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Effect of Planting Depth on the Survival and Height Growth of Container-Grown Longleaf Seedlings

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Introduction

It is well documented that bareroot longleaf seedlings are sensitive to planting depth. Planting bareroot longleaf seedlings too shallow where the root collar is exposed decreases survival (Wakely 1954). Similar research is not available for container-grown longleaf seedlings. It has been suggested that if containerized seedlings are planted shallow increased mortality will result due to a"wicking effect" thought to dry out the seedling's root system (Larson 2000, White, et.al. 1988). To avoid this we are encouraged to plant seedlings with the plug just below the soil surface, but with the terminal bud exposed above the surface (Goodwin 1978). Soil movement can both expose the seedlings tap root or cover its terminal bud. Additionally, tree planters tend to plant longleaf seedlings too deep thereby covering the terminal bud. This study examines the effect of planting depth on container grown longleaf seedlings. The study hypothesizes that incorrect planting depth is detrimental to container-grown longleaf seedling survival and subsequent growth. Seedlings planted too deep will have increased mortality rates and delayed height growth initiation. Shallow planted seedlings will have increased mortality due to the drying out of the exposed root plug. The first study was established in February 2003 and was followed by a second in November of 2003. First year survival rates are reported for both test sites as well as second year survival and growth data for the first test site.

Methods

The study is located in southeastern North Carolina at the Bladen Lakes State Forest on a Keenan fine sand soil. The study site is a former cutover tract that was treated with glyphosate herbicide prior to planting the longleaf container seedlings. Seedlings were hand planted using a "potapukee" tube-type planting tool. Adjusting the foot plate allowed us to vary the planting depth. Precise depth control proved difficult due to variations in the length of the seedlings plug . The seedling plug ranged from 4.0 to 4.5 inches long and averaged 5.5 cubic inches in volume. Five planting depths examined in the study are: 1) Container plug at ground level, 2) Container plug exposed-½ inch above ground level, 3) Container plug exposed-1 inch above ground level, 4) Container plug exposed-2 inches above ground level, and 5)

Figure 1. Longleaf seedling with terminal bud exposed approximately 1-inch above the ground level.

Figure 2. Longleaf seedling with terminal bud covered approximately 1-inch below ground level

Container plug covered-1 inch below ground level. The treatments are replicated six times in a randomized complete block design with 20 seedlings per treatment per rep. Seedling survival was tallied every 2 months the first year and both height and seedling survival measured at the end of 2 growing seasons in February 2005. Measurement data was analyzed using Duncan's multiple range test.

Results

Survival

Test #1

After one growing season survival is statistically not different across all treatments. Survival ranges from 68% to 78%. Numerically the deep-planted seedlings have the best survival rate at 78% Visually however, they are much smaller with fewer needles and appear to be having difficulty pushing new needles to the surface. Uncovering the deep-planted seedling bud revealed the needles to be chlorotic and crinkled up. A majority of the shallow depth seedlings were generally healthier looking with a dense needle tuft and green needle color.

By the end of the first growing the exposed taproot of the seedlings planted 1 1/2 inches above the soil surface appeared to have callused over with bark. The degree of protection provided by the newly formed bark, particularly from fire, is still in question. By the end of the second growing season survival across all planting depths was, although 3 to 8 points lower, statistically the same. Interestingly the biggest drop in survival was seen in the deep planted treatment. Numerically the 1-inch deep seedlings and the 1/2-inch shallow seedlings had the highest number of seedlings alive. The 2-inch shallow seedlings have the lowest number of seedlings alive and thus the poorest survival rate. Differences in survival rate decreased at the end of the second growing season. Treatment 5 (deep planted) had a higher number of seedlings die in the second growing season. Table 1. summarizes the results.

Table 1. Test #1 seedling survival as measured in # seedlings alive at end of 1st and 2nd year

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Treatment	# seedlings alive (mean) **		% survival	
	Year 1	Year 2	Year 1	Year 2
4) 2 " Shallow	13.7 a	13.0 a	68%	65 %
1) Even	14.3 a	13.2 a	72 %	66 %
3) 1" Shallow	14.5 a	13.3 a	73 %	67 %
2) 1/2 " Shallow	15.0 a	14.0 a	75 %	70 %
5) 1" Deep	15.7 a	14.0 a	78 %	70 %

values followed by the same letter are not significantly different P = 0.05)

Test #2

At the end of one growing season survival rates for the seedlings in Test #2 were poor, but statistically not different across all planting depths. The author has not determined the reason for the poor survival rates which ranged from 34 percent (2" shallow) to 47 percent (1" shallow). The deep-planted treatment ranked fourth at 41percent. For both test sites first year survival rate was numerically the lowest for the 2-inch shallow planted seedling, but was not significantly different at p=0.05. These results are similar to those reported for Test #1. Table 2 summarizes the results from Test #2.

Table #2. Test #2 seedling survival as measured in # seedlings alive after one growing season

Treatment	# seedlings alive (mean) **	% survival
4) 2 " Shallow	6.8 a	34%
1) even	8.8 a	44%
3) 1" Shallow	9.3 a	47%
2) 1/2 " Shallow	8.0 a	40%
5) 1" Deep	8.2 a	41%

** values followed by the same letter are not significantly different (P = 0.05)

Height Initiation

Test #1

Height growth measurements were taken (Test #1 only) at the end of the second growing season. We defined height as the distance from the ground surface to the tip of the terminal bud. Seedlings less than 5" in height were determined to be in the grass stage and were recorded as zero inches tall.

Figure 3. This photo illustrates the height differences measured in the study. From left to right is Treatment 3 (1 -inch shallow), Treatment 5 (1-inch deep), and Treatment 1 (even)

Table 3. Height (inches) after 2 growing season and % of seedlings initiating height growth

Treatment	Height—end of year 2	% Initiating Height Growth
3) 1" Shallow	12.0 a	81% a
1) even	10.6 ab	72% a
4) 2 " Shallow	10.4 ab	78% a
2) 1/2 " Shallow	7.8 b	63% a
5) 1" Deep	3.0 c	31% b

Table 3 shows the average mean heights for the five planting depths.

** values followed by the same letter are not significantly different (P = 0.05)

Seedlings in the shallow planted treatments were significantly taller than the deep-planted ones. Treatment 3 had the highest number of seedlings initiating height growth at 81% and the greatest mean height at 12 inches. Heights of seedlings planted at 1-inch above, even with, and 2-inches above ground level are not significantly different. Height of seedlings planted 1-inch deep average 3.0 inches tall, significantly less than any other planting depth. The deep planted treatment had the fewest seedlings initiating height growth at 31%.

Conclusions

The data shows that seedlings planted with the plug exposed survive and grow at rates as good as those planted with the plug even with the soil surface and better than the deep planted plugs whose terminal bud is covered with soil.

No significant difference in survival is found when container grown seedling are planted with the plug exposed. Deep-planted seedlings where the terminal bud is covered with soil also did not show increased mortality. However, height growth initiation and subsequently second year height was significantly less for the deep planted seedlings. Increased risk of mortality and a delay in height growth initiation with deep planted longleaf seedlings is also more likely on heavy textured soils. Study results are similar to those reported by Hainds of the Longleaf Alliance (Hainds 2003). Hainds concluded that container grown longleaf seedlings appear tolerant of "shallow planting" where the plug is exposed. He discredits the "wicking theory" and suggests that most planting depth guidelines for longleaf containerized seedlings are incorrect.

This study and similar research by the Longleaf Alliance support the importance of keeping the terminal bud exposed. Seedlings planted with the terminal bud beneath the soil surface remain in the grass stage longer and experience reduced early height growth. On flat-planted sites tree planters should assure that the terminal bud is positioned above the soil surface even if that causes the plug to be exposed. Tree planters should also anticipate conditions where longleaf seedlings terminal bud is likely to become covered by soil and adjust the position of the plug so the bud remains exposed. On scalped sites this may require leaving one inch or more of the plug exposed. On bedded sites determining how much and how quickly a soil settles is difficult and depends on soil texture (which often changes across the planting site). Too often longleaf seedlings are planted too deep and even after the soil settles the bud is covered. For a bedded site position the terminal bud should be planted at or slightly below the soil surface so that it remains above the soil surface after the bedded soil has settled. For all planting conditions it is better to plant shallow than deep.

As a word of caution, Hainds and Pickens observed that the exposed tap root of shallow planted seedlings is sensitive to freezing . They are more likely to suffer freeze damage if exposed to temperatures below freezing than seedling whose root color is below the soil surface.

Additionally, some are concerned that shallow planted seedlings are susceptible to prescribed burn especially while in the grass stage. This concern requires further research, but visual observation show that the taproot begins to callus over with bark tissue shortly after exposure. Formation of bark tissue provides a degree of protection.

Figure 4. This photo depicts freeze damage to a shallow planted seedling that occurred as result of the taproot being exposed to nighttime temperatures in the low teens.

Literature Cited

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