EFFECTS OF LIFTING METHOD, SEEDLING SIZE, AND HERBACEOUS WEED CONTROL ON FIRST-YEAR GROWTH OF LOBLOLLY PINE SEEDLINGS

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Abstract—In fall, 1999, an experiment was installed to measure the effects and interactions of lifting method, seedling size, and weed competition on growth of loblolly pine (*P. teada*) seedlings during the first two growing seasons. Loblolly pine seedlings grown at two bed densities and lifted either by hand or machine were planted in southwestern Georgia and either given complete weed control or no weed control. The treatments were arranged in a 2 x 2 x 2 factorial and replicated three times. Mean root collar diameter was 5.7 mm for seedlings grown and 301/m^2 and 7.6 mm for seedlings grown at 161/ m^2. Total height of all seedlings was measured after planting and at the end of the 1st growing season. Ground line diameter was also measured at the end of the first growing season. This paper will present the main effects and their interaction on height and volume after the first growing season.

INTRODUCTION

There has been an increased interest from the forest industry throughout the South in large, high vigor seedlings. The industry's desire is to produce high quality pine seedlings, which not only survive planting, but begin growth during the first growing season. Seedling quality research has shown that variables such as root system size, stem caliper, and root/shoot ratio affect growth and survival of pine seedlings (South and others. 1995). The method of lifting seedlings from the nursery beds has also been shown to influence growth and survival (Greene & Danley,1999 , South & Stumpff, 1990). As part of a continuing series of seedling quality studies, an experiment was designed to look at the main effects and interactions of three factors that affect seedling performance. These factors are as follows:

1) Seedling size (large or small) controlled by seed bed density at the nursery;
2) The method of lifting (hand or machine); and
3) The presence or absence of herbaceous competition during the first growing season.

METHODS AND MATERIALS

This study was installed to look at the effects and interactions of the treatments throughout the first two growing seasons. The study design was a 2 X 2 X 2 factorial randomized complete block with three replications. The seedlings were planted in row plots at a 1.2-m x 3-m spacing. A total of 840 measurement trees were measured for the variables of interest.

The seedlings for this study were grown at two densities (301/m^2) and (161/m^2) at a nursery in Marion County, Georgia. The seedlings were lifted either by hand or by a two-row Mathis belt lifter, stored under refrigeration for two days and planted by researchers. The study was installed on a small field dominated by bermudagrass (*Cynodon dactylon)* and bahiagrass *(Paspalum notatum)*, which provided a high level of uniform competition throughout the growing season. The study plots either received total weed control throughout the growing season or no weed control. Planted heights and root collar diameters were measured at the time of planting. At the end of the first year, survival, height, and ground line diameter were measured.

In addition to the planted seedlings, 120 seedlings were destructively sampled for morphological characteristics; thirty trees from both densities and lift methods. Measurements taken from these seedlings included root collar diameter, dry shoot weight, and dry lateral and taproot weight.

RESULTS AND DISCUSSION

Seedling Sample Results

Seedling caliper was positively affected by lower seedbed density. Mean root collar diameter (RCD) was 5.7 mm for the seedlings grown at the higher seed bed density while the lower density seedlings had a mean diameter of 7.6 mm. The lifting method had a significant effect on lateral root weights where the hand lifted seedlings had greater dry weight than did the machine lifted seedlings. Total root weight was also affected by density where high-density seedlings had significantly less total root weight than did the low-density seedlings. Seedling diameters and weights by bed density and lifting method are presented in table 1. Significance levels for the treatment effects are presented in table 2.

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Table 1— Dry weight means (grams) for the treatments from 120 seedlings sampled for morphology

Seedbed Density	Lifting method	Shoot weight (g)	Taproot weight (g)	Lateral root weight (g)	Total Root weight (g)	Shoot:Root ratio	RCD (mm)
Low	Hand	6.25	1.21	0.84	2.05	3.23	7.67
Low	Machine	5.71	1.21	0.74	1.94	2.98	7.61
High	Hand	3.45	0.57	0.72	1.29	2.74	5.61
High	Machine	3.25	0.57	0.47	1.04	3.38	5.71

Table 2— Significance levels for treatment terms in ANOVA models for the dry weights of the dependent variables from 120 seedlings sampled for morphology

Treatments	Shoot	Tap root	Lateral root	Total root	Shoot:Root	RCD
Significance	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr >F
Bed Density	0.000	0.000	0.009	0.000	0.726	0.000
Lift Method	0.25	0.979	0.014	0.143	0.185	0.798
Density X Lift	0.59	0.936	0.291	0.561	0.003	0.213

First Year Growth Effects

Seedbed Density—Although the lower seedbed density did produce larger seedlings, density was not a significant predictor of survival or height growth through the first year. This does not concur with previous experience or with published data (South and others 1995). Seedbed density was, however, a significant predictor of first-year volume and height. Further analysis was done using root collar diameter as a covariant to determine if there were any addition affects from seedbed density beyond seedling caliper differences. No additional variance was explained by bed density.

Lifting Method—Lifting method significantly improved first year survival and growth of seedlings. This affect can be explained by the greater retention of lateral root mass by the hand lifted seedling over that of the machine lifted seedlings. Table 1 shows that high density seedlings lifted by hand had nearly the same weight in lateral roots as did the machine lifted low density seedlings.

Herbaceous Weed Control—As expected, herbaceous weed control (HWC) significantly improved first year height growth, ground line diameter, survival, and volume index. The interaction of lifting method X HWC on volume index was significant at a 9 percent level of confidence. This interaction showed a greater positive response by hand lifted seedlings to weed control than those which were machine lifted, implying a more favorable response to silviculture from seedlings with more lateral root mass.

Significance levels for the treatments as they relate to the study plots are shown in table 3. First-year means for height and volume index are presented in figures 1 & 2 respectively. Table 4 presents the main effect means for the three randomized complete blocks. The means for all combinations of treatments are listed in table 5.

Table 3 – Significance levels for dependent variables for seedlings in three randomized complete blocks in South West, GA

Source of Variation	Percent survival	Volume index year 1 (cc)	Year 1 height growth (cm)	Year 1 height (cm)	GLD year 1 (mm)
Block	0.9911	0.8191	0.8211	0.9860	0.9851
Bed density	0.4091	0.0398	0.9231	0.0401	0.0068
Lift Method	0.0473	0.0254	0.0298	0.0162	0.0496
Weed Control	0.0473	0.0001	0.0003	0.0003	0.0001
Density X Lift Method	0.3159	0.4106	0.4652	0.3190	0.6555
Density X HWC	0.4091	0.9485	0.1564	0.1943	0.5189
Lift Method X HWC	0.4091	0.0974	0.1448	0.1293	0.2771
Density X Lift X HWC	0.7808	0.8004	0.8670	0.9221	0.9309

Table 4—Main effect means of survival, first flush length, height increment, and end-of-season height, ground line diameter, and volume index for seedlings planted in three randomized complete blocks in Southwest, Georgia in 2000

Level of Main effect	Survival (percent)	First flush length (cm)	Volume index year 1 (cc)	Height growth year 1 (cm)	Height year 1 (cm)	Ground line diameter year 1 (mm)
			DENSITY			
LOW	92 a	15 a	14 a	31 a	54 a	9.3 a
HIGH	95 a	13 b	11 b	31 a	49 b	8.3 b
			LIFTING			
HAND	97 a	15 a	14 a	34 a	54 a	9.4 a
MACHINE	89 b	13 b	11 b	29 b	49 b	8.4 b
			HWC			
YES	97 a	14 b	18 a	36 a	56 a	10.7 a
NO	89 b	15 a	7 b	26 b	47 b	6.9 b

A difference in letters indicates significant difference at p=0.05 from Duncan's multiple range test.

Table 5 – Year 1 means for all treatments from seedlings planted in Southwest, Georgia in 2000

Seedbed Density	Lift method	HWC	Survival (percent)	Height growth	Height	Diameter	Volume index
high	hand	no	93	25	43	6.3	5
high	hand	yes	100	41	59	10.7	19
high	machine	no	85	25	44	6.2	5
high	machine	yes	100	34	52	9.8	14
low	hand	no	96	30	53	7.7	9
low	hand	yes	99	40	62	11.7	24
low	machine	no	83	26	48	7.3	7
low	machine	yes	89	30	52	10.5	16

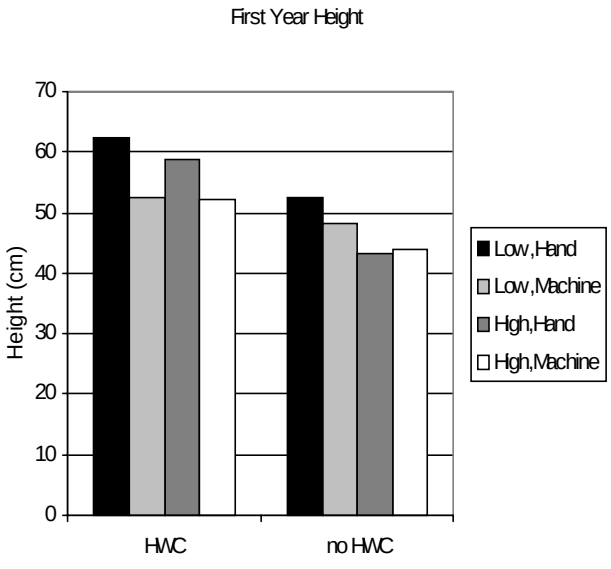

Figure 1— First year incremental height growth of the various treatments. Significant at p = 0.05 level on lifting method and weed control.

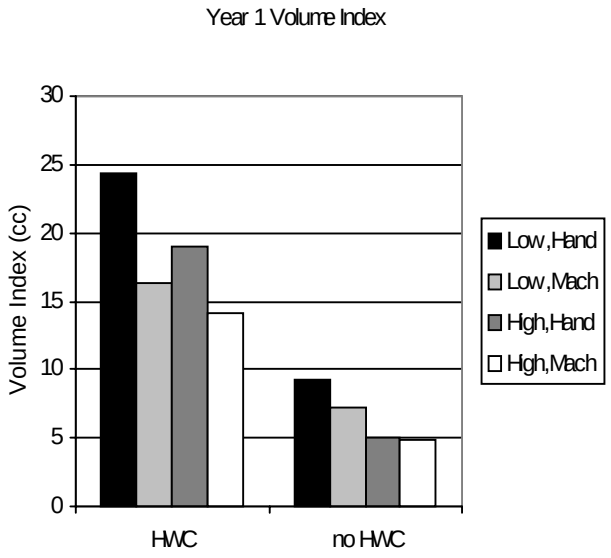

Figure 2—First year volume index of the various treatments. Significant at p = 0.05 for all treatments.

CONCLUSIONS

The results from this study indicate that seedling quality has a significant impact on first year performance of loblolly plantations. Larger seedlings have greater volume through the first year than do smaller seedlings. Hand lifting seedlings improves lateral root mass retention. As a result, hand lifted seedlings have greater first year growth and survival than machine lifted seedlings. Herbaceous weed control during the first year improves survival and growth of seedlings. Furthermore, there is some evidence to suggest that high quality, vigorous seedlings, respond more favorably to the silvicultural treatment of weed control.

Therefore, nursery practices that produce large caliper, vigorous seedlings, and lifting methods which limit damage to the seedling's stem and root system are encourage due to the seedling's superior performance in the field. In order to realize the full benefit of the investments of silvicultural treatments in a plantation, the use of high quality seedlings that are cared for properly should be considered a key tool to plantation success.

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