Auburn University
Southern Forest Nursery
Management Cooperative

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WARM NIGHTTIME TEMPERATURES (WITH TENTS) AFFECT TERMINAL BUDS OF LOBLOLLY PINE SEEDLINGS

by
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INTRODUCTION

Freeze injury to pine seedlings has become a frequent event over the past 2 decades (South 2006). In some cases, deacclimation has occurred due to warm weather events which increase the risk of freeze injury. Unfortunately, deacclimation of loblolly pine seedlings is often overlooked, in part because we have no guidelines that alert nursery managers to potential deacclimation events. Only a few research studies have addressed the deacclimation of pines with most of the research from more northern latitudes (Burr et al. 1990; Jokela et al. 1998; Ryyppö et al. 1998a; 1998b, Granhus et al. 2009).

A few questions have been raised with respect to warm weather events: what effect does deacclimation have on seedlings not exposed to freezing temperatures? Is deacclimation of any consequence if seedlings are lifted and outplanted and no freeze event occurs? The objective of this study was to determine if warm nighttime temperatures in January (using heaters and tents) will affect seedling biomass and root-growth potential of loblolly pine seedlings.

METHODOLOGY

Seed from loblolly pine (family 8-1514) were sown on April 24, 2008 and the seedlings were cultured using standard nursery practices. Natural chilling occurred and on January 26, three heated plastic tents were erected over the seedlings. Within each tent, heat was provided during four nights using a propane gas heater (Figure 1). In the morning, the tarp was removed so that seedlings could receive full sunlight. Tents remained in place for 14 to 16 hr per night. After 2 and 4 days, seedling samples were collected from under each tent and from adjacent areas that were outside of each tent (n = 6). Seedlings were then transported to Auburn University and were place in aquarium root growth potential (RGP) tanks for evaluation. The root-collar diameter was measured on each seedling.

On each sampling date, soil samples were taken from the top 15 cm of soil. Soil moisture was determined by comparing moist weights with dry weights (following 7 days of drying at 70° C). Seedling fresh weights were recorded and the percent moisture content was determined by dividing fresh weights by dry weight (and then subtracting 1). Root growth potential was determined 4 weeks later by counting all white root tips that were longer than 0.5 cm in length. New roots from the first sample date were counted on February 25 and seedlings lifted on the second date were counted on February 27. For each seedling, the terminal bud (i.e. a terminal with bud scales) was assessed and was declared either present or absent. Broken buds were counted if some bud scales were open. Regardless of bud status, terminals were classified as either elongating or not elongating.

RESULTS

The temperatures for treated and untreated seedlings are shown in Figure 2. For the duration of the study, the seedlings under the tents were exposed, on a daily average, to 10°F warmer temperatures than seedlings outside. During the night when heat was applied, temperatures inside the tent were 22°F (first night), 17°F (second night), 8°F (third night) and 15°F (fourth night) warmer than seedlings outside. The third night was windy which explains the lower differential while the fourth night was coldest but with not much wind.

The temperatures outside were above freezing (from 4 P.M. on the 26th till the end of the study on 11:59 A.M. January 30th). Temperatures inside the tent fell below 46° F only after 5:15 AM on January 29th.

At time of lifting, the tent/heat treatment had a significant effect on soil moisture and seedling biomass (Table 1). Root growth potential was affected by sample date but not by the tent/heat treatment (Table 2). A regression analysis indicates that RGP was related to sampling date and RCD (measured at the end of the RGP test).

Table 1. Effect of tent plus nighttime heat on soil moisture, seedling biomass and initial root collar diameter (study initiated at dusk on January 26, 2009).

Location of Seedlings		Out	Tent	Out	Tent	P>F tent	P>F date	LSD (0.05)
Sample date		1/28	1/28	1/30	1/30	--	--	--
Hours of tent/heat	hrs	0	16+15	0	15.5+14	--	--	--
Hours above 60 F	hrs	24.5	39.0	30.5	51.5	--	--	--
Maximum temperature	F	77.3	88.1	67.2	73.5	--	--	--
Minimum temperature	F	46.4	57.3	32.7	35.7	--	--	--
Soil moisture	%	12.2	5.7	8.2	5.0	0.0001	0.0001	0.83
Seedling Fresh weight	g	18.8	14.6	18.7	15.4	0.0003	0.5259	1.76
Seedling dry weight	g	7.8	5.5	7.0	5.8	0.0007	0.3345	0.97
Seedling moisture content (%)	%	140	166	169	168	0.0117	0.0151	15.7
Root collar diameter – initial	mm	5.3	5.2	5.3	5.2	0.5082	0.9385	0.70

Significant tent by date interactions for soil moisture (P>F = 0.0005) and seedling moisture content (P>F = 0.0241).

DISCUSSION

The amount of chilling accumulation by New Year's Eve was about average in 2008 (Figure 3). At Brewton, AL, there were about 222, 464, 640, 369, 417, 479, 380, 645, 265 and 444 h of chilling hours (<46 F) on New Years Eve for 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2007, 2008, respectively. This average for these years is 433 hours. By the beginning of the test (January 26, 2009), there were about 648 chilling hours and at the end of the test (January 30, 2009) there were about 672 chilling hours.

Rainfall

There was no rain on Jan. 26 and 27 but 1.02 inch of rain occurred during the early morning of Jan. 28th and the tents kept the rain off seedlings. Therefore, soil moisture at 9 AM on the 28th was affected by drying of soil and keeping rain from replenishing soil moisture. This likely explains the intereaction between sample date and tent/heat treatment (Table 1). As a result, the soil was about twice as moist in seedling beds that received rainfall prior to sampling. After 4 days, the soil under the tents had dried further to 5% soil moisture.

Seedling biomass

The tent/heat treatment had an effect on seedling biomass at lifting. The fresh weight was 21 to 29% greater for seedlings growing outside the tent vs. seedlings growing inside the tent. This suggests the tent/heat treatment dried out the seedlings. Suprisingly, the tent/heat treatment also reduced the dry biomass of seedlings. This difference might be due to: (1) greater nighttime respiration, (2) less photosynthesis, or (3) more soil adhearing to roots of seedings collected from outside the tent. The soil theory is supported by a lack of difference in either shoot or root dry weight for seedlings placed in the RGP tanks (Table 2). The average dry weight of "outside" seedlings was less than 6 g (vs 7 to 7.8 g for seedlings with soil). The root-collar diameter of treated seedlings at lifting was not statistically significant from seedlings grown outside.

Root growth potential test

The tent/heat treatment had no effect on root growth potential (Table 2) but the time of sampling was significant. Seedling lifted by Dr. South had about 11 fewer new roots than seedlings sampled by Dr. Enebak two days later. The tent/heat treatment had no significant effect on either root or shoot dry weight of seedlings in the RGP study.

Table 2. Effect of tent plus nighttime heat on root collar diameter (after the test), RGP, terminal buds, buds with open bud scales, and signs of active shoot growth (study terminated on February 25 and 27, 2009).

Location of Seedlings		Out	Tent	Out	Tent	P>F tent	P>F date	LSD (0.05)
Sample date		1/28	1/28	1/30	1/30			
Root collar diameter	mm	5.3	5.2	5.4	5.4	0.8133	0.3203	0.49
Root growth potential	#	19.8	19.0	32.2	31.4	0.6645	0.0003	4.2
Terminal buds	%	85	82	83	77	0.8027	0.5268	12.1
Buds open	%	48	36	54	57	0.1737	0.0048	7.6
Shoots elongating	%	32	44	45	50	0.1477	0.1120	12.5
Shoot dry weight	g	4.6	4.3	4.1	4.4	0.9578	0.1152	0.37
Root dry weight	g	1.3	1.1	1.2	1.2	0.1345	0.7082	0.14

The only significant tent by date interaction was for buds open (P>F = 0.0464)

Regardless of sampling date, the RCD of seedlings affected RGP (Figure 4). A regression analysis could account of 74% of the variation in RGP among 510 seedlings. The regression was: RGP = +9.5 (if seedlings sampled on Jan 30) + 4.8 (RCD in mm) – 4.6 (Replication number) – 6.0 (if the seedling had a bud). The tent effect (P=0.4145) was not significant but other variables were significant at P<0.001.

Terminal Buds

There was a significant interaction between the tent/heat treatment and sample date. Seedlings exposed to the most heat (51 hours >60° F) had the fewest terminal buds (77%). About half of the seedlings exposed to this amount of heat were exhibiting shoot growth at the end of the RGP study. In contrast, only 32% of the outside-grown seedlings sampled on Jan 28 (and exposed to the fewest amount of natural heat in the field) had elongating shoots after the RGP test (Table 2). An interesting observation involved a relationship between seedling size and terminal buds. In this study, large-diameter seedlings kept in a greenhouse for 4 weeks had fewer terminals with bud scales than did 3.5 mm seedlings (Figure 5). Apparently, for every 1 mm increase, there were about 10% fewer seedlings with a terminal bud.

MANAGEMENT IMPLICATIONS

The data from this study are not definitive, but they indicate that in the absence of a freeze, RGP was not affected by 2 or 4 nights of warm temperatures. The results do suggest that warm nights might encourage bud break and shoot elongation. Managers who wish to improve the RGP of their seedlings might consider ways to produce seedlings that have more roots and a larger RCD.

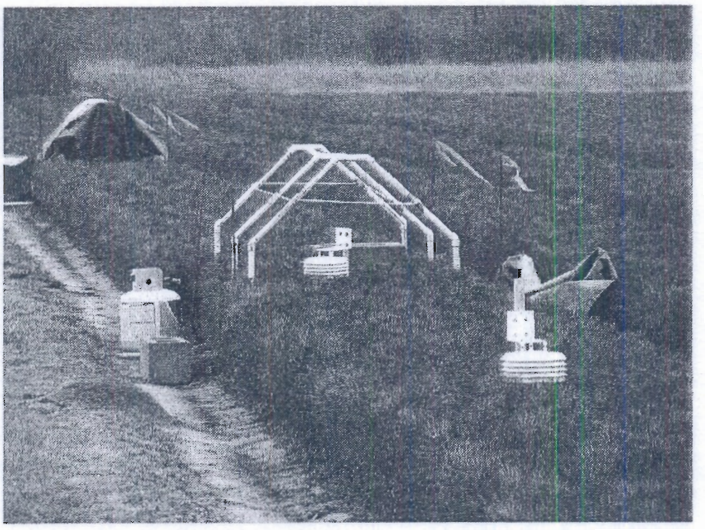

Figure 1. Seedlings under the tent were heated during the night with a propane heater and the tarp was removed each morning (approximately 7:30 AM).

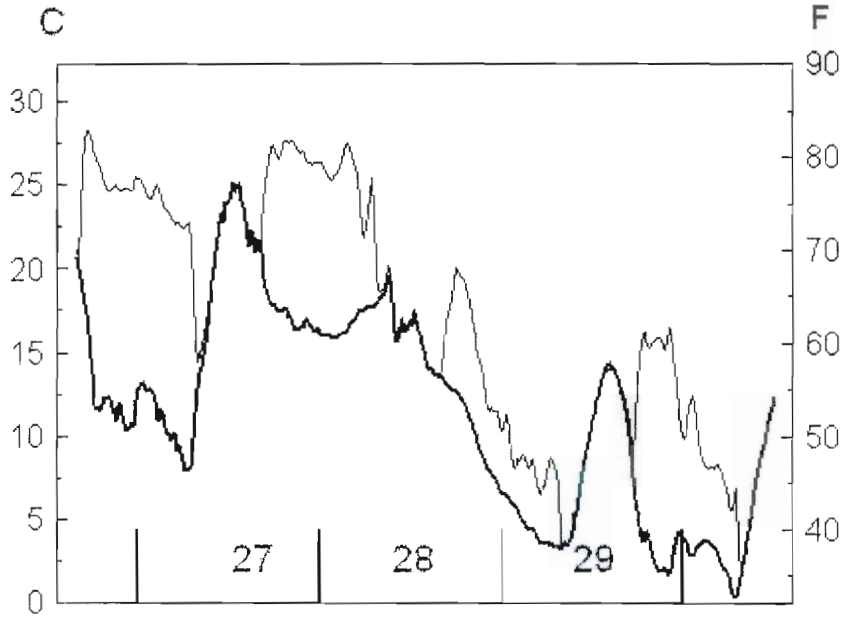

Figure 2. Temperatures at Rock Creek Nursery during the test period in January 2009. The thin line represents temperature under the tents while the thick line represents temperature outside the tent.

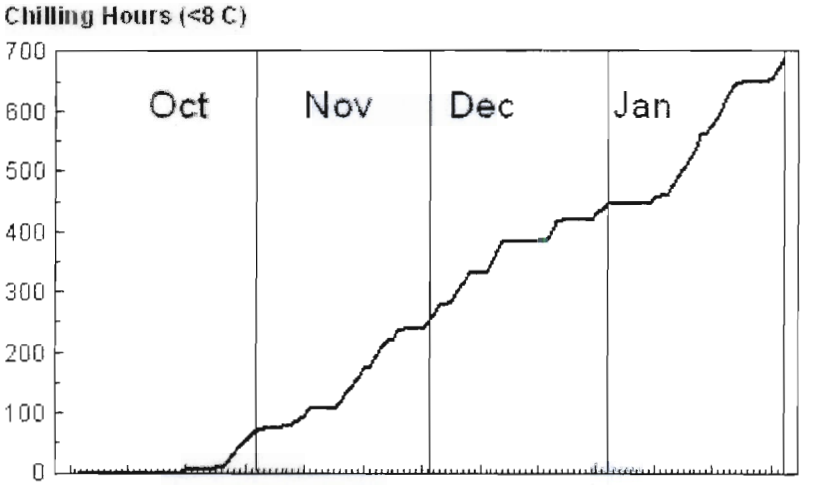

Figure 3. Estimated chilling hours (<46°F) for Brewton, AL for 2008-09.

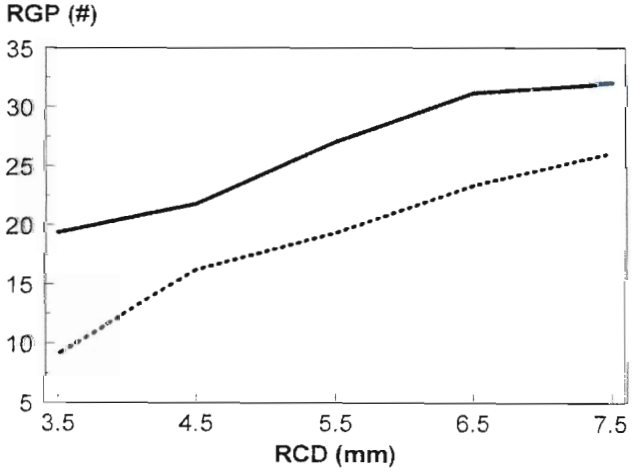

Figure 4. General relationship between RCD and RGP for seedlings lifted on January 28, 2009 (dashed line) and January 30, 2009 (solid line).

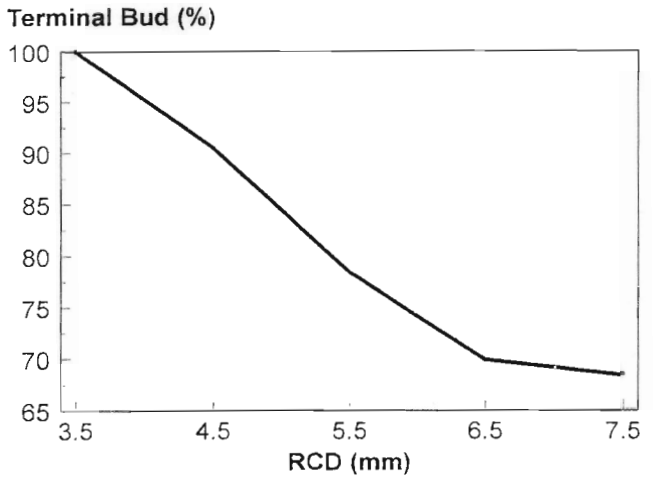

Figure 5. Relationship between the percentage of seedlings with a terminal bud (at the end of February) and RCD.

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