches, create wounds for the pathogen to invade. Weather-related injuries such as those from wind and hail may also serve as entry points. Hurricanes and tornados in recent years have caused intensification of pitch canker in at least two seed orchards, one shortleaf and the other Virginia pine, in Alabama. The role of insect damage in the disease complex has not been completely elucidated, but the deodar weevil (Pissodes nemorensis Germar.), the subtropical pine tip moth (Rhyaciona subtropica Miller), and the needle midge (Contarinia sp.) have been linked to the disease (Blakeslee et al. 1978b; Matthews 1962; Overgaard et al. 1976).

HOST VARIATION

Within pine species, the incidence of pitch canker is frequently related to the geographic source or provenance of the host (Dwinell et al., 1977). In three loblolly pine seed orchards on the Coastal Plain, for example, incidence of pitch canker on loblolly pine was higher on Piedmont than on Coastal Plain seed sources (unpublished data). In Florida, Blakeslee and Rockwood (1978) found that slash pine clones from central Florida were more resistant than clones from other geographic areas.

Individual clones within species also vary greatly in their susceptibility to infection by F. moniliforme var. subglutinans (Dwinell et al. 1977; Phelps and Chellman 1976). This phenomenon has been noted for loblolly, slash,

longleaf, shortleaf, and Virginia pines grown in southern seed orchards. In a Virginia pine progeny test, Barnett and Thor (1978) also found clonal variation in the incidence of pitch canker.

CONELETS, CONES AND SEED

Fusarium moniliforme var. subglutinans does not limit its activities to causing cankers. Miller and Bramlett (1978) demonstrated that the fungus can cause the abortion of female strobili and conelets and mortality of maturing cones of slash pine. They also found that the fungus is carried in seeds and causes deterioration in stored seedlots. Fusarium moniliforme Sheldon is known to cause damping-off of coniferous seedlings (Spaulding 1914) and Barnard and Blakeslee (1980) reported pitch canker on seedlings in forest tree nurseries in Florida. However, linkages between these various host-parasite interactions and disease situations have yet to be demonstrated.

CONTROL

Although pitch canker was first described over 35 years ago (Hepting and Roth 1946), the current lack of information on the inoculum source and other aspects of the disease cycle precludes many control measures. Because wounds are known to be a prerequiste for disease initiation, control recommendations are limited to altering management practices to reduce wounding, especially during periods of high disease risk, primarily in the fall and winter. Tree shakers should be properly adjusted and operated by trained personnel. Loblolly pine cones should be harvested by clipping rather than tearing to reduce stripping of the bark. Mower damage to the tree stem and anchor roots should be avoided (Blakeslee et al. 1980).

Because seed orchard trees have high monetary value, chemical control of the disease is economically feasible. Systemic fungicides of the benzimidazole group have demonstrated effective inhibition of F. moniliforme var. subglutinans in vitro (unpublished data). Several promising fungicides applied by injector are being evaluated for control of the disease in seed orchards.

Presently, a soil bacterium, Arthrobacter sp., is being evaluated as a biological control agent of the pitch canker fungus (Barrows-Broaddus and Kerr 1981). Studies are underway involving the colonization of artificially created wounds on slash pine boles with Arthrobacter and other antagonists and to monitor not only development of pitch canker in inoculated and noninoculated trees, but also to evaluate persistance of introduced microflora and host response to colonization by the pathogen and/or antagonists of the pathogen. The ultimate goal of this research is to determine how to manipulate the bark environment in order to aid the tree's own defense responses against invasion by F. moniliforme var. subglutinans.

Since seed orchard management practices may contribute to the incidence of pitch canker, two simulated slash pine seed orchards have been established in cooperation with the Georgia Forestry Commission. These disease research seed

orchards are being used to study the effects of balanced fertilizer application in the spring, ammonium nitrate application in late summer, and tree shaker useage on the development of the disease. One seed orchard, at the Baldwin State Forest, is also being used to study systemic fungicides, biological control, and wounding in an effort to develop sound control strategies.

LITERATURE CITED

Agrawal, S. C., M. N. Khare, and L. S. Kushwara. 1973. A selective medium for isolation and quantitative estimation of Fusarium in soil. Sci. Cult. 39: 555-556.

Barrows-Broaddus, J. and. T. J. Kerr. 1981. Inhibition of Fusarium moniliforme var. subglutinans, the causal agent of pine pitch canker, by the soil bacterium Arthrobacter sp. Can. J. Microbiol. 27:20-27.

Barnard, E. L. and G. M. Blakeslee. 1980. Pitch canker of slash pine seedlings: A new disease in forest tree nurseries. Plant Dis. 64:695-696.

Barnett, P. E. and E. Thor. 1978. Effects of site and inheritance on Fusarium incidence in Virginia pine. p. 159-161. In Proc. Symposium for management of pine of the interior South. (Knoxville Tenn., Nov. 1978). USDA For. Serv. Southeast. Area State and Private Forestry Tech. Publ. SA-TP2.

Blakeslee, G. M. and D. L. Rockwood. 1978. Variation in resistance of slash pine to pitch canker caused by Fusarium moniliforme var. subglutinans. Phytopath. News 12:207-208. (Abstr.)

Blakeslee, G. M., S. H. Kratka, R. A. Schmidt and C. S. Moses. 1978a. Sporodochia of the pitch canker fungus (Fusarium moniliforme var. subglutinans) as found on diseased slash pine in Florida. Plant Dis. Rep. 62:656-657.

Blakeslee, G. M., S. W. Oak, W. Gregory and C. S. Moses. 1978b. Natural association of Fusarium moniliforme var, subglutinans with Pissodes nemorensis. Phytopath. News 12:208. (Abstr.)

Blakeslee, G. M., L. D. Dwinell and R. L. Anderson. 1980. Pitch canker of southern pines: identification and management considerations. USDA For. Serv. Southeast. Area State and Private For. For. Rep. SA-FR11. 15 p.

Dwinell, L. D. and W. R. Phelps. 1977. Pitch canker of slash pine in Florida. J. For. 75:488-489.

Dwinell, L. D., P. L. Ryan and E. G. Kuhlman. 1977. Pitch canker of loblolly pine in seed orchards. In Proc. 14th South. For. Tree. Improv. Conf., p. 130-137. (Gainesville, Fla., June 1977).

Dwinell, L. D. 1978. Susceptibility of southern pines to infection by Fusarium moniliforme var. subglutinans. Plant Dis, Rep. 62:108-111.

Hepting, G. H. and E. R. Roth. 1946. Pitch canker, a new disease of some southern pines. J. For. 44:742-744.

Kuhlman, E. G., L. D. Dwinell, P. E. Nelson and C. Booth. 1978. Characterization of the Fusarium causing pitch canker of southern pines. Mycologia 70:1131-1143.

Matthews, F. R. 1962. Pitch canker-tip moth damage association on slash pine seedlings. J. For. 60:825-826.

Miller, T. and D. L. Bramlett. 1978. Damage to reproductive structures of slash pine by two seed-borne pathogens: Diplodia gossypina and Fusarium moniliforme var. subglutinans. In Bonner, F. (ed.). p. 347-355. A symposium on flowering and seed development. USDA For. Serv., South. For. Exp. Stn., New Orleans. 379 p.

Overgaard, N. A., H. N. Wallace, C. Stein and G. H. Hedet. 1976. Needle midge (Diptera: Cecidomyiidae) damage to loblolly pines in the Erambert Federal Seed Orchard, Mississippi. USDA For. Serv., Southeastern State and Private For. Rep. 76-213.

Phelps, W. R. and C. W. Chellman. 1976. Evaluation of "pitch canker" in Florida slash pine plantations and seed orchards--1976. USDA For. Serv., Southeast. Area State and Private For., Atlanta, Ga., Unnumb. Publ. 22 0.

Spaulding, P. 1914. The damping-off of coniferous seedlings. Phytopathology 4:73-88.