Loss of Feeder Roots Lowers Seedling Survival More Than Severe Black Root Rot

S. J. Rowan
Principal Research Plant Pathologist, USDA Forest Service, Southeastern Forest Experiment Station, Athens, Ca.

Loblolly pine seedlings with 50 or 75 percent of their feeder roots excised suffered greater mortality than did those with severe black root rot.

The etiology of black root rot of slash pine *(Pinus elliottii* Engelm.) and loblolly pine (*P. taeda* L.) is complex and may involve any of several soilborne pathogens. *Macrophomina phaseolina* (Tassi) Goid. *(Sclerotium bataticola* Taub.) and *Fusarium oxysporum* Schlecht. emend. Snyd. & Hans. are most commonly associated with the disease (4). However, *F. solani* (Mart.) Appl. & Wr. emend. Snyd. & Hans., *Rhizoctonia solani* Kühn, *Pythium spp., Phytophthora spp.,* and certain parasitic nematodes may also be involved in this disease complex (2, 3, *5, 6, 7, 8, 9).*

Black root rot is one of the most important diseases in southern forest tree nurseries (1, *8),* and it can also cause subsequent problems in outplantings. This was made evident by complaints of landowners that the majority of seedlings purchased from the Andrews State Nursery near Chief land, Fla., died during each of several successive years. This prompted a State agency to condemn seedlings, quarantine the nursery, and order the destruction of 16.5 million diseased seedlings.

In the winter of 1976, several Florida landowners and State agencies, Southeastern Area State and Private Forestry of the Forest Service, and I joined in a cooperative effort to determine the rate of survival of the most and least severely affected seedlings from this one Florida nursery; results of this study will be published later. However, in a previous and as yet unpublished study, seedlings affected with black root rot were graded into several root rot severity classes and outplanted in an attempt to correlate disease severity in the nursery to field survival (Foster, A. A., personal communication). Significant mortality occurred only where root rot was so severe that only a blackened taproot with few, if any, lateral roots remained. My involvement in the 1976 cooperative study in Florida and knowledge of A. A. Fosters unpublished data led me to establish a study in 1978 to determine if the severity of black root rot or the loss of feeder roots by any cause was more important to seedling survival. In this study, I compared the rate of survival of seedlings with differing degrees of black root rot with that of seedlings with little root rot but with 50 or 75 percent of their feeder roots removed.

Methods

Slash pine seedlings were lifted from one Georgia nursery and loblolly pine seedlings were lifted from five nurseries in Georgia and one in Alabama during January 1978. All seedlings were lifted by hand except those with little or no root rot (average seedlings) from the Continental Forest Industries and Great Southern Nurseries, which were machine lifted. Seedlings were lifted from areas where few, if any, root rot symptoms were visible and from areas with appreciable amounts of root rot in four of the same nurseries. The amount of root rot present was assessed by determining an index of root rot severity. The root systems of 25 randomly selected seedlings from each seedbed area from each nursery were examined under a dissecting microscope. The following data were recorded for each seedling: the number of primary and secondary roots, number of primary and secondary roots with one or more root rot lesions, length of primary and secondary roots, and the length of root rot lesions. The root rot index was calculated as the percentage of primary and secondary root length with lesions.

Seedlings with little or no root rot from four of the five Georgia nurseries (table 1) were subdivided into three groups; and, with the aid of a pocketknife, 50 or 75 percent of the feeder roots were excised from seedlings in each of two of the three groups. All seedlings were outplanted in January 1978 on a deep sand (Lakeland series) in Georgia. The seedlings were planted in a randomized complete block design with five replications. The study included 19 treatments, and each treatment replicate was a 25-tree row planted at a 5- by 8-foot spacing. Initial height measurements were made in February 1978 and the first-year survival and growth increment data were recorded in

February 1979. Correlation analyses were computed between root rot severity and growth increment, between disease severity and field survival, and between percentage of feeder roots removed and field survival. Individual analyses of variance were computed for (1) the average seedlings with little or no root rot; (2) the root rot and average loblolly seedlings from the Herty, Great Southern, Continental Forest Industries, and Hauss Nurseries; and (3) all loblolly seedlings (average, root rot, 50 percent, and 75 percent) from the Herty, Morgan, Great Southern, and Continental Forest Industries Nurseries (table 1). The error mean square of each of these analyses was used to perform Duncan's multiple range test (table 1).

Table 1.—Percentage of mortality of mechanically injured and black root rot affected (1-0) pine seedlings 12 months after planting on a deep sand in Georgia in January 1978

Species and nursery source	Average seedlings	Root rot seedlings	Seedlings with feeder roots reduced 50%	75%
Loblolly pine				
Herty, Ga.	13.6aAB[1]	3.2aA	29.6aBC	48.0aC
Morgan, Ga.	52.0bcA	-[2]	66.4bA	70.4bA
Great Southern, Ga.	41.6bcA	31.2bA	70.4b8	76.8bB
Cont. For. Ind., Ga.	80.0dB	53.6cA	96.0c8	94.4cB
Hauss, Ala.	42.4bcA	69.6cB	-	-
Walker, Ga.	54.4c	-	-	-
Slash pine				
Morgan, Ga.	38.4b	-	-	-

[1]Means within the same column followed by & common lower-case letter and means within the same row followed by a common capital letter do not differ at $P = 0.05$ according to Duncan's multiple range test.

[2] — = not applicable or not available.

Results and Discussion

Although black root rot was severe on seedlings from the Hauss, Continental Forest Industries, and Great Southern Nurseries, root rot increased mortality only in seedlings from the Hauss Nursery (table 1). On the other hand, removal of feeder roots significantly increased mortality of seedlings from the Herty and Great Southern Nurseries (table 1). Seedling quality, as measured by the number of feeder roots, is a most important attribute of pine seedlings and was significantly correlated \with field survival *(r = 0.*57). Root rot severity, on the other hand, was not correlated with field survival *(r* = 0.36). Because feeder roots are often destroyed or lost during routine lifting operations, this nursery practice, whether done by hand or machine, deserves very careful attention so that the number of feeder roots retained on planting stock is at the practical maximum. The high mortality of seedlings from the Continental Forest Industries Nursery with little root rot (average seedlings) compared to the lower mortality of seedlings with severe root rot (tables 1 and 2) was possibly caused by the loss of feeder roots during mechanical lifting operations. Numbers of feeder roots were not counted in this study, but the seedlings affected with root rot had noticeably more feeder roots than the average seedlings.

Except for seedlings from the Herty Nursery, seedling mortality was high regardless of root rot severity or nursery source (table 1). Seedlings from the Herty Nursery were grown at low seedbed densities and had more lateral and feeder roots than seedlings from the other nurseries. The high mortality was augmented by the deep sand on which the seedlings were planted and the severe drought during the summer of 1978. Slash pine seedlings, which may be better ecologically adapted to droughty sites, survived significantly better than loblolly seedlings from the same nursery source (tables 1 and 2).

Growth increment, 1 year after outplanting, was not correlated with root rot severity or rate of seedling survival (table 2). However, because growth increment and rate of survival increased numerically together (table 2), these two parameters may become significantly correlated in some later year.

Table *2.-Relationship between black root rot severity, growth, and mortality 12 months after planting of pine seedlings on a deep sand in Georgia in January 1978*

Species and nursery source	Root rot severity index	Mortality	Grow increment[1]
Slash pine		%	Cm
Morgan, Ga.	0.2	38.4cde[2]	40.8
Loblolly pine			
Morgan, Ga.	.2	52.0eg	26.9
Walker, Ga.	2.3	54.4efg	24.8
Great Southern, Ga.	6.0	41.6cde	35.7
Cont. For. Ind., Ga.	6.0	80.0hi	31.6
Harty, Ga.	8.0	13.6ab	37.3
Herty, Ga.	28.5	3.2a	45.9
Hauss, Ala.	38.4	42.4cde	35.3
Cont. For. Ind., Ga.	39.0	53.6efg	32.0
Hauss, Ala.	66.4	69.6fgh	32.6
Great Southern, Ga.	86.2	31.2bcd	44.6

[1]There was no difference ($P = 0.05$) in growth increment due to nursery source or root rot severity according to Fisher's F test.

[2]Means followed by a common letter do not differ at $P = 0.05$ according to Duncan's multiple range test.

The results of this study indicate that root rot, mechanical injury, or any other agent that reduces the number of feeder roots on seedlings at any time before outplanting may substantially decrease field survival.

Similarly, a meaningful index of root rot severity must reflect the relative number of feeder roots if the index is to be correlated with the field performance of seedlings.

Literature Cited

1. Foster, A. A. Control of black root rot of pine seedlings by soil fumigation in the nursery. Rep. 8. Macon, GA: Georgia Forestry Research Council; 1961. 5 p.
2. Hansen, E. M.; Hamm, R. B.; Roth, L. F.; Julius, A. J. Isolation, incidence, and management of *Phytophthora* in forest tree nurseries in the Pacific Northwest. Plant Dis. Rep. 63: 607-611; 1979.
3. Hendrix, F. F., Jr.; Campbell, W. A. Pythiaceous fungi isolated from Southern Forest Nursery soils and their pathogenicity to pine seedlings. For. Sci. 14: 292-297;1968.
4. Hodges, C. S. Black root rot of pine seedlings. Phytopathol. 52: 210-219; 1962.
5. Peterson, G. W.; Smith, R. S., Jr. Forest nursery diseases in the United States. Agric. Handb. 470. Washington, DC: U.S. Department of Agriculture; 1975. 125 p.
6. Rowan, S. J. Soil fertilization, fumigation, and temperature affect severity of black root rot of slash pine. Phytopathol. 61(2): 184-187; 1971.
7. Seymour, C. P. Charcoal rot of nursery-grown pines in Florida. Phytopathol. 59:89-92; 1969.
8. Seymour, C. P.; Cordell, C. E. Control of charcoal root rot with methyl bromide in forest nurseries. South. J. Appl. For. 3(3):104-108; 1979.
9. Smith, R. S., Jr.; Bega, R. V. *Macrophomina phaseoli* in the forest nurseries of California. Plant Dis. Rep. 48: 206; 1964