Susceptibility of Five Provenances of Ponderosa Pine to Dothistroma Needle Blight

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ABSTRACT

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An 11-yr-old provenance trial of *Pinus ponderosa* was assessed for differences in susceptibility to *Dothistroma septospora*. Marked differences in percentage of needles infected, number of lesions per needle, and percentage of dead needle tissue indicated two groups. When grown in an inland area with little maritime influence, provenances from inland regions were less susceptible to *Dothistroma* than were trees originating in humid coastal climates.

Dothistroma needle blight occurs on many *Pinus* spp. (6,7,10), including *Pinus ponderosa*. Although *P. ponderosa* may be susceptible, a survey in California showed no infection in natural stands of this species but disease in plantations of other species (2). *Dothistroma* generally does not cause appreciable damage in natural stands of *P. ponderosa*, but it severely attacks *P. ponderosa* planted outside its native range (1).

Resistance of individual trees of *P. ponderosa* to *Dothistroma* varies (9). In the Nebraska National Forest, *Dothistroma* was epidemic in plantations of *P. nigra* but not in adjacent plantations of *P. ponderosa* (10). Genetic and environmental factors appear to cause considerable variation in susceptibility to *Dothistroma*.

Needle blight of pines caused by *Dothistroma septospora* (Dorog.) Morelet (= *D. pini* Hulbary) was first recorded in Australia in 1975 on *P. radiata* (4) and occurs on this species in the southern and northern highlands of New South Wales (5) and in southeastern Queensland (B. N. Brown, *personal communication*). In mid-1977, needle blight was noted in an 11-yr-old provenance trial of *P. ponderosa* at Two Mile Top in Nundle State Forest near Tamworth, New South Wales. Although the disease could only have been established recently, it appeared that infection levels already differed according to provenance. Our study was done to determine whether these apparent differences were real.

MATERIALS AND METHODS

The *P. ponderosa* provenance trial is at an altitude of 1,260 m, with a northeasterly aspect. The original vegetation, predominantly *Eucalyptus obliqua* and *E. viminalis*, had been cleared in 1964. The trees were planted in 1965 but failed after drought and frost, and more were planted in 1966. The sources of the five groups of trees are shown in Table 1.

The trial was established as a 5 × 5 latin square (3). Each plot contained 49 trees in seven rows of seven trees each, at 2.4 × 2.4 m spacing. Before this study, only height had been measured (Fig. 1).

When trees were sampled in December 1977, disease expression was clear, and second-year needles, as defined by Peterson (11), were being cast.

Fifty trees, two from each plot, were selected at random. The crowns of the trees generally extended to the ground, and samples were taken from the lower half of the crown where symptoms were most evident. The height of the tree and the length of the living crown were measured; the lower half was divided in two, giving two sampling units of quarters of the crown height. The lower quarter was called the first quarter, and the upper, the second quarter. Within each quarter two shoots were taken at random heights and random compass bearings, making a total of four samples per tree.

Shoots were labeled and placed in new polyethylene bags, which were placed on ice in portable coolers and stored in a cool room at 4 C until they were examined in the laboratory.

Needle age was specified as first year (current needles), second year, and so on (11), and each sample twig was divided into segments bearing needles of one age class. From each growth segment, five fascicles were selected at random for detailed examination under a stereomicroscope. Each needle from the fascicle was recorded as infected or uninfected by *Dothistroma*; if infected, the number of lesions was recorded. One needle from each of these fascicles was selected at random and measured. The total length of the needle and the length of dead tissue attributable to *Dothistroma* infection were recorded.

Least squares analyses of variance of the number of lesions per needle, percentage of needles infected, and percentage of dead needle tissue were done separately for each quarter of the crown and for the lower half of the crown.

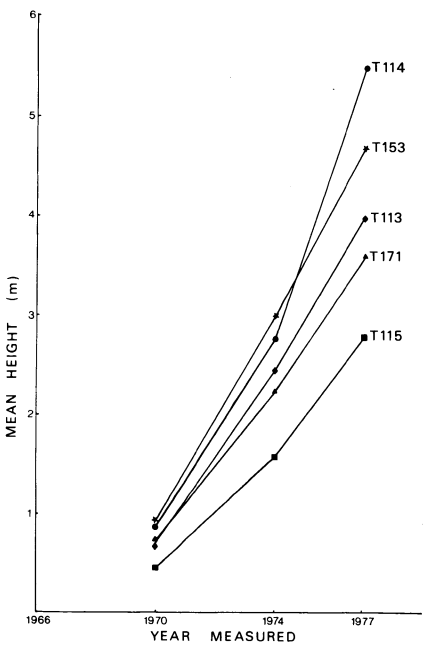

Fig. 1. Mean height of five provenances of ponderosa pine planted in 1966 at Nundle State Forest.

Table 1. Source of seeds for the Nundle State Forest *Pinus ponderosa* plantation

Code	Origin	Latitude	Longitude	Elevation (m)
T113	Prospect, Oregon	42°45′N	122°30′W	1,220
T114	Redding, California	40°30′N	122°30′W	915
T115	Bend, Oregon	43°45′N	121°20′W	1,220
T153[a]	Quincy, California	40°00′N	121°00′W	1,067
T171	Baker Butte, Arizona	34°30′N	111°30′W	1,525

[a] Seed collected from 1928 planting, Bago State Forest, Batlow, New South Wales. Quincy is the most probable origin.

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RESULTS

First-year needles were virtually free of visible symptoms of *Dothistroma* infection, but second-year needles showed considerable infection. Because the third-year needles had been cast from a large proportion of the samples, the data from second-year needles were used to assess differences.

Although the pattern in quarters of the crown varied slightly, the overall pattern was essentially the same for all three variables (Table 2). By the percentage of needle tissue killed, T114 was the most severely affected, followed by T113, but no significant differences were detected ($P = 0.01$) between these provenances for the other two variables. The remaining three provenances differed significantly ($P = 0.01$) from the first two provenances for all three variables but were not significantly different from one another except for percentage of needle tissue killed, where T171 was significantly ($P = 0.01$) less affected than T115.

For all provenances except T113, the first quarter of the crown was significantly more affected by *Dothistroma* than the second quarter.

Table 2. Differences in susceptibilities of *Pinus ponderosa* second-year needles

	Lesions per needle (no.)			Needles infected (%)			Dead needle tissue (%)		
Code	Q_1[a]	Q_2	Mean	Q_1	Q_2	Mean	Q_1	Q_2	Mean
T114	3.7 a	1.5 ab	2.6 a	49 a	36 a	43 a	42 a	22 a	32 a
T113	2.0 ab	1.7 a	1.8 a	36 ab	35 a	36 a	22 b	21 a	21 b
T153	0.9 b	0.4 b	0.6 b	27 abc	13 b	20 b	15 bc	7 b	11 cd
T115	0.8 b	0.4 b	0.6 b	23 bc	12 b	18 b	16 bc	9 b	13 c
T171	0.6 b	0.2 b	0.4 b	10 c	4 b	7 b	7 c	2 b	5 d
Quarter means[b]	1.6	0.8		29	20		21	12	

[a] Q_1 and Q_2 refer to the lower and second quarters of the living crown, respectively. Values in a column followed by the same letter are not significantly different ($P = 0.01$).
[b] Quarter means are significantly different at least at $P = 0.05$.

DISCUSSION

This study supports the view that *P. ponderosa* is more susceptible than many other pines to *Dothistroma* (7,10), but susceptibility also differed markedly among provenances when these were grown in Nundle State Forest. This is best illustrated by the proportion of second-year needle tissue lost to *Dothistroma* infection in the lower half of the living crown. For instance, trees from Baker Butte, Arizona, (T171) lost 4.6% of this needle tissue and trees from Redding, California, (T114) lost 32%.

The two provenances originating the farthest west (T114 and T113) were significantly more susceptible to *Dothistroma* by all three variables. These trees originated in the humid maritime climate west of the Cascade Ranges and Sierra Nevada in Oregon and northern California (8). With the possible exception of T153, the susceptibility of the provenances can be categorized according to accepted climatic zones (8). When grown in Nundle State Forest (an inland climatic zone with little maritime influence), the provenances from inland climatic zones were less susceptible to *Dothistroma*. The provenances that always showed appreciably less infection originated from the most inland site.

The factors that mediated the differences in susceptibility to *Dothistroma* in our study are not known. Because the provenances originated in zones of marked climatic differences (8), variable responses to the uniform climate in the trial site may account for some of the differences in susceptibility.

Gibson (6) concluded that discrepancies evident in three studies on the relative susceptibilities of pine species to *Dothistroma* were most probably related to variable reactions to different strains of the pathogen or to variations in host reaction. Only one strain of *Dothistroma* has been observed in New South Wales (5). If we accept Gibson's conclusions, variations in resistance in our study most probably result from variations in host reaction depending on the genetic makeup of the trees by provenance.

Bingham and co-workers (1) suggest that the pattern of occurrence of *Dothistroma* on the same species of pine planted in different locations indicates a delicate balance between host resistance and the environment. Although our results suggest that climatic influence accounts for part of the differences in this balance, other environmental factors such as the availability of essential nutrients to the tree may be significant.

Dothistroma needle blight became established in the plantation only recently, and 1977 was the first year that infection was obvious. The growth patterns for the five provenances before 1977 (Fig. 1) suggest that the trees that grew most rapidly before infection were most susceptible to *Dothistroma*. The two least susceptible provenances, T171 and T115, produced the smallest trees after 11 yr. Growth has not been measured since infection became obvious, but future measurements will be examined to determine the effects of *Dothistroma*.

The relationship between host resistance and the environment in a specific locality should be an important consideration when selecting for resistant species or strains. When selecting for resistance, the relationship between growth performance and resistance at a particular locality also must be taken into account.

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