

Incidence, Severity, and Growth Effects of *Heterobasidion annosum* in Unthinned Loblolly Pine Plantations

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Contribution 407, Department of Plant Pathology and Physiology, Virginia Polytechnic Institute and State University, Blacksburg.

Accepted for publication 23 November 1980.

ABSTRACT

Webb, R. S., Alexander, S. A., and Skelly, J. M. 1981. Incidence, severity and growth effects of *Heterobasidion annosum* in unthinned loblolly pine plantations. *Phytopathology* 71:661-662.

The root systems of 648 loblolly pines in high and low hazard unthinned plantations in Virginia were mechanically excavated and examined for the incidence and severity of *Heterobasidion annosum* root rot. Radial increment growth at diameter breast height (1.4 m) was determined for the 10-yr period prior to excavation for each tree. Of the 348 trees observed in high hazard plantations, 8.3% were infected by this pathogen, while 3.3% of

the 300 trees observed in low hazard plantations were infected. Overall disease incidence and severity were minor among trees from either plantation hazard type. Duncan's multiple range analysis detected no significant differences ($P = 0.05$) in radial increment growth between trees infected and uninfected with *H. annosum* ($P = 0.5$). Implications for management strategies are discussed.

Following initial reports of southern pine mortality attributed to *Heterobasidion annosum* (Fr.) Bref. (2,4,5), an extensive survey of loblolly (*Pinus taeda* L.) and slash pine (*P. elliotii* Englem.) plantations was conducted (8). They concluded that annosum root rot had seldom been a problem either in thinned or unthinned natural stands of slash and loblolly pine. In thinned slash and loblolly pine plantations, 2.2 and 2.8% (respectively) of the trees were reported to be either dead or dying of annosum root rot. No incidence figures were given for unthinned stands. Based upon previous descriptions (6,9-11) of the pathogen's infection biology, most studies have been conducted in thinned plantations where colonization of freshly cut stumps threatened survival of residual pines. As a result, the incidence, severity and growth impact of annosum root rot in unthinned stands were deemphasized and were not fully determined (13). Accordingly, these three aspects of the disease in unthinned loblolly pine plantations became the objectives of this study.

MATERIALS AND METHODS

Morris and Frazier's (7) soil hazard rating scheme for expected levels of *H. annosum* were used to select five high and four low hazard, unthinned, old field, first generation, loblolly pine plantations. Sand content was determined by using the pipette method (3). Survey plantations were provided by the Chesapeake Corp. (West Point, VA 23181), Union Camp Corp. (Franklin, VA 23851) and the Virginia Division of Forestry (Cumberland State Forest, Cumberland, VA). All high hazard plantations were located in the Virginia coastal plain while three low hazard plantations were selected from the Piedmont area. The remaining low hazard plantation, Union Camp Corp. (Plot UC306, Table 1), was situated in the coastal plain.

Stand description, plot designations, age, location, and hazard rating data are described in Table 1. Two circular 0.02-ha plots were established in each plantation except UC219 and UC306 where, owing to their large areas, two pairs of plots were installed. No plot perimeter was located less than 40 m from any natural or artificial stand disturbance; ie, mortality due to southern pine bark

beetle infestations or woods roads. A plot area of 0.02 ha was selected because it provided both an acceptable number of trees; ie, an average of 30 trees per plot, to assure adequate representation of the disease in each plantation, and enough root systems to excavate and rate efficiently by 2- to 3-man crews in a reasonable period of time.

By following the procedures described by Bradford et al (1),

TABLE 1. Incidence of *Heterobasidion annosum* infection in unthinned loblolly pine plantations^a

Plot	Trees (no.)	Age (yr)	Trees infected ^a (no.)	No. trees colonized >1%	No. trees with conks
High hazard					
C6601-1	25	13	0	0	0
C6601-2	27	13	0	0	0
UC4-1	25	21	2	0	0
UC4-2	25	18	9	4	2
UC39-1	25	23	2	0	0
UC39-2	25	23	3	0	0
UC219-1	39	19	0	0	0
UC219-2	47	19	2	1	0
UC219-3	27	19	4	0	0
UC219-4	32	19	2	0	0
UC223-1	26	16	2	0	0
UC223-2	25	17	3	0	0
Totals	348		29	5	2
Average (%)				8.3	
Low hazard					
J15-1	40	13	0	0	0
J15-2	36	13	1	1	0
J28-1	44	15	0	0	0
J28-2	37	15	0	0	0
RQ23-1	41	17	0	0	0
RQ23-2	42	17	0	0	0
UC306-2	18	44	2	0	0
UC306-3	14	45	4	1	0
UC306-4	11	44	0	0	0
UC306-5	17	44	3	0	0
Totals	300		10	2	0
Average (%)				3.3	

^aResin-soaked and stringy root tissues were recorded as symptomatic expressions of infection and colonization by *H. annosum*, and confirmed by laboratory isolation of the pathogen.

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loblolly pines within these plots were selected, excavated, and rated for *H. annosum* root rot incidence and severity. The root systems were excavated by using a bulldozer. Each root system was rated as to the level of *H. annosum*. Those trees with >1% of their root systems colonized by *H. annosum*, as determined by resin-soaked or decayed root tissue, were measured. All primary and secondary roots were measured by root length and divided into three symptomatic categories: 1 = healthy; 2 = resin-soaked; 3 = stringy. Categories 2 and 3 are symptomatic expressions of *H. annosum* colonization.

Roots with a resin-soaked or stringy, decayed appearance were stored on ice for transfer to the laboratory. Chips approximately 1 cm³ in size were excised from the symptomatic margin of each root and plated onto *o*-phenylphenol (OPP) (12) medium. Cultures were incubated 7–10 days at 24 C and examined for the presence of *Spiniger meinelkellus* (A. J. Olson) Stalpers (*Oedocephalum lineatum* Bakshi), the asexual stage of *H. annosum*.

A disk was removed at breast height (1.4 m) from the trunk of each tree and radial increment growth measurements were made with an Addo-X dendrochronograph (Facit-Addo, Secaucus, NJ 07094) at four points on the disk. Beginning at the radius with the highest growth rate, measurements for the record were made at 90° intervals. For each tree, the growth rate was the average of the four measurements.

RESULTS

The aboveground portions of trees selected for excavation were consistently asymptomatic. Also, no symptoms of crown decline or root system weakness (leaning or windthrown trees) were observed among trees in any of the experimental plots. Two trees within UC4-2 bore basidiocarps of *H. annosum*. The average plantation age was 22 yr and ranged from 13 to 45 yr.

The incidence of annosum root rot in high and low hazard unthinned loblolly pine plantations is presented in Table 1. Twenty-nine of the 348 trees (8.3%) located on high hazard sites were infected by *H. annosum*. Only 1.4% exhibited >1% colonization of the total excavated root system. Only two trees (both located in UC4-2) had basidiocarps of *H. annosum* at the time of excavation. On low hazard sites, 3.3% of the trees were infected by *H. annosum* with 0.7% of these exhibiting >1% colonization of the total root system. Nine of 10 infected trees were located in the older plantations (44–45 yr). No basidiocarps of this pathogen were observed on trees in the low hazard plots.

Severity data for high and low hazard unthinned loblolly pine plantations revealed only five and two trees, respectively, substantially colonized by *H. annosum*. Four of these trees were located in UC4-2 and the root systems exhibited an average 34% decay by length. The only other infected tree occurred in UC219-2 and had 25% of its root length colonized. The primary symptom exhibited by infected roots on these high hazard sites was resinosis, which is indicative of incipient decay. On low hazard sites, only two trees (0.7%) were infected; one with 84% and the other with 68% decay by length. These two trees exhibited symptoms of stringy decay suggesting prolonged colonization by *H. annosum*. Isolation of *H. annosum* from resin-soaked or stringy roots was 100%.

Loblolly pines infected by *H. annosum* occurred in 13 of the 22 unthinned plantation plots. With Duncan's multiple range analysis no significant ($P = 0.05$) difference was detected in mean radial increment growth between trees infected and uninfected by *H. annosum* over the 10 yr period prior to excavation with the exception of UC219-2.

DISCUSSION

With the exception of this survey, no systematic study, utilizing mechanical means, of entire root system excavation has been conducted to determine the incidence and severity of *H. annosum*

infection in unthinned loblolly pine plantations. Thus, interpretation of these results must be more qualitative than quantitative since no other survey exists for comparison. A survey of *H. annosum* by Bradford et al (2) utilized bulldozer excavation but concentrated in thinned loblolly pine natural stands and plantations, which represent a higher disease incidence (85% infection on high hazard sites) from that detected in unthinned plantations (8.3% infected on high hazard sites).

Annosum root rot incidence was low among high hazard unthinned loblolly pine plantations and very low among low hazard plantations. In the high hazard plots, the few severely colonized trees exhibited symptoms of recent infection; however, none were associated with root contacts. The greater incidence of infection on high hazard plots suggests the spread of *H. annosum* from infected trees to other adjacent trees may occur within a stand. The severely colonized trees from low hazard plantations exhibited symptoms of prolonged root decay possibly from early contact with buried inoculum. No evidence of spread from colonized trees to adjacent trees was observed on low hazard plots.

Thus, the majority of trees in this study of unthinned plantations was not infected by *H. annosum*. Among the few trees that were infected, all were asymptomatic aboveground and the disease incidence and severity were so minor that they had no immediate impact upon tree growth. However, since all selected plantations were of the first generation, *H. annosum* may yet be a serious management consideration among residual trees once thinning or replanting has occurred. Should an infected tree be cut during thinning, subsequent colonization within the residual root system would be quickly enhanced. This would potentially create loci of inoculum production within the plantation from basidiocarps produced on these stumps or through the increased availability of roots colonized by *H. annosum* in the soil.

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