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 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 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 within several weeks they were all dying. We 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?

COLD HARDINESS

We grew longleaf pine seedlings at Flagstaff, AZ, during the summer. After reaching a suitable size the seedlings experienced a fall and winter simulation in a growth chamber while the rest of the seedlings remained in a warm greenhouse. We then measured cold hardiness of the two groups, which determined maximum and minimum cold hardiness.

Concurrently, at Pineville, LA, we measured cold hardiness of longleaf pine seedlings from the Ashe Nursery at 2-week intervals from November 1996 through February 1997.

We used the electrolyte leakage test at both the Arizona and Louisiana locations (Rietveld and Tinus 1987, Burr and others 1990). We cut the root-segment tissue into reasonably uniform samples and placed them in test tubes with a small amount of deionized water. We froze groups of tubes at a series of successively lower temperatures; then thawed and placed them on a shaker for 24 hours. We measured the conductivity of the solution, and damage to the tissue from the amount of electrolytes that leaked out. Then we boiled the tubes to kill the tissue completely, shook them for 24 hours, and remeasured.

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

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 is only a few degrees between temperatures that damage seedlings beyond being usable and those that do not, so the margin for error is quite small.

We corroborated these findings in the Louisiana lab that winter. Differences in cold hardiness during the late fall and winter were small. Maximum cold hardiness occurred in December and was lost in January and February (fig. 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) Nonharded	Hardened	Expected damage
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=0.05. Lowercase is for columns, uppercase for rows

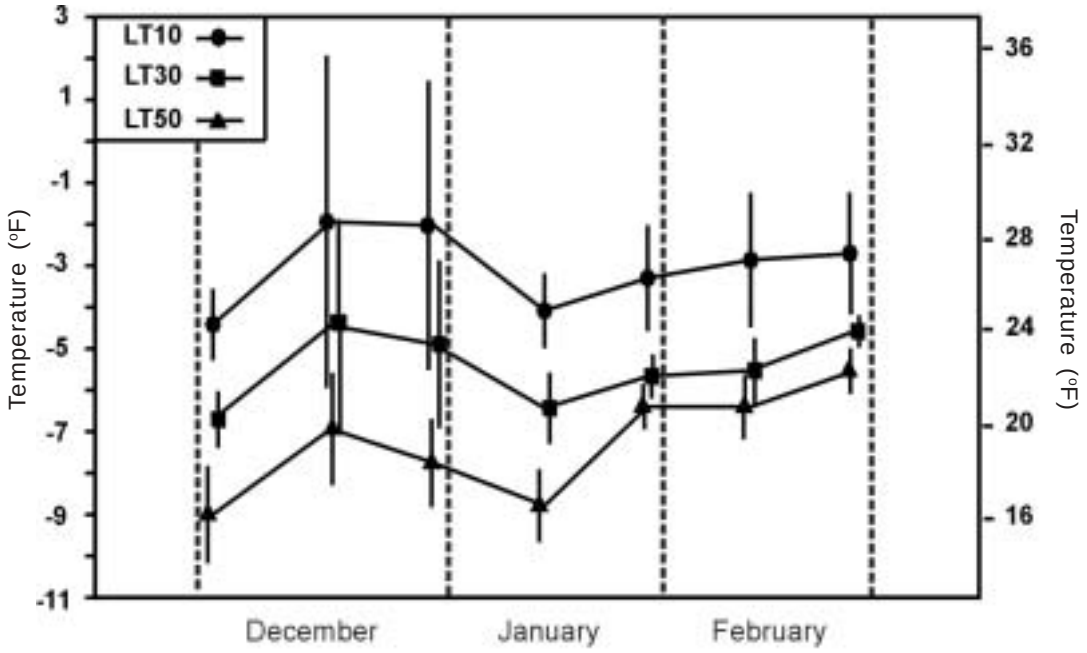

Figure 1—Root cold hardiness of longleaf pine seedlings grown at the USDA Forest Service W.W. Ashe Nursery in Brooklyn, Mississippi during 1996. Temperatures associated with an index of injury equal to 10 percent (LT10) are the minimum temperature without significant damage to seedlings. Temperatures associated with indices of injury equal to 30 percent (LT30) and 50 percent (LT50) are temperatures at which seedlings will be damaged beyond use.

RISK PERIOD

To assess the risk of damaging temperatures by month, we used 10 years of data from a weather station that had been operating at the Ashe Nursery since 1985. At Ashe Nursery in southern Mississippi, 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 one 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.

PROTECTION

How can the seedlings be protected? In March 1996 when we tested covering the exposed seedlings with black polyethylene, overnight heat retention kept the rootballs 10 to l2 °F warmer than the ambient outside air temperature. Covering appears to be 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,

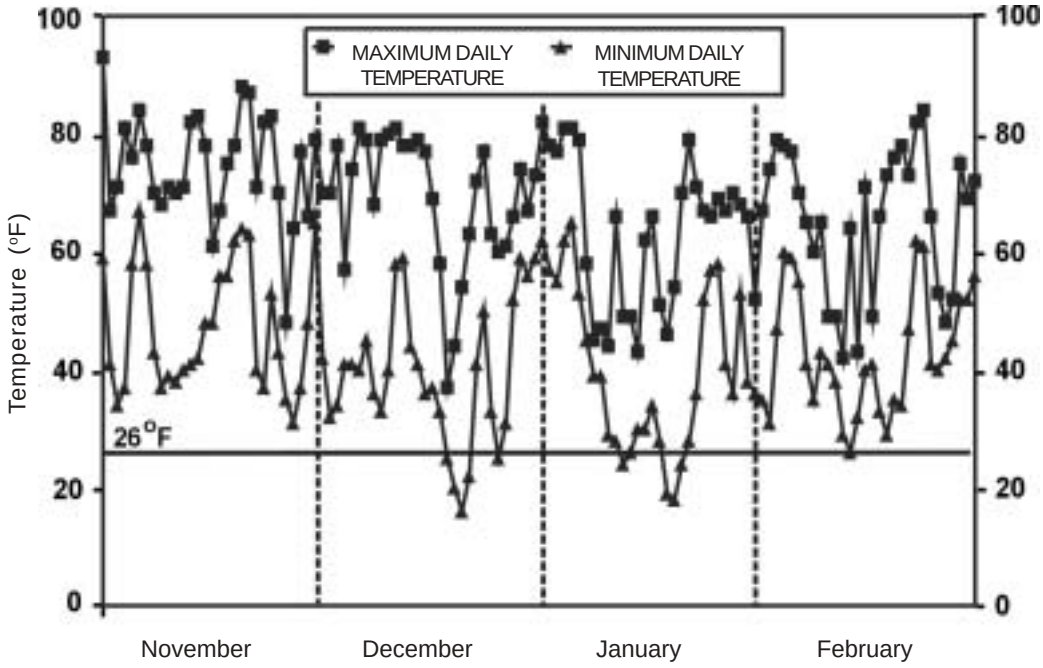

Figure 2—Daily maximum and minimum temperatures at the USDA Forest Service W.W. Ashe Nursery in Brooklyn, Mississippi in November 1996 through February 1997. On two occasions the exposed longleaf pine seedlings needed protection to prevent root damage by cold temperatures.

but a sample of seedlings that were not covered were damaged. Apparently, the plastic cover worked. Plastic covers have saved the crop several times since, most recently January 3 through 5, 1999, when overnight air temperature dropped to about 13 °F. The rootballs of seedlings covered with plastic did not freeze.

Incidentally, clear plastic works almost as well at retaining heat overnight as black. However, if the following day is sunny, it is 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 for customers to take their seedlings and outplant 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 method was demonstrated in December 1996 by retrieving longleaf seedlings that had been outplanted before the freeze. The electrolyte leakage test showed no damage to the roots.

CONCLUSIONS

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 strategy 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.

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