FIELD TRIALS FOR CONTROL OF RHIZOCTONIA BLIGHT OF LONGLEAF PINE SEEDLINGS: EFFECTS OF SEEDBED PLANTING DENSITIES, FUNGICIDES AND MULCHES

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ABSTRACT

A blight caused by a species of Rhizoctonia is a serious problem affecting longleaf pine seedlings in several Florida nurseries. Two seedbed planting densities (150 and 350 seed/m^2), four mulches (Hydromulch®, hardwood chips, pine straw as operationally applied [1X], and pine straw applied at twice the operational rate [2X]), and four fungicides (benomyl, thiophanate methyl, thiophanate methyl + mancozeb, and benodanil) were evaluated for their individual and combined potential for disease control in an operational study involving 300,000 seedlings. Disease impact was assessed by recording 1) the number of Rhizoctonia infection centers/10 m seedbed length, 2) the number of seedlings/infection center, and 3) the percentage seedling loss within each treatment. Decreased seedbed planting density resulted in an overall reduction in disease severity, but the hardwood chip mulch consistently provided the most effective control. Pine straw applied at twice the operational rate appeared to provide a useful level of control while Hydromulch®and pine straw applied at the normally operational rate were ineffective. Fungicide treatments produced variable results, but exhibited promise. Benodanil and thiophanate methyl appeared most effective.

Trade names of fungicides are used in this publication solely to provide specific information. Mention of a trademark or proprietory product does not constitute a guaranty or warranty of the product by the Division of Forestry, nor imply its approval to the exclusion of other products that may also be suitable.

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Renewed interest in the use of longleaf pine (Pinus palustris Mill.) for reforestation in the southeastern United States is reflected in increasing demands for longleaf pine planting stock. In Florida alone, the production of longleaf pine seedlings has increased from approximately 2 million in 1981 to 7 million in 1985.

The production of quality longleaf seedlings can be limited by a destructive blight caused by a binucleate Rhizoctonia solani-like fungus belonging to anastomosis group 3 of Ceratobasidium spp. (Barnard 1979, Davis 1941, English et al. 1985). Several nurseries in Florida have suffered losses to Rhizoctonia blight over the past decade, one losing an estimated 20% of its 1983 crop. The incidence of and damage due to Rhizoctonia blight is generally more common in nurseries with sandy soils. This is often related to the accumulation of sand at or covering seedling buds, which are typically located at the ground line due to the grass stage habit of longleaf pine. The pathogen invades the bases of susceptible needles, causing a water-soaked chlorotic lesion which eventually becomes necrotic and results in the death of the entire needle. Infection then may progress into the bud, often resulting in the death of seedlings. Infection apparently spreads within the nursery bed via mycelial growth through the soil, resulting in expanding circular to irregular patches of dead and/or dying trees. Rhizoctonia blight appears in nursery beds in late spring and progresses throughout most of the remaining growing season.

Little information is available regarding effective strategies for control of Rhizoctonia blight of longleaf pine. For example, no experimental data exist on the relationship between Rhizoctonia blight and seedbed density, although some nurserymen have commented that reduced seedbed densities appear to retard disease development. Experimental data on the relative efficacies of fungicides for control of this disease are also lacking, and applications of benomyl by Florida nurserymen historically have proven ineffective. Local experience, as well as observations by Davis (1941), suggest that certain seedbed mulching materials and fall seed sowing may provide some control.

Recent severe losses to Rhizoctonia blight, coupled with the aforementioned lack of proven effective control measures, prompted the design of a multifaceted experiment from which basic information on both the biology and control of Rhizoctonia blight could be obtained. The objectives of this study were to evaluate the effects of seedbed density, mulching material, and fungicide application on 1) the incidence and spread of Rhizoctonia blight in longleaf pine nursery beds, and 2) the growth and development of the longleaf pine seedlings themselves.

METHODS

The study was established in late March 1984 at the Andrews State Forest Tree Nursery in Chiefland, Florida where Rhizoctonia blight has been a persistent problem. Prior to planting, customary seedbed preparation procedures were followed, which included 1) methyl bromide soil fumigation (393 kg/ha MC-2®) and 2) preplant incorporation of 225 kg/ha 15-0-15 fertilizer. All combinations of two planting densities, four mulching materials, and four fungicides were included in the study which comprised 300,000 seedlings covering 16, 1.25 x 175.0 m nursery beds (Fig. 1). Half of the seedbeds were planted at 350

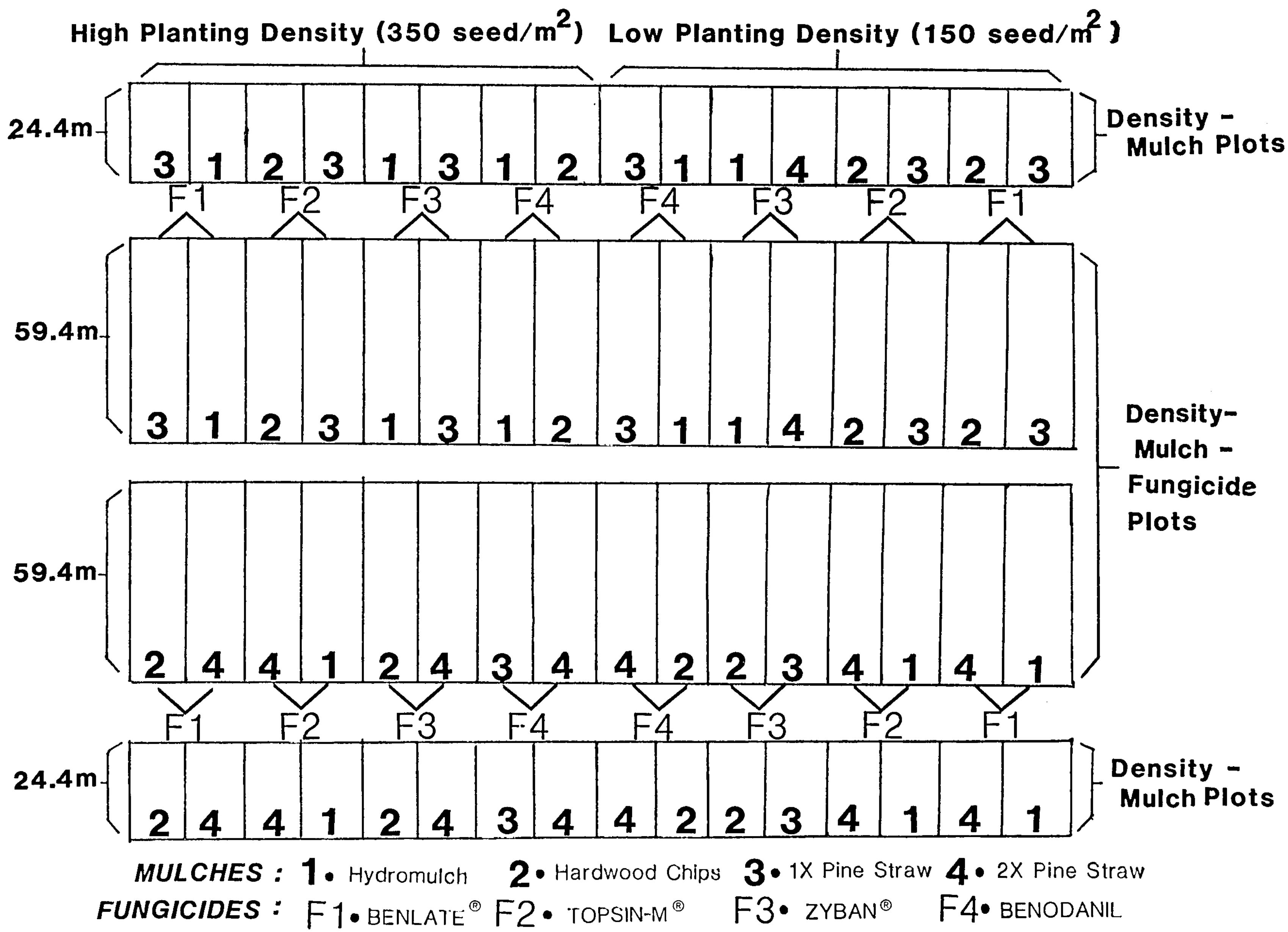

Fig. 1. Schematic of planting density, mulch, and fungicide treatments evaluated for control of Rhizoctonia needle blight in longleaf pine nursery beds.

seed/m^2 (HIGH), and half were planted at 150 seed/m^2 (LOW). Test mulches were applied immediately after seeding and included: 1) pine straw - as operationally applied, 6-12 mm thick, 2) pine straw - applied at twice the operational rate, 12-25 mm thick, 3) hardwood chips (crude mix of hardwood bark and wood residue from a 1/4 in. cut-off saw in an industrial woodyard) applied to a depth of 12-25 mm, and 4) Hydromulch®, a wood fiber slurry hydraulically applied to seedbeds (ca. 1180 kg/ha). Mulches were randomly applied to plots as depicted in Fig. 1, and test fungicides were applied as illustrated (Fig. 1) at rates and frequencies indicated in Table 1.

Table 1. Formulation rate, and frequency of application for four fungicides evaluated for control of Rhizoctonia blight.

Common Name	Trade Name	Formulation	Rate of Application (kg/ha)[1]	Application Frequency
benomyl	Benlate®	50WP	2.3	weekly
thiophanate methyl	Topsin-M®	70WP	3.4	bi-weekly
thiophanate methyl (15%) + mancozeb (60%)	Zyban®	75WP	3.4	weekly
benodanil	(MF-654)	50WP	1.8	bi-weekly

[1]Sprayer calibrated to deliver 153 L/ha finished spray.

Systematically located 0.37 m^2 life history plots (1 per test plot) were utilized to monitor treatment effects on seed germination and seedling survival. The number of seed (or seedlings) in each plot was recorded 1) immediately following seed sowing 2) 34 days later, and 3) at the end of the growing season.

All test plots were carefully examined for evidence of Rhizoctonia blight on each of six dates between July 5 and November 11. Wooden markers were placed in the ground beside each diseased seedling, and at the end of the test period, the total number of markers in each infection center (i.e., 1 or more seedlings showing symptoms of infection) were recorded. Incidence and severity of Rhizoctonia blight were evaluated by 1) the number of Rhizoctonia infection centers/10 m of bed length, 2) the average number of infected seedlings/infection center, 3) the total number of infected seedlings/10 m bed length, and 4) average percentage seedling loss.

At the end of the nursery growing season, two 0.37 m^2 subplots were systematically established in each density-mulch plot and four such subplots were established in each of the density-mulch-fungicide combination plots. The number of seedlings in each of these subplots were counted and ten seedlings were randomly selected from each subplot for determinations of a) root collar diameters (RCD) and b) oven-dry weights.

RESULTS & DISCUSSION

Differences in germination between mulch treatments were significant (Table 2). Highest germination occurred in beds mulched with hardwood chips and 2X pine straw, followed by 1X pine straw and Hydromulch®. This order was consistent in both planting densities. Germination in Hydromulch® plots was so low that end-of-season seedbed stocking (i.e., seedlings per unit area) in "high planting density" Hydromulch® plots was comparable to that in the "low planting density" plots of the other three mulches. Not surprisingly, seedlings grown in sparsely stocked Hydromulch plots were somewhat larger than seedlings grown in plots with other mulches. Within each planting density, seedlings from hardwood chip beds were slightly smaller than seedlings from 1X or 2X pine straw plots, even though seedbed densities were comparable. Within all mulch treatments, seedlings attained greater oven-dry weights and RCD's when grown at the lower planting density.

Table 2. Production parameters as affected by planting density and mulch[1].

Mulch Treatment	Germination %	Seedlings/M2	Total Oven Dry Weight (g)	Root Collar Diameter (mm)
----------------low planting density (150 seed/m^2)----------------				
Hydromulch®	26.2a	30.5a	8.6a	9.2a
Hardwood chips	54.7c	86.5b	7.6a	8.6a
1X Pine Straw	40.2b	76.5b	8.3a	8.8a
2X Pine Straw	58.3c	82.4b	8.4a	8.8a
----------------high planting density (350 seed/m^2)----------------				
Hydromulch®	31.1a	90.8a	5.6a	7.4a
Hardwood chips	53.3c	164.6c	4.9a	7.3a
1X Pine Straw	42.2b	125.7b	5.4a	7.3a
2X Pine Straw	54.5c	158.9bc	5.4a	7.1a

[1]Values within columns and seedbed planting densities followed by same letter are not significantly different at $P \leq 0.05$. Oven dry weights and RCD's differed significantly ($P \leq 0.05$) between low and high density plantings.

Dry weights and RCD's for seedlings from the various planting density-mulch-fungicide combinations are summarized in Table 3. Although these data are from unreplicated plots, the influences of planting density and mulching materials appear similar to those observed in replicated plots where fungicides were not applied (Table 2). Seedling dry weights and root collar diameters were apparently unaffected by fungicides. In general, seedbed density was again the major factor influencing seedling size.

Table 3. Oven dry weights and root collar diameters of longleaf pine seedlings as affected by planting density, fungicides, and mulches.

	Total Oven Dry Weight (g)				Root Collar Diameter (mm)			
Fungicide Treatment	Hydromulch®	Hardwood Chips	1X Pine Straw	2X Pine Straw	Hydromulch®	Hardwood Chips	1X Pine Straw	2X Pine Straw
low planting density (150 seed/m²)								
BENLATE®	12.2	6.5	9.5	7.8	10.4	7.8	9.3	8.3
TOPSIN-M®	12.1	6.5	8.4	9.7	10.0	8.6	8.5	9.9
ZYBAN®	7.8	7.4	10.2	6.2	8.7	8.2	9.1	8.1
BENODANIL	10.3	7.4	9.3	8.8	9.4	8.7	8.6	9.4
high planting density (350 seed/m²)								
BENLATE®	5.4	6.2	4.8	6.4	7.7	7.7	7.2	7.3
TOPSIN-M®	7.2	5.2	5.3	6.9	8.0	7.3	7.2	7.6
ZYBAN®	5.4	3.9	4.2	5.2	6.4	6.1	6.4	7.1
BENODANIL	5.9	5.1	5.6	5.9	7.6	6.8	7.3	7.4

Table 4 summarizes results with respect to disease incidence and severity within treatment plots. Again, due to the nature of the study, these data represent single plot observations, not the means of replicated plots. Nonetheless, some reasonably definitive trends are obvious. For example, seedbeds mulched with 1X pine straw across all fungicides and planting densities, consistently had the highest numbers of dead seedlings per 10 linear m of seedbed and the highest percentage seedling loss (i.e., no. of dead seedlings adjusted to reflect differences in seedbed stocking). The poor showing of this mulch treatment was also reflected in its generally high numbers of infection centers per 10 linear m of seedbed, and numbers of seedlings per infection center (highest across all planting density-fungicide combinations with only one exception for each parameter). In contrast, seedbeds mulched with hardwood chips exhibited, with only one exception, the lowest percentage seedling losses across all planting density-fungicide combinations. Seedbeds mulched with this material consistently exhibited relatively low numbers of infection centers and dead seedlings per 10 linear m of seedbed and generally low numbers of seedlings per infection center. Losses incurred in seedbeds receiving Hydromulch®and 2X pine straw treatments were generally intermediate between those sustained in seedbeds receiving 1X pine straw and hardwood chips. Trends observed between mulches in the various fungicide plots paralleled those observed in the replicated controls where fungicides were not applied (Table 4).

Mean numbers of seedlings per infection center were generally low across all fungicide treatments in Hydromulch®treated seedbeds at the high seedbed planting density (Table 4). While this might initially suggest some level of disease control, it is equally and perhaps more likely that these data reflect differences in seedbed stocking as a function of the extremely poor seed germination incurred in Hydromulch®treated plots (Table 2). Slower spread of the pathogen from seedling to seedling via mycelial growth would be expected at low seedling densities, and such a phenomemon is supported by the generally lower numbers of seedlings per infection center at the low seedbed planting density as compared to the high seedbed planting density within all fungicide-mulch combinations (Table 4).

Effects of fungicide treatments were, in general, much less pronounced than those of the various mulches. Slight evidence of fungicidal suppression of disease were apparent, however, especially at the high seedbed planting density (Table 4). For example, percentage seedling losses within each fungicide treatment, across all mulch treatments, were lower than those of the appropriate controls at the high seedbed planting density. In addition, there were markedly fewer infection centers and consequently fewer dead seedlings per 10 linear m of seedbed in the heavily diseased, 1X pine straw-mulched seedbeds where benodanil and Topsin M®were applied than in 1X pine straw controls where fungicides were not applied.

No definitive evidence of fungicidal phytotoxicity was observed during the course of this study with the possible exception of a slight foliar yellowing on Zyban®-treated seedlings. In this respect, it is perhaps noteworthy that Zyban®-treated seedlings often tended to be somewhat smaller than companion seedlings treated with other fungicides under similar planting density-mulch combinations (Table 3). Whether or not a Zyban®phytoxicity is real and of substantive concern requires further testing.

Table 4. Effects of planting density, fungicides and mulches on Rhizoctonia blight of longleaf pine.

Fungicide-Mulch Treatment	Low Planting Density (150 seed/m^2) No. Inf. Centers/ 10 m Bed	Mean No. Seedlings/ Inf. Center	No. Dead Seedlings/ 10 m Bed	Seedling Loss (%)	High Planting Density (350 seed/m^2) No. Inf. Centers/ 10 m Bed	Mean No. Seedlings/ Inf. Center	No. Dead Seedlings/ 10 m Bed	Seedling Loss (%)
BENLATE®								
Hydromulch®	2.7	5.1	13.8	3.5	5.4	1.7	9.2	0.5
Hdwd Chips	0.8	1.0	0.8	0.1	0.7	7.8	5.4	0.3
1X Pine Straw	3.9	5.3	20.7	3.4	10.9	14.3	155.9	10.0
2X Pine Straw	2.7	2.5	6.8	0.4	1.3	8.5	11.9	0.5
TOPSIN-M®								
Hydromulch®	5.7	1.6	10.7	2.5	2.0	3.6	7.2	0.7
Hdwd Chips	0.8	1.0	0.8	0.1	2.0	4.1	8.2	0.4
1X Pine Straw	6.7	5.0	33.5	3.9	3.2	12.3	39.4	2.4
2X Pine Straw	2.0	4.0	8.0	0.9	1.5	7.7	11.6	0.6
ZYBAN®								
Hydromulch®	5.6	1.7	9.5	1.9	5.1	3.5	17.9	1.4
Hdwd Chips	2.2	1.1	2.4	0.3	3.7	7.1	26.3	1.1
1X Pine Straw	4.7	5.6	26.3	3.7	7.1	16.3	115.7	6.7
2X Pine Straw	4.5	2.1	9.5	1.2	4.9	10.1	49.5	2.1
BENODANIL								
Hydromulch®	3.7	1.3	6.1	1.0	1.7	6.3	10.7	0.7
Hdwd Chips	1.2	1.3	2.5	0.2	1.0	5.5	5.5	0.3
1X Pine Straw	5.7	4.0	22.8	3.6	1.7	13.5	23.0	1.2
2X Pine Straw	3.7	1.3	4.8	0.5	1.0	2.0	2.0	0.1
CONTROL[1]								
Hydromulch®	6.6a	1.5a	9.9	2.7	7.1ac	5.5a	39.1	3.5
Hdwd Chips	3.3a	1.6a	5.3	0.5	5.5a	6.4a	35.2	1.7
1X Pine Straw	6.8a	5.3a	36.0	3.9	11.6bc	14.8a	171.7	11.3
2X Pine Straw	4.5a	6.7a	30.2	3.0	5.1a	10.6a	54.1	2.8

[1]Means of four replicate plots. Values within columns followed by same letter are not significantly different at $P \leq 0.05$.

Davis (1941) reported reduced incidence of Rhizoctonia infections in longleaf pine seedbeds mulched with 6-12 mm of sawdust and suggested that mulching materials might provide useful disease control. Our results support this contention, and of the materials employed hardwood chips appear to suppress Rhizoctonia most effectively. The consistently poor performance of our 1X pine straw mulch treatment clearly indicates that traditional use of this mulching regime may be one reason why Rhizoctonia needle blight has remained a persistent problem in certain Florida nurseries. The employment of a 2X pine straw mulching regime, while apparently somewhat less effective than hardwood chips, appears to offer some potential for disease control. Experiments are now underway in Florida to examine the utility of repeated applications of mulching materials (i.e., pine straw and hardwood chips) to longleaf pine seedling crops during the early months of the growing season.

The specific mechanism(s) involved in the reduction of disease activity by mulches in our study are unconfirmed. Two possibilities deserve consideration. First, there is the possibility that mulching materials may physically restrict the accumulation of sand at or on seedling buds. Our observations indicate this to be a very real possibility, especially with respect to the hardwood chip mulch. Hardwood chips employed in our study formed a distinct carpet-like mat on the seedbed soil surface which appeared to be very effective in reducing the otherwise prevalent "sand splash". Alternatively or perhaps in addition, mulching materials such as the hardwood chips may have provided some measure of direct or indirect biological control. The suppressive effects of composted hardwood bark on a variety of pathogens, including *Rhizoctonia solani* Kühn, have been well documented (Hoitink 1980, Hoitink *et al*. 1983, Nelson and Hoitink 1982, 1983, Nelson *et al*. 1983).

While certain mulches appeared more effective for control of Rhizoctonia blight in our study, the use of fungicides should not be ruled out altogether. Use of Benlate® by Florida nurserymen historically has not proven effective, and in our study this fungicide appeared least effective of the four fungicides tested. On the other hand, Topsin M® and benodanil exhibited some promise. Further testing of selected fungicide materials is warranted since the availability of suitable mulch materials could be limited for some nurseries in certain years.

Whether or not reductions in seedbed planting densities will prove to be a viable alternative for control of Rhizoctonia blight is uncertain. In our study, reduced losses were sometimes associated with lower seedbed planting density and/or reduced seedling stocking. However, such relationsips were not consistent. In addition, the extent to which seedbed planting densities can be justifiably reduced will be a function of managerial and economic constraints which will vary between individual nurseries.

LITERATURE CITED

Barnard, E. L. 1979. Rhizoctonia blight of longleaf pine seedlings. Fla. Dept. Agric. & Consumer Serv., Div. Plant Ind., Pathol. Circ. No. 207. 2p.

Davis, W. C. 1941. Damping-off of longleaf pine. Phytopathology 31:1011-1016.

English, J. T., Ploetz, R. C., and Barnard, E. L. 1985. Seedling blight of longleaf pine caused by a binucleate *Rhizoctonia solani*-like fungus. Plant Dis. 69:(in press).

Hoitink, H. A. J. 1980. Composted bark, a lightweight growth medium with fungicidal properties. Plant Dis. 64:142-147.

Hoitink, H. A. J., Vandoren, D. M., Jr., and Schmitthenner, A. F. 1977. Suppression of *Phytophthora cinnamomi* in a composted hardwood bark potting medium. Phytopathology 67:561-565.

Kuter, G. A., Nelson, E. B., Hoitink, H. A. J., and Madden, L. V. 1983. Fungal populations in container media amended with composted hardwood bark suppressive and conducive to Rhizoctonia damping-off. Phytopathology 73:1450-1456.

Nelson, E. B., and Hoitink, H. A. J. 1982. Factors affecting suppression of *Rhizoctonia solani* in container media. Phytopathology 72:275-279.

Nelson, E. B., and Hoitink, H. A. J. 1983. The role of microorganisms in the suppression of *Rhizoctonia solani* in container media amended with composted hardwood bark. Phytopathology 73:274-278.

Nelson, E. B., Kuter, G. A., and Hoitink, H. A. J. 1983. Effects of fungal antagonists and compost age on suppression of Rhizoctonia damping-off in container media amended with composted hardwood bark. Phytopathology 73:1457-1462.