Incidence of Pitch Canker Among Clones of Loblolly Pine in Seed Orchards

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ABSTRACT

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Significant differences in severity of pitch canker (caused by *Fusarium moniliforme* var. *subglutinans*) were observed among loblolly pine (*Pinus taeda*) clones in American Can Company seed orchards at Myrtlewood and Bellamy, AL, in 1980. Disease severity was greatly diminished in the Myrtlewood orchard in 1981, although the relative ranking of clones for disease severity was similar to that of 1980. No differences in pathogenicity were found among nine isolates of the pathogen obtained from various clones and tested on loblolly seedlings in the greenhouse. Occurrence of the disease as early as 1978 in a shortleaf orchard adjacent to the loblolly orchard at Myrtlewood indicated that absence of the disease in the loblolly orchard prior to 1980 was not the result of a lack of inoculum. It is postulated that wounds on the loblolly trees caused by Hurricane Frederic in September 1979 provided a sufficient number of infection courts for the pitch canker fungus to initiate the epidemic.

Additional key words: *Pinus echinata*, sporodochia

Pitch canker disease of pines, caused by *Fusarium moniliforme* Sheld. var. *subglutinans* Wollenw. and Reink. (10), was first described in 1946 (9). However, it was not until the 1970s that this disease was recognized as a serious economic problem in slash pine (*Pinus elliottii* Engelm. var. *elliottii*) plantations (4,11,12). Since then it has been shown to be a problem in seed orchards (8,11) and, more recently, in slash pine nursery beds (1) and in plantations of sand pine (*P. clausa* (Chapm.) Vasey var. *clausa* Ward. and var. *immuginata* Ward.) (5).

Considerable variation in susceptibility to pitch canker has been observed in loblolly (*P. taeda* L.) seed orchards among clones from different geographic areas (8) and among seedlings of southern pine species inoculated with the pathogen (6,7). The disease results in a shoot dieback that can severely reduce production of cones.

Seed orchards are required for the production of large quantities of quality seeds from trees selected for form, growth rate, disease resistance, and other desirable characteristics. Thus, seed orchards are comprised of large numbers of trees that were cloned from a few select individuals. These trees are intensively managed to maximize production of cones, and problems that interfere with this goal are of real concern to seed orchard managers.

In 1978, *F. moniliforme* var. *subglutinans* was isolated from several severely diseased shortleaf pines (*P. echinata* Mill.) at the American Can Company shortleaf seed orchard near Myrtlewood (Marengo County), AL; at that time the disease was not evident in the adjacent loblolly seed orchard. In the spring of 1980, severe shoot dieback was observed on trees scattered throughout the loblolly orchard, and subsequent isolations from affected shoots yielded *F. moniliforme* var. *subglutinans*. By this time, many of diseased shortleaf trees in the adjacent orchard had died and been removed from the orchard.

In the loblolly orchard it was apparent that some trees were more severely diseased than others, and permission was obtained to survey this orchard and another loblolly seed orchard located about 30 km northeast of Myrtlewood at Bellamy (Sumter County), AL. Both orchards contained several common clones.

Objectives of the study were to determine whether differences in incidence of pitch canker occurred among clones of loblolly pine selected from within a limited geographic area, to determine whether differences in pathogenicity existed among isolates of the pathogen obtained from diseased tissue collected from several clones, and to determine possible bases for the epidemic that occurred in 1980.

MATERIALS AND METHODS

Orchards. The orchard at Myrtlewood consists of three contiguous sections established during 1964, 1965, and 1966; stand density in 1980 was 63 trees per hectare. Clones were randomly distributed throughout the sections.

The orchard at Bellamy is divided into two sections, both of which were established during 1968; stand density in 1980 was 119 trees per hectare. All trees in the Myrtlewood and Bellamy orchards were cloned from trees selected from within a 145-km radius of the Myrtlewood orchard.

Disease survey. Each tree was rated for disease severity on the following scale: 0 = no disease, 1 = <1% of the shoots exhibiting dieback, 2 = 1–10%, 3 = 11–20%, 4 = 21–50%, and 5 = >50%. In assigning disease severity ratings, the evaluator did not know the identities (clone numbers) of the trees being evaluated, and trees were observed from at least three vantage points before being rated.

The initial survey of the two orchards was conducted in mid-May 1980; a second survey of the Myrtlewood orchard was conducted early June 1981. Data from the three sections at Myrtlewood and the two sections at Bellamy were kept separate.

Laboratory and greenhouse studies. Shoots with dieback were collected randomly from various clones throughout the orchards at the time of the survey. Small sections of stem (2–4 cm long) were surface-disinfested by serially washing 10 times for 15 min each in sterile water on a Burrell wrist-action shaker. Stem pieces were sectioned and small pieces were plated on potato-dextrose agar (PDA) acidified with one drop of 50% lactic acid per dish. Dishes were incubated at 26 C for 6–10 days and examined for *F. moniliforme* var. *subglutinans*. Suspected colonies were transferred to fresh PDA and grown for several days, and identification was confirmed. Four isolates each from clones in the Bellamy and Myrtlewood orchards and one isolate from the shortleaf orchard at Myrtlewood were tested for pathogenicity in the greenhouse.

Inoculations were performed on 6-mo-old loblolly pine seedlings obtained from the USDA Forest Service Rust Testing Center near Asheville, NC. Seedlings were from a single seed source and were growing in plastic trays (34 × 13 × 10 cm;

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No. 135 Planter, Ball Seed Co., West Chicago, IL), each containing 20 seedlings (two rows of 10 each). Before inoculation, each tray was thinned to 10 seedlings by removing every other seedling in each of the two rows. The test was arranged in completely randomized blocks with five replicates (trays) per isolate of *F. moniliforme* var. *subglutinans*.

A conidial suspension was prepared for each of the nine isolates by pipetting 5 ml of sterile water onto each of two 10-day-old cultures growing on PDA in petri dishes. Cultures were scraped gently with a glass rod to dislodge conidia, and the suspensions in two dishes per isolate were combined and used immediately as inoculum. No attempt was made to standardize the number of conidia per milliliter of inoculum among the isolates.

Five seedlings at one end of a tray were inoculated by placing a drop of conidial suspension on a wound created by removing a primary needle 5 cm below the terminal bud of each seedling. For controls, five seedlings at the opposite end of the tray were treated similarly except that drops of sterile water were substituted for the conidial suspension. Seedlings were maintained in a greenhouse at a daytime temperature of 36 ± 3 C for the duration of the study.

Six weeks after inoculation, seedlings were evaluated for pitch canker symptoms. Randomly selected seedlings representing each of the nine *F. moniliforme* var. *subglutinans* isolates were used to recover the pathogen.

Other observations. During the disease survey of the two orchards in 1980, observations were made on the extent of damage by the pathogen to individual shoots. The length of dead tissue proximal to the apical bud was estimated; shoots with dieback were collected from the lower limbs of several trees representing each of six clones at the two orchards, and the length of dead tissue was measured for each. Prior to measuring the dead tissue, needle fascicle scars on each shoot were examined (×25 magnification) for sporodochia (3) of *F. moniliforme* var. *subglutinans*. No more than 6 hr elapsed between collection and examination.

Statistical analyses. Data were subjected to analysis of variance and, where appropriate, means were compared by Duncan's multiple range test. Data from the greenhouse study were subjected to arc sine transformation prior to analysis (13).

Table 1. Severity of pitch canker in loblolly pine clones common to the Myrtlewood and Bellamy seed orchards in 1980

Clone	No. of trees	Disease severity rating[x]	
		Average[y]	Range
17-4	133	1.65 c	1.11–2.03
17-15	74	0.36 g	0.17–0.69
17-16	73	0.26 gh	0.00–0.70
17-19	82	0.73 f	0.07–0.89
17-24	67	1.40 d	0.50–2.33
17-26	98	0.19 gh	0.00–0.67
17-27	28	0.82 ef	0.25–0.91
17-34	82	1.00 e	0.67–1.36
17-37	75	3.13 a	2.65–3.94
17-39	36	0.17 gh	0.00–1.00
17-40	19	1.00 ef	0.57–1.50
17-41	83	2.00 b	1.42–2.35
17-43	13	0.23 gh	0.00–0.40
17-44	57	0.03 h	0.00–0.14
17-46	63	0.30 gh	0.05–0.87
17-49	44	0.07 gh	0.00–0.10
17-54	49	0.26 gh	0.00–0.50
8-524	63	0.30 gh	0.00–0.69

[x] Five-point scale: 0 = no disease, 1 = <1% of the shoots exhibiting dieback, 2 = 1–10%, 3 = 11–20%, 4 = 21–50%, and 5 = >50%.

[y] Means followed by the same lowercase letter within a column do not differ ($P = 0.05$) according to Duncan's multiple range test.

Table 2. Severity of pitch canker in loblolly pine clones common to sections of the Myrtlewood seed orchard in 1981

Clone	No. of trees	Disease severity rating[x]	
		Average[y]	Range
17-4	53	1.02 b	0.97–1.09
17-15	32	0.09 d	0.00–0.18
17-16	39	0.00 d	...
17-19	33	0.12 d	0.10–0.14
17-24	33	0.24 cd	0.00–0.31
17-26	40	0.00 d	...
17-27	22	0.45 c	0.00–0.71
17-34	39	0.33 c	0.15–0.60
17-37	30	1.87 a	1.75–1.94
17-39	12	0.00 d	...
17-40	7	0.57 bc	0.00–1.00
17-41	36	0.89 b	0.67–1.00
17-43	5	0.00 d	...
17-44	13	0.00 d	...
17-46	23	0.04 d	0.00–0.07
17-49	14	0.00 d	...
17-54	14	0.07 d	0.00–0.10
8-524	17	0.18 d	0.00–0.23

[x] Five-point scale: 0 = no disease, 1 = <1% of the shoots exhibiting dieback, 2 = 1–10%, 3 = 11–20%, 4 = 21–50%, and 5 = >50%.

[y] Means followed by the same lowercase letter within a column do not differ ($P = 0.05$) according to Duncan's multiple range test.

RESULTS

Disease survey. In 1980, there were significant differences in disease severity among clones within each section of the orchards but not between common clones among sections of the orchards (*data not shown*). The most severely diseased clones that were common to the Myrtlewood and Bellamy orchards were 17-37 > 17-41 > 17-4 > 17-24 (Table 1).

In 1981, severity of pitch canker in the Myrtlewood orchard was much reduced from 1980 levels (Table 2); however, the relative ranking of clones for disease severity was similar to that of 1980.

Laboratory and greenhouse studies. Cultures of the pathogen were obtained from 87% of the symptomatic shoots; the other 13% yielded a variety of fungi considered to be nonpathogenic.

There were no significant differences ($P = 0.05$) in pathogenicity among the nine isolates of *F. moniliforme* var. *subglutinans* tested. Percentages of inoculated seedlings that became infected ranged from 56 to 92% among the nine isolates tested; in all cases, tissue distal from the point of inoculation was necrotic on infected seedlings. Uninoculated control seedlings did not become diseased. The pathogen was recovered from all of the seedlings randomly selected for isolations.

Other observations. Observations during the 1980 survey indicated that shoot dieback on lower limbs was generally limited to about 15 cm of stem immediately proximal to the apical bud. Shoot dieback occurred prior to budbreak and initiation of new growth; however, new growth from axillary buds proximal to necrotic areas was observed.

There were no significant differences in lengths of dead stems sampled from the

six clones in each orchard. Average length of dead stem was 8.04 cm (range of 2.0 to 19.2 cm). Sporodochia of *F. moniliforme* var. *subglutinans* were observed on only 19.4% of the dead stems collected. Sporodochia were most often found in needle fascicle scars at the proximal ends of the dead stems.

DISCUSSION

As noted during the 1980 survey, branches with shoot dieback were killed prior to budbreak in the spring, indicating that the pathogen was well established in the host tissue prior to initiation of spring growth. It has been reported that trees are mostly infected during the summer and fall and that symptoms may occur as late as the following spring (2; E. G. Kuhlman, *personal communication*). Appearance of symptoms from infections occurring late in the season would likely be delayed until the following spring; therefore, infections in the loblolly orchards probably occurred in the fall of 1979.

The likelihood that infections occurred in the fall of 1979 is supported by the fact that Hurricane Frederic passed over the two orchards on the night of 12–13 September 1979, with sustained winds of 128 km/hr and gusts up to 160 km/hr. Wind damage resulted in losses of approximately 10 trees per hectare at Bellamy and 22 trees per hectare at Myrtlewood. Damage from the hurricane was also reflected in the amount of cones harvested, particularly in the fall of 1980. Cone harvest in October 1979 yielded 544 bu (0.2 hl/tree) from 971 trees on the Bellamy orchard and 2,311 bu (1.5 hl/tree), including 300 bu (106 hl) collected from the ground after the hurricane, from 559 trees on the Myrtlewood orchard. As the wind-thrown cones were being recovered at Myrtlewood, numerous first-year cones and green needles were observed on the ground. Cone harvest in October 1980 yielded only 60 bu (0.02 hl/tree) from Bellamy and 12 bu (0.01 hl/tree) from Myrtlewood.

The decrease in cone yields in the two orchards in 1980 resulted from a combination of hurricane damage and the ensuing pitch canker outbreak. Wounds resulting from wind-thrown needles and first-year cones provided a large number of infection courts for the pitch canker fungus. This interpretation is supported by the fact that by June 1981 the disease in the loblolly orchard at Myrtlewood was significantly decreased, whereas diseased trees in the adjacent shortleaf orchard still were dying and being removed. This indicates that inoculum was available and suggests that the observed decrease in disease incidence among loblolly trees was the result of a lack of wounds to serve as infection courts.

Results of this study emphasize that: a) significant differences in incidence of pitch canker occurred among loblolly pine clones selected from within a limited area; b) wounds caused by hurricane Frederic in September 1979 most probably served as infection courts for the pitch canker pathogen; c) disease severity ratings for affected clones in 1981 were considerably decreased from 1980, indicating that loblolly pines have a capacity to overcome rather severe pitch canker incidence; and d) the occurrence of pitch canker in the shortleaf orchard at Myrtlewood for 2 yr prior to the outbreak in the loblolly orchard suggests that inoculum was present and that the limiting factor for this disease in the loblolly orchard was the absence of wounds.

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LITERATURE CITED

1. Barnard, E. L., and Blakeslee, G. M. 1980. Pitch canker of slash pine seedlings: A new disease in forest tree nurseries. Plant Dis. 64:695-696.
2. Blakeslee, G. M., Dwinell, L. D., and Anderson, R. L. 1980. Pitch canker of southern pines, identification and management considerations. U.S. For. Serv. For. Rep. SA-FR 11. 15 pp.
3. Blakeslee, G. M., Kratka, S. H., Schmidt, R. A., and Moses, C. S. 1978. Sporodochia of the pitch canker fungus (*Fusarium moniliforme* var. *subglutinans*) as found in diseased slash pine in Florida. Plant Dis. Rep. 62:656-657.
4. Blakeslee, G. M., and Oak, S. W. 1979. Significant mortality associated with pitch canker infection of slash pine in Florida. Plant Dis. Rep. 63:1023-1025.
5. Blakeslee, G. M., Oak, S. W., and Kratka, S. H. 1980. Shoot dieback of planted sand pine caused by *Fusarium moniliforme* var. *subglutinans*. Plant Dis. 64:703-704.
6. Dwinell, L. D. 1978. Susceptibility of southern pines to infection by *Fusarium moniliforme* var. *subglutinans*. Plant Dis. Rep. 62:108-111.
7. Dwinell, L. D., and Barrows-Broaddus, J. 1979. Susceptibility of half-sib families of slash and loblolly pine to the pitch canker fungus, *Fusarium moniliforme* var. *subglutinans*. (Abstr.) Phytopathology 69:527.
8. Dwinell, L. D., Ryan, P. L., and Kuhlman, E. G. 1977. Pitch canker of loblolly pine in seed orchards. Pages 130-137 in: Proc. South. For. Tree Improv. Conf., 14th. Gainesville, FL.
9. Hepting, G. H., and Roth, E. R. 1946. Pitch canker, a new disease of some southern pines. J. For. 44:742-744.
10. Kuhlman, E. G., Dwinell, L. D., Nelson, P. E., and Booth, C. 1978. Characterization of the *Fusarium* causing pitch canker of southern pines. Mycologia 70:1131-1143.
11. Phelps, W. R., and Chellman, C. W. 1976. Evaluation of "pitch canker" in Florida slash pine plantations and seed orchards. U.S. For. Serv. State Priv. For. Southeast. Area. 22 pp.
12. Schmidt, R. A., and Underhill, E. M. 1974. Incidence and impact of pitch canker in slash pine plantations in Florida. Plant Dis. Rep. 58:451-454.
13. Steel, R. G. D., and Torrie, J. H. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., New York. 481 pp.