



Effects of Extended Cold Storage on the Survival and Performance of Container Grown Longleaf Seedlings

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Abstract: - This study evaluates the effects of extended cold storage on the survival and growth performance of container grown longleaf seedlings. The seedlings were lifted on four different dates in October and November, stored, and out-planted every two weeks up to a 10 week storage length. Seedlings were measured for: 1) Survival at age one, 2) number out-of-grass stage at age two, 3) height at age two, and 4) height and DBH (*diameter at breast height*) at age eight.

The study shows that length of storage affects the survival and performance of container grown longleaf pine. Survival was significantly lower for seedlings stored longer than six weeks. Storage for more than two weeks reduced the number of seedlings that initiated height growth and height of those seedlings at age two. Affects of storage length on growth are still present at age eight. At age eight, seedlings stored two weeks or less have significantly better height and DBH. A significantly higher number of seedlings not stored, or stored for only two weeks, initiated height growth at the end of two years than those stored longer than four weeks. The date seedlings are lifted had no apparent affect on survival, but did affect early growth. Significantly more seedlings lifted on October 2 or October 16 initiated height growth at age two than those lifted October 30th and November 13th. However, lift date affects on height and DBH were not retained and were not present at age eight. Planting date affected seedling survival and out-planting performance. Seedlings planted before mid-November are taller and have a higher percentage of seedlings out-of-the grass stage at age two. Study data suggest that for best survival and performance container grown longleaf seedlings should not be stored longer than two weeks. While not a part of this study results support the recommendation that fall planting improves early growth but does not necessarily improve survival.

Introduction

Research has documented the survival of bareroot longleaf pine (*Pinus palustris*) is significantly reduced by extended cold storage¹. Similar research for container

grown longleaf seedlings has not been conducted². An increase in the demand for containerized seedlings has occurred across the Southeast over the last decade. In response nursery production increased to its current level of thirty million seedlings annually³. To meet the needs of its customers, the nursery manager must store an increasing number of container longleaf seedlings for extended periods. Without storage, inventory losses to seedlings left on the benches exposed to extended periods of freezing temperatures are possible. Extended storage allows the nursery manager to utilize lifting and packing crews efficiently. Nursery managers need to know how long container longleaf seedlings can be stored without affecting out-planting survival. With this information decisions concerning lifting schedules, inventory control, and protecting the seedlings from freezing temperatures can be made.

Methods

The test was initiated in the fall of 2001 on a site at the Bladen Lakes State Forest in southeastern North Carolina. 120 container grown longleaf seedlings were lifted at the N.C. Division of Forest Resources Claridge Nursery on four different dates; October 5th, October 16th, October 30th, and November 13th. The 480 total seedlings lifted were boxed and stored at 35 degree Fahrenheit for periods of zero storage, two week, four week, six week, eight week, and 10 week. The 24 treatments



Figure 1. Bladen Lakes State Forest personnel helped measure height and DBH after 8 growing seasons.

(four lifting dates multiplied by six storage lengths) were planted in a 20 tree row random block design that was replicated four times. Survival counts were completed one year after out-planting in November. Two years after out-planting the surviving trees were counted and their height measured. Second year survival and percentage of seedlings initiating height growth was determined. Seedlings less than 4 inches tall were considered to still be in the grass stage. Total height and tree diameter at breast height was measured eight growing seasons after out-planting. Statistical analysis (Waller-Duncan K-ratio t test) was completed using SAS software.

Results

Storage Length

The length of storage prior has significant effect on survival and early growth of container grown longleaf pine seedlings. Numerically, seedling survival decreased as storage length increased. Survival at age one for seedlings stored up to six weeks was not significantly different statistically from those not stored. Seedlings stored for eight weeks and 10 weeks experienced a 12 point and 19 point drop in percent survival respectively (Table 2). These results are similar to those reported in previous unpublished studies. Empirical evidence in this and other studies suggest weather extremes and plant cold hardiness may impact seedling survivability. Performance as measured by height growth initiation after two growing seasons and height and diameter at breast measured after eight growing seasons was significantly affected by storage length. The percentage of seedlings out of the grass stage at age two and the height of those seedlings decreased the longer seedlings were stored.(table 1). At age two the number of seedlings out of the grass stage and the height of those seedlings

Table1. Percent number of seedling out-of-the grass stage at age two by length of storage and planting date. Significant differences for length of storage are shown (p < .0001).

	Percent Number Seedlings Out-of- Grass Stage						Mean	
	none	2 week	4 week	6 week	8 week	10 week		
2-Oct	96%	92%	79%	79%	60%	57%	77%	a
16-Oct	84%	99%	90%	89%	48%	42%	75%	a
30-Oct	81%	87%	76%	44%	53%	53%	66%	a
13-Nov	87%	90%	55%	64%	74%	82%	76%	a
Mean	87%	92%	75%	69%	59%	58%		
	a	a	b	b	b	b		

were significantly higher for seedlings stored two weeks or less. The number out of the grass stage ranged from 93 percent for seedlings stored two weeks to 69 percent for seedlings stored eight weeks. Seedling height at age two continued to decrease the longer the seedlings were stored. Seedlings stored 10 weeks were the shortest at 0.41 feet while those stored two-weeks were the tallest at 1.04 feet. The effects of storage length on longleaf pine growth were still present at age eight.

Lift Date

Differences in survival due to lifting date were found, but no clear trend was apparent. Survival for the seedlings lifted October 2 and November 13 (the first and last lifting dates), at 92 percent and 94 percent respectively, were significantly better than the October 16th and October 30th lifting dates with 80 percent and 78 percent survival. By the end of the second growing season after out-planting, 73 percent of the seedlings across all treatments had initiated height growth. Percent number of seedlings out-of-the -grass was 77 percent, 75 percent, 66 percent, and 76 percent for October 2nd, October 16th, October 30th, and November 13th lift dates respectively. Lift date did not have a statistically significant effect on height initiation (Table 1).

Planting Date

Significant differences by planting date were recorded for percent survival at age two. Percent survival for the October and November planting dates and the January 22nd date ranged from 88 to 92 percent. The December 13th and January 2nd dates were seven to 13 points lower at 81 percent and 79 percent respectively. The lowest mean survival was seen for the December 22nd planting date at 60 percent. The worst overall survival (38 percent) occurred for seedlings lifted in mid October and out-planted on December 22nd. The second poorest survival (50 percent) occurred for seedlings planted on December 22nd and lifted on October 30th (Table 3). At the end of the second growing season a significant difference (p<.0001) in percent number trees out of the grass stage and the height of those seedlings was found. It is suspected that minimum temperatures extremes after planting have adversely impacted seedling survival. Several days with night time temperatures below freezing were recorded after the planting days with the poorest survival rates. Overall, seedlings planted before mid November initiated height growth sooner and were taller at age two.

Table 2. Mean percent survival at age one by lift date and storage length

Percent Survival		
Mean Lift Date		
2-Oct	92%	A
16-Oct	80	B
30-Oct	78	B
13-Nov	94	A
Mean Storage		
None	93%	A
2week	92	A
4week	91	A
6week	90	A
8week	78	B
10week	71	C

Performance at Age Eight

Affects of storage length on longleaf pine growth are still present at age eight. Both height and DBH decreased as storage length increased. Height growth and DBH is significantly better for seedlings stored less than two weeks. At age eight seedlings stored less than two weeks were the tallest (Table 4). Lift date had no significant affect on height or DBH at age eight. After eight growing seasons overall height across all treatments averaged 11.6 feet. Average DBH was 1.9 inches.

Conclusions

- Length of seedling storage was found to have significant affect on survival and growth.
- Longleaf pine seedlings stored for two weeks perform as well as seedlings lifted and planted immediately.
- Longleaf pine seedlings stored as long as six weeks survive as well as seedlings not stored before planting.
- The longer longleaf pine seedlings are stored the worse they perform for all traits tested (Year 1 Survival, Number Out of Grass Stage at age two, Height at age two, Height-DBH-Volume at age eight).
- Adverse affects of increased storage time (greater than two weeks) on longleaf pine seedling productivity are still present at age eight.
- A significantly higher percentage of seedlings not stored or stored for two weeks emerged out of the grass stage sooner than those stored for four weeks or longer.

References:

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2. R.Kasten Dumroesen and J.P. Barnett 2003. In: Riley, L. E.; Dumroese, R. K.; Landis, T. D., tech coords. National proceedings: Forest and Conservation Nursery Associations—2003; 2003 June 9-12; Coeur d'Alene, ID; and 2003 July 14- 17; Springfield, IL. Proc. RMRS-P-33. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station
3. Hains MJ. 2002. Longleaf seedling trends. In: Barnett JP, Dumroese RK, Moorhead DJ, editors. Proceedings of workshops on growing longleaf pine in containers—1999 and 2001. Asheville (NC): USDA Forest Service Southern Research Station. General Technical Report SRS-56. p 3-4

Table 3. Survival at age 2 by planting date and lifting date. Differences in survival are significant for both planting date and lifting date and the lift date*plant date interaction (p<.0001)

Planting Date	Lift Date					mean
	2-Oct	16-Oct	30-Oct	13-Nov		
	3-Oct	92	.	.	.	92 a
	17-Oct	90	86	.	.	88 ab
	1-Nov	90	89	86	.	88 ab
	14-Nov	95	90	86	96	92 a
	29-Nov	88	90	92	90	90 a
	13-Dec	86	79	76	86	82 bc
	Sustained Freezing Temperatures at Planting Site 16-Dec-01					
	22-Dec	.	38	50	91	60 d
8-Jan	.	.	66	92	79 bc	
22-Jan	.	.	.	92	92 a	
mean	90 a	77 b	76 b	91 a		

Table 4. Average percent survival and growth data at age eight. Height and DBH values are significantly different at (p<.0001)

Storage Length	% survival	Height (feet)	DBH (inches)
None	76%	13.0 a	2.01 a
2-weeks	77%	12.6 a	1.93 ab
4-weeks	70%	11.6 b	1.94 bc
6-weeks	67%	11.2 bc	1.84 b
8-weeks	56%	10.7 c	1.76 cd
10-weeks	51%	10.2 c	1.62 d
Mean	66%	11.6	1.85