DEVELOPMENT AND FIELD PERFORMANCE OF SLASH AND LOBLOLLY PINE SEEDLINGS PRODUCED IN FUMIGATED NURSERY SEEDBEDS AND SEEDBEDS AMENDED WITH ORGANIC RESIDUES[1]

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ABSTRACT

Evaluations of pine seedling production, quality, and disease in southern forest nurseries in soils fumigated with methyl bromide or amended with pine bark or composted organic residues are ongoing. This paper provides a summary of seedling production and quality data for three slash pine and two loblolly pine seedling crops produced in two different southern pine nurseries. In addition, survival and growth data are provided for two of the slash pine seedling crops and one of the loblolly pine seedling crops one year after seedlings were outplanted operationally on commercial forest sites. To date, treatment effects have been minimal, and statistically significant treatment differences vary among crop-years, treatments, and specific measurement parameters. Evaluation of relative disease suppression efficacies for the soil amendments has been hampered by a general lack of soilborne pathogen populations and associated root disease development.

INTRODUCTION

The Montreal Protocol assessment of 1991 identified methyl bromide as a chemical contributing to depletion of the stratospheric ozone layer and the U.S. Environmental Protection Agency (EPA) proposed to eliminate production and use of methyl bromide pursuant to the Clean Air Act of 1990 (Civerolo *et al.* 1993; Smith and Fraedrich 1993). This action has generated a flurry of activity to identify and assess alternatives to methyl bromide for control of soil-borne pests in forest tree nurseries. As part of a national initiative funded by the USDA Forest Service, Forest Health Protection (James *et al.* 1993), we are growing southern pine seedlings in southern forest nurseries in successive years in

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seedbeds amended with pine bark or composted organic residues, or treated with methyl bromide. Project objectives include (1) assessing effects of organic soil amendments on disease suppression and seedling quality and production, (2) evaluating field outplant performance of treated seedlings, (3) assessing comparative costs and benefits of treatments, and (4) developing methods and baseline data for nursery disease forecasting and risk assessment. Several progress reports have been published previously (Barnard *et al.* 1994, 1996; Kannwischer-Mitchell *et al.* 1994). This paper updates results before the fourth and final year of the project. The focus of this paper is on seedling development and field performance. Microbiological and seedling nutrient data will be published elsewhere.

MATERIALS AND METHODS

Three nurseries were initially involved in this project. However, unanticipated problems at the USDA Forest Service's Ashe Nursery in Brooklyn, MS., resulted in major infestations of nutsedge (*Cyperus* spp.), unusual seed infestations by *Fusarium subglutinans* (Wollenweb. & Reinking) Nelson, Toussoun, & Marasas, and mid-study plot relocations. Therefore, we will only report results from our studies of slash pine (*Pinus elliottii* Engelm.) at the Florida Division of Forestry's Andrews Nursery (Chiefland, FL.), and loblolly pine (*P. taeda* L.) at International Paper (IP) Company's Supertree Nursery in Blenheim, SC.

Field trials began at the Andrews Nursery in 1993 and the IP Supertree Nursery in 1994. Fumigated study plots received standard operational treatment with methyl bromide and chloropicrin prior to sowing each seedling crop. Plots amended with organic residues received annual applications of either pine bark or composted organic materials. Organic residues consisted of composted yard waste at Andrews Nursery in 1993 and 1994, aged hardwood bark at IP's Supertree Nursery in 1994, and a commercially available composted municipal waste from Tennessee (Bedminster, Inc.) at both nurseries in 1995-96. These materials were applied either at 2.5 cm (1X) or 5.0 cm (2X) depths and mechanically incorporated into soils to a depth of 15-20 cm prior to the sowing. Check plots received no treatment other than routine soil tillage and seedbed preparation, which was standard across all treatments. All plots were operationally irrigated, fertilized, and treated with topically applied herbicides. No supplemental treatments were applied to any plots other than the 1996 compost plots at Andrews Nursery. These received an additional 560 kg per ha of sulfur to ameliorate treatment-induced pH problems. Plot layout and distribution are described in Figures 1 and 2.

Seedling stand counts were performed periodically (weekly for 4-6 weeks; mid-summer, and end-of-season) within three permanent subplots (0.3 X 1.2 m) in the center of each treatment plot. Seedlings from each treatment plot were also systematically sampled at early, mid and end of growing season for comparative morphology measurements, nutrient analyses, and rhizosphere microbe assays. Soil samples collected simultaneously with seedling samples were subjected to standard nutrient and nematological assays. Bacterial, actinomycete, and general fungal populations were assayed from soil from the Andrews' Nursery plots at the beginning, middle, and end of the growing season. In addition, populations of *Fusarium* spp., *Rhizoctonia* spp., *Pythium* spp., *Phytophthora* spp., and *Macrophomina phaseolina* were assayed using selective isolation techniques and media (Singleton *et al.*, 1992)

At the end of each crop year, seedlings from each treatment plot were outplanted onto operationally prepared reforestation sites in three replicate 50-seedling row plots in a randomized complete block design. Survival and growth of these seedlings were periodically monitored and measurements were taken at the end of the first growing season following outplanting.

RESULTS AND DISCUSSION

Treatment effects thus far have not been large. Although interesting and sometimes subtle treatment differences with respect to rhizosphere microorganisms, seedling nutrition, and seedling size, are apparent, few statistically significant differences were consistent among treatments across study years. Organic residue amendments have clearly influenced soil organic matter and pH. For example, soil organic matter in composted yard waste-amended soils (2X rate) in the Andrews Nursery were above 2.0% after two seedling crops, while that in all other soils was between 0.5 and 1.0%. Similarly, seedbed soil pH values in the Andrews Nursery were well above 6.5 after 2 years of amending with composted yard waste, whereas pH values in all other treatments were approximately 5.0. Overall, however, differences in seedling quality and field performance have been minimal. Tables 1-4 provide a summary of our seedling quality and performance data to date. Field performance data for the 1995 nursery seedling crops will be collected during the winter of 1996-97, and 1996 crop data are still being collected.

Serious root disease problems have not occurred in our study plots, despite the fact that plots at the Andrews Nursery were purposely located in a compartment with a history of charcoal root rot caused by *Macrophomina phaseolina* (Tassi) Goid. In fact, the only indication of any root disease present in our plots was scattered damping-off, apparently caused by species of *Fusarium*, *Pythium*, and *Rhizoctonia*, and possibly other fungi. In the 1993 crop, damping-off caused primarily by *Pythium myriotylum* Drechs., resulted in statistically significant reductions in seedling numbers in check plots compared to methyl-bromide treated plots (Table 1). However, this difference was not maintained in the 1994 and 1995 crops even though treatment plots have been maintained in the same locations throughout the study.

Organic residues used as soil amendments were selected because of their availability and potential to suppress soilborne pathogens (Hoitink and Fahy 1986, Pokorny 1982). Rates of application were designed to sufficiently load soils typically deficient in organic matter to induce beneficial changes in soil microflora over time. Effects on soil microbiology are still being evaluated. However, pine bark appears generally preferable to other composted materials.

Lack of background root disease in all plots has precluded meaningful evaluation of organic amendments with respect to disease suppression. Nevertheless, lack of disease development in both fumigated and non-fumigated plots raises legitimate questions regarding the need for and cost-effectiveness of routine use of methyl bromide for root disease control in these two test nurseries.

Once this project is completed, a final report will be issued which will discuss all the data and our conclusions regarding the issue of methyl bromide fumigation in forest tree nurseries. Even though much of our data are relatively inconclusive, it will provide a substantial and useful baseline for continued discussions and considerations of new approaches.

Table 2. **Loblolly pine seedling production and morphology at International Paper Company's Supertree Nursery in Blenheim, SC.**[1]

Measurement[2]	Treatment			
	Check	Methyl Bromide	Pine Bark 2.5 cm	Compost 2.5 cm
1994 CROP YEAR				
Seedlings density	28.8 a	26.4 ab	24.7 ab	23.8 ab
Height	33.6 ab	35.3 a	33.3 ab	31.7 ab
Root Collar Diameter	5.0 ab	5.1 ab	5.4 a	4.6 a
Shoot/Root Ratio	3.9 a	4.1 a	3.5 b	3.6 b
1995 CROP YEAR				
Seedling density	23.3 ab	23.9 a	21.4 b	24 a
Height	28.7 b	28.6 b	27.2 b	31.5 a
Root Collar Diameter	4.2 a	4.1 a	4.2 a	4.4 a
Shoot/Root Ratio	3.2 b	3.3 b	3.5 b	4.2 a

[1] Mean seedling counts based on 12 subplot counts per treatment. All other means based on measurements of 160 seedlings per treatment. Treatment means for each variable (rows) followed by the same letter are not significantly different according to Duncan's multiple range test ($p=0.05$).

[2] Seedling density based on number of seedlings per $929 cm^2$ ($1 ft^2$); height given in cm; root collar diameter given in mm.

Table 3. **First-year field outplant performance of slash pine seedlings from the Andrews Nursery in Chiefland, FL.**[1]

	Treatment					
			Pine Bark		Compost	
Measurement[2]	Check	Methyl Bromide	2.5 cm	5.0 cm	2.5 cm	5.0 cm
1993 SEEDLING CROP						
Percent Survival	100 a	99.2 a	99.3 a	99.2 a	99.3 a	99.7 a
Height	56.7 ab	53.4 b	59.4 ab	60.7 ab	59.9 ab	62.6 a
Root Collar Diameter	20.7 a	19.1 a	20.3 a	21.9 a	20.8 a	22.2 a
Plot Volume Index	121.7 ab	100.0 b	123.6 ab	146.1 ab	129.5 ab	157.0 a
1994 SEEDLING CROP						
Percent Survival	99.6 a	98.8 a	100.0 a	99.0 a	99.2 a	99.4 a
Height	51.1 a	52.9 a	55.4 a	53.3 a	55.1 a	55.8 a
Root Collar Diameter	15.1 a	14.6 a	15.9 a	16.4 a	16.1 a	17.3 a
Plot Volume Index	58.9 a	59.5 a	72.7 a	71.6 a	72.2 a	83.6 a

[1] Survival means based on 12, 50-tree plots per treatment. Mean heights based on 25 seedlings per plot (=300 seedlings per treatment). Mean root collar diameters based on 15 seedlings per plot (=180 seedlings per treatment). Treatment means for each variable (rows) followed by the same letter are not significantly different according to Duncan's multiple range test ($p=0.05$).

[2] Height given in cm; root collar diameter given in mm; plot volume index = (mean height) x (mean root collar diameter)^2 x (mean no. surviving seedlings/plot).

Table 4. **First-year field outplant performance of loblolly pine seedlings from International Paper Company's Supertree Nursery in Blenheim, SC.**[1]

	Treatment			
			Pine Bark	Compost
Measurement[2]	Check	Methyl Bromide	2.5 cm	2.5 cm
1994 SEEDLING CROP				
Percent Survival	97.0 a	97.5 a	95.5 ab	97 a
Height	52.9 a	53.4 a	51.4 ab	48.8 b
Root Collar Diameter	8.6 ab	9.0 a	8.2 b	8.1 b
Plot Volume Index	19.0 ab	21.3 a	16.5 b	15.7 b

[1] Survival means based on 12, 50-tree plots per treatment. Mean heights based on 25 seedlings per plot (=300 seedlings per treatment). Mean root collar diameters based on 15 seedlings per plot (=180 seedlings per treatment). Treatment means for each variable (rows) followed by the same letter are not significantly different according to Duncan's multiple range test ($p=0.05$).

[2] Height given in cm; root collar diameter in mm. Plot volume index = (mean height) x (mean root collar diameter)^2 x (mean no. surviving seedlings/plot).

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LITERATURE CITED

Barnard, E. L.; M. E. Kannwischer-Mitchell, D. J. Mitchell, and S. W. Fraedrich. 1996. Progress and trends: Southeastern regional component of a national technology development effort evaluating nursery management and seedling development without dependence on methyl bromide. Southwide Forest Disease Workshop, Clemson, SC. January 22-25, 1996. (Abstr.)

Barnard, E. L.; M. E. Mitchell, D. J. Mitchell and S. W. Fraedrich. 1994. Evaluating the efficacy of organic soil amendments as alternatives to methyl bromide for control of soilborne pathogens in forest tree nurseries. Southwide Forest Disease Workshop, Asheville, NC. June 7-9, 1994. (Abstr.)

Civerolo, E. L.; S. K. Narang, R. Ross, K. W. Vick and L. Greczy. (eds). 1993. Alternatives to methyl bromide: assessment of research needs and priorities. Proceedings from the USDA Workshop on Alternatives to Methyl Bromide. Arlington, VA. June 29-July 1, 1993. 85 p.

Hoitink, H. A. J. and P. C. Fahy. 1986. Basis for the control of soilborne plant pathogens with composts. Annual Review of Phytopathology 24:93-114.

James, R. L., D. M. Hildebrand, S. J. Frankel, M. M. Cram and J. G. O'Brien. 1993. Alternative technologies for management of soil-borne diseases in bareroot forest nurseries in the United States. *In* Landis, T. D. (Tech. Coord.) Proceedings: Forest and Conservation Nursery Associations. USDA Forest Service, General Technical Report GTR-RM-257. pp. 91-96.

Kannwischer-Mitchell, M. E.; E. L. Barnard, D. J. Mitchell and S. W. Fraedrich 1994. Organic soil amendments as potential alternatives to methyl bromide for control of soilborne pathogens in forest tree nurseries. *In*: Landis, T. D. and R. K. Dumroese (Tech. Coords.). Proceedings: Forest and Conservation Nursery Proceedings. USDA Forest Service, General Technical Report GTR-RM-257. pp. 12-15.

Pokorny, F. A. 1982. Pine bark as a soil amendment. *In* Brissette, J. and C. Lantz (compilers). Proceedings: 1982 Southern Nursery Conferences. USDA Forest Service. Technical Publication R8-TP4. pp. 131-139.

Singleton, L. L., J. D. Mihail and C. M. Rush, eds. 1992. Methods for Research on Soilborne Pythopathogenic Fungi. APS Press, St. Paul, MN. 265 pp.

Smith, R. S., Jr. and S. W. Fraedrich. 1993. Back to the future - pest management without methyl bromide. Tree Planters' Notes 44:87-90.

LIST OF FIGURES

Fumigated		Compost (2.5 cm)	
	Pine Bark (5 cm)		Compost (5 cm)
Check		Pine Bark (2.5 cm)	
	Compost (2.5 cm)		Fumigated
Pine Bark (2.5 cm)		Fumigated	
	Pine Bark (2.5 cm)		Pine Bark (5 cm)
Compost (5 cm)		Check	
	Fumigated		Compost (2.5 cm)
Compost (2.5 cm)		Pine Bark (5 cm)	
	Compost (5 cm)		Check
Pine Bark (5 cm)		Compost (5 cm)	
	Check		Pine Bark (2.5 cm)

Figure 1. Field layout of study plots at the Florida Division of Forestry's Andrews Nursery in Chiefland, FL. Individual treatment plots are three seedbeds wide (3.7 m) by 36.6 m long. Fumigated buffers are indicated by shaded areas.

Fum		Ch		Ch		Fum		Com		Fum
Com		Com		PB		PB		Ch		
PB		Fum		Com		Ch		PB		

Figure 2. Field layout of study plots at International Paper Company's Supertree Nursery in Blenheim, SC. Individual treatment plots are three seedbeds wide (3.7 m) by 12.2 m long. Fumigated buffers are indicated by shaded areas (Fum = fumigated, Com = compost 2.5 cm, PB = pine bark 2.5 cm, Ch = check).