PREVENTION OF COLD DAMAGE TO CONTAINER-GROWN LONGLEAF PINE ROOTS

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Abstract-- When longleaf pine (*Pinus palustris* Mill.) seedlings are container-grown in open fields, their roots may be exposed to damaging, cold temperatures. Major losses in some nurseries have occurred. Between November 1996 and February 1997, we measured the cold hardiness of container-grown longleaf pine roots by measuring electrolyte leakage (a) of greenhouse-grown and growth-chamber hardened seedlings representing minimum and maximum cold hardiness, respectively, and (b) of outdoor grown seedlings. Minimum tolerable root temperature was 25 °F, which varied little with season; a few degrees lower was lethal. Weather records at the W.W. Ashe Nursery near Brooklyn, MS, showed that damaging temperatures occurred on 7 nights per year on average. Covering the seedlings with black plastic overnight held rootball temperatures 10 to 12 °F above ambient air temperature and saved the crop twice in December 1996. However, the best management strategy is to outplant seedlings before the onset of damaging, cold temperatures because once outplanted, the seedlings are safe.

INTRODUCTION

In recent years, the technology for growing longleaf pine in containers has been developed and has come into widespread use because of its success in field establishment and early height growth. However, container-longleaf pine is commonly grown in the open with the trays elevated for air pruning. This exposes the roots to ambient air temperature, which in winter can be cold enough to damage them, a situation that seedlings growing in the ground do not encounter.

In February 1996, a cold South-wide freeze received national attention because of the damage it did to fruits and vegetables. Also exposed to the freeze were some 400,000 container-grown longleaf pine seedlings at the USDA Forest Service W. W. Ashe Nursery in southern Mississippi. Following the freeze, the seedlings looked fine, so they were shipped to the ranger districts and planted, but a couple of weeks later they were all dying. It was determined that the seedling roots had been killed even though the tops were undamaged, so we initiated a study to find out:

(1) How low a temperature can the roots tolerate without damage, and how does this vary seasonally?

(2) When are damaging temperatures likely to occur and how often?

(3) What can we do to protect the seedlings?

Longleaf pine seedlings were grown at Flagstaff, AZ. during the summer. After reaching a suitable size the seedlings were put through a fall and winter simulation in a growth chamber while the rest of the seedlings remained in a warm greenhouse. Cold hardiness of the two groups was then measured, which determined maximum and minimum cold hardiness.

Meanwhile, Mary Anne Sword at Pineville, LA, measured cold hardiness of longleaf pine seedlings sent to her from the Ashe Nursery at two-week intervals from November 1996 through February 1997.

The electrolyte leakage test was used at both the Arizona and Louisiana locations. The tissue to be tested, root segments, was cut into reasonably uniform samples and placed in test tubes with a small amount of deionized water. Groups of tubes are frozen to a series of successively lower temperatures: then they are thawed and placed on a shaker for 24 hours. The conductivity of the solution is measured, and damage to the tissue from freezing will be indicated by the amount of electrolytes that has leaked out. Then the tubes are boiled to kill the tissue completely, shaken for 24 hours, and remeasured.

Using the two conductivity measurements for each tube, an index of injury is calculated. From a regression equation calculated from the whole data set, we calculate the temperature corresponding to the 10%, 30%, and 50% indices of injury.

Here is what we found: First, comparing the succulent greenhouse grown seedlings with the fully hardy seedlings from the growth chamber showed only a few degrees of difference in cold hardiness, so the seasonal variation is close to zero (Table 1). Second, the difference between temperatures that damage beyond being usable and those that do not is only a few degrees, so the margin for error is quite small.

These findings were corroborated in the Louisiana lab that winter. It was seen that, to the extent that there were any differences in cold hardiness during the late fall and winter, they were small, and maximum cold hardiness occurred in December and was lost in January and February (Figure 1). Therefore, the answer to the first question is simple: Do not let the roots get colder than about 26 °F at any time.

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Table 1--Cold hardiness of longleaf pine roots from a warm greenhouse and after hardening in a growth chamber.

Index of Injury (Percent)	Corresponding temperatures (°F)		Expected Damaged
10	26aA	25aA	Not significant will recover
30	25aA	22aA	Heavy damage not shippable
50	24aA	18bB	Dead

* Values with the same letter are not significantly different at p = .05. Lowercase is for columns, uppercase for rows

To assess the risk of damaging temperatures by month, 10 years of data from a weather station that had been operating at the Ashe Nursery since 1985 was used. At Ashe, the most risky period is December 15 to February 15. During an average year, there will be seven nights between December 1 and February 28 when exposed container longleaf may need protection, and 1 night every other year that may be so cold that they cannot be protected. Figure 2 illustrates the situation. In the winter of 1996-97, there were two occasions when the minimum temperature was below 26 °F, which could have damaged the seedlings.

How can the seedlings be protected? In March 1996 we tested covering the exposed seedlings with black polyethylene and found that overnight heat retention kept the rootballs 10 to12 °F warmer than the ambient outside air temperature, so here was a viable way to protect the seedlings from short-term cold spells.

In early December 1996 a hard freeze was forecast that would be cold enough to damage the longleaf seedlings, so the Ashe Nursery crew purchased all the black plastic they could find in three nearby towns in southern Mississippi and covered the crop. After the freeze, electrolyte leakage tests showed that there was no damage to the covered seedlings, but a sample of seedlings that were not covered were damaged, so the plastic cover worked. Plastic covers have saved the crop several times since, most recently January 3 through 5, 1999, when overnight air temperature got down to about 13 °F. The rootballs of seedlings covered with plastic did not freeze.

Incidentally, clear plastic is almost as good at retaining heat overnight as black. If the following day is sunny, it will be important to remove the plastic quickly before it overheats the seedlings. Covering with plastic may be a simple solution, but it is not cheap, or easy, especially if the wind is blowing. The best solution is to get the customers to take their seedlings and out plant them before any damaging cold weather hits. Once in the ground, with its large thermal reservoir, the roots of longleaf pine seedlings are safe. This was demonstrated in December 1996 by retrieving longleaf seedlings that had been outplanted before the freeze and had endured it in the field. The electrolyte leakage test showed no damage to the roots.

Unlike bare-root seedlings, outdoor grown container stock is ready to go to the field any time during the fall, so there is no reason not to begin planting the seedlings as soon as there is sufficient moisture in the soil. This may involve educating tree planters who are not aware of the difference, but it would entirely avoid the need for heroic efforts to protect the seedlings at the nursery.

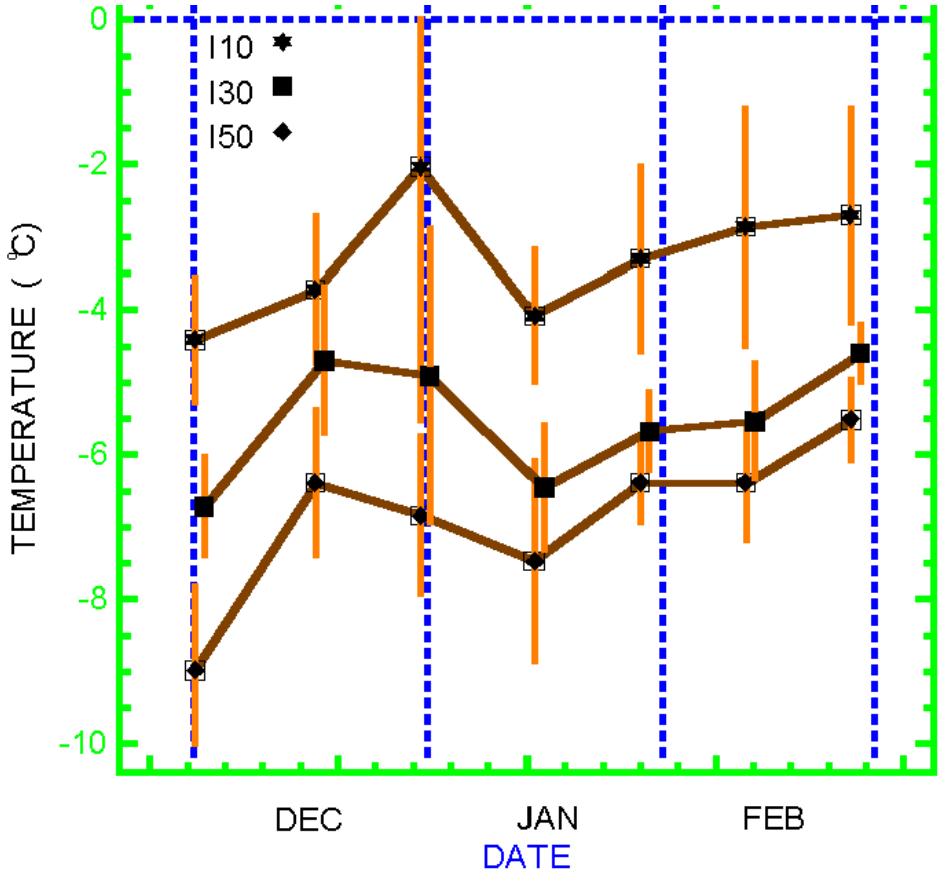

Figure 1--Root cold hardiness, as measured by index of injury, of container-grown longleaf pine seedlings from the W.W. Ashe Nursery, Brooklyn, MS, December 1996 to February 1997. Error bars are the 95% confidence interval.

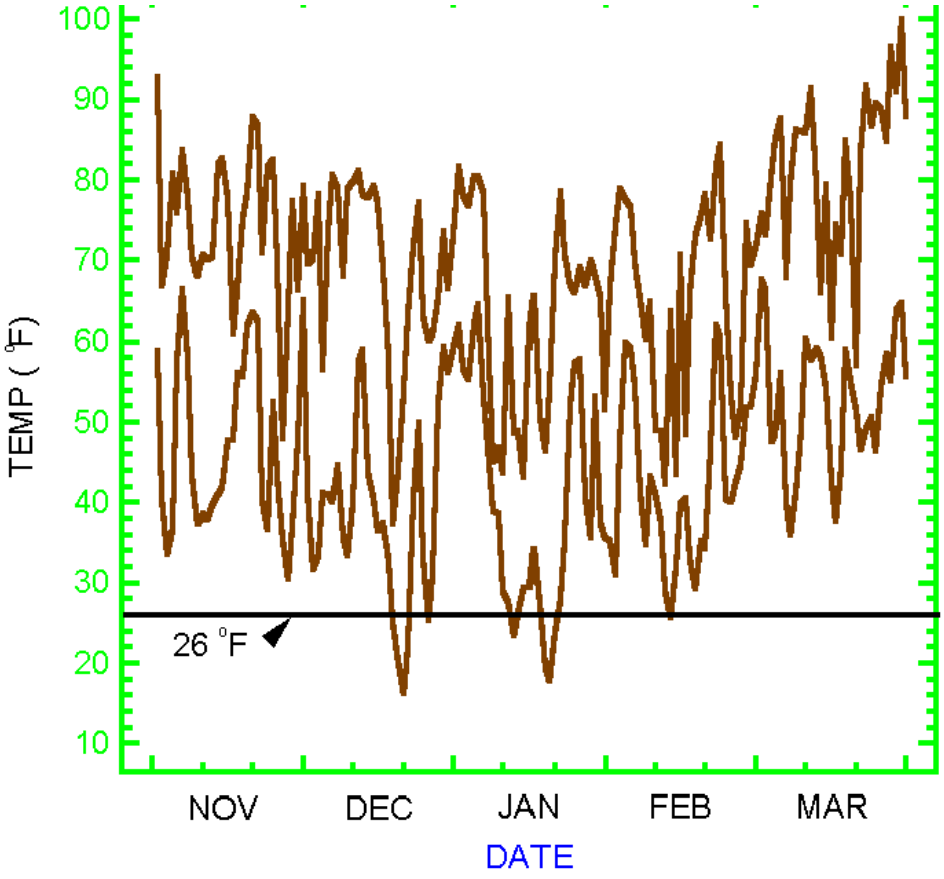

Figure 2--Daily maximum and minimum temperatures at the W.W. Ashe Nursery, Brooklyn, MS, November 1996 to March 1997. Horizontal line at 26 °F is the threshold for root damage; This shows that seedlings would have needed protection on two occasions that winter.