Long-Term Container Effects On Root System Architecture Of Longleaf Pine

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ABSTRACT

Longleaf pine (Pinus palustris Mill.) seedlings were cultured in three container cavity volumes and two cavity types (with and without copper coating for root pruning). Copper root pruning did not affect seedling height or dry weight growth three years after planting. Cavity volume significantly affected seedling field performance up to three years. Seedlings from small cavities (60 ml) were smaller than those from medium (93 ml) or large (170 ml) cavities. All excavated seedlings, regardless of cavity treatments, had about 56%, 37%, and 7% of their first-order lateral roots (FOLR) originating from the top, middle, and bottom thirds of the root plug. For Cu seedlings, the FOLR egress pattern was similar to the FOLR originating pattern. However, the non-Cu seedlings had similar amount of FOLR egress from each of the root plug zones. Still, Cu coating did not completely ameliorate seedling lateral root deformity as observed in the non-Cu seedlings. Sapling toppling was observed in Cu plots after Hurricane Gustav in 2008. More sapling toppling was recorded from all cavity treatment plots in August 2009. Possible causes of sapling toppling are discussed.

INTRODUCTION

Across the South, of the 33 million longleaf pine seedlings produced in the 2005-2006 planting season, 70% was container stock and the rest was bareroot stock (McNabb and Enebak 2008). This was a 7% increase for the container stock production from the year before. The trend of increasing production of the container stock continues even to date. One of the rationales for this increase is that container-grown seedlings usually have a higher survival rate than bare-root stock (South et al. 2005 and references cited therein). However, saplings from container stock, but not bareroot stock, have experienced wind-throw during high wind events (South et al. 2001). Some cavity improvements in the morphological quality of root systems in container seedlings were made to address this issue. For example, low concentration of copper (Cu) was used to coat the cavity wall to stop lateral roots from elongating once they reach the cavity wall and thus to decrease root spiraling (Ruehle 1985). Lodgepole pine (*P. contorta*) grown in Cu-coated containers had fewer leaning seedlings three years after planting than those from non-Cu containers (Krasowski 2003).

A study comparing the effects of container cavity volume and Cu root pruning on longleaf pine seedling performance and sapling stability was implemented in 2004 in central Louisiana, USA. Results for seedling growth and root system characteristics at planting and one year after planting were reported by Sword Sayer et al. (in press). Here, we present the container effects on growth and root system architecture of the seedlings three years after planting.

MATERIALS AND METHODS

Longleaf pine seeds of a Florida seed source were sown into containers in April, 2004. There were 3 cavity volume by 2 cavity coating factorial container treatments. Cavity top diameter (cm)/depth (cm)/volume (ml) for the small (S), medium (M) and large (L) sizes were 2.8/13.3/60, 3.6/14.9/93, and 4.2/15.2/170, respectively. Styroblock® and Copperblock® containers of the above-mentioned cavity dimensions were used for non-copper (R) and copper root pruning (Cu) treatments, respectively. Seedlings were grown for 27 weeks and planted at the Palustris Experimental Forest in central LA (31°11'N, 92°41'W) in early November 2004. The soil is a moderately well-drained, gently sloping Beauregard silt loam (fine silty, siliceous, superactive, thermic, Plinthaquic Paludult). The study was a randomized complete block factorial design with four replications. Each of the 24 plots had 144 seedlings planted at 2 x 2 m spacing.

Three years after planting, four seedlings from each plot were excavated with shovels in November, 2007. Seedlings were excavated at a 30-cm radius from the stem and to the depth of the deepest root. Dry weight allocation and woody root system architecture were assessed for each seedling. Each first-order lateral root (FOLR, > 3mm diameter) was recorded for its originating and egress zones (top, medium, and bottom) along the root plug. Egress of FOLR from the bottom end of the root plug was designated as the end zone egress.

Literature cited

Kormanik et al. (1998) South J Appl For 22: 117-123.
McNabb K, Enebak S (2008) Tree Planters' Notes 53(1): 47-56.
Ruehle JL (1985) Can J For Res 15: 586-692.
Ramsey CL et al. (2003) For Ecol Manage 172: 281-289.
South DB et al. (2001) Native Plant J 2:126-130.
South DB et al. (2005) For Ecol Manage 204: 385-398.
Sword Sayer MA et al. (in press) For Sci.
Tsakaldimi MM, Ganatsas PP (2006) Scient Hort 109: 183-189.

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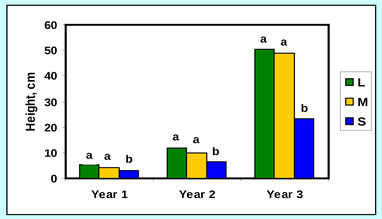
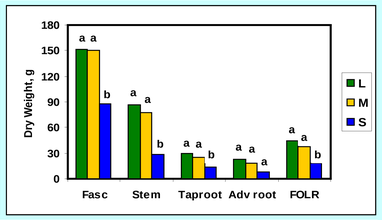
RESULTS AND DISCUSSION

Copper root pruning did not affect container stock longleaf pine seedling field performance three years after planting. Seedling number of FOLR was increased by the Cu treatment.

Copper root pruning did not significantly affect height (Ht), root collar diameter (RCD), or dry weight (DW) of the excavated seedlings (data not shown). Cavity type and volume significantly affected the number of FOLR. Copper increased the number of FOLR from 7.1 in R seedlings to 8.6. Seedlings of the L, M, and S cavities had 9.1, 8.3, and 6.2 FOLR. Number of FOLR has been reported to be associated with the growth of seedlings and young trees (Kormanik et al. 1998).

Increasing cavity volume showed persistent, positive effects on longleaf pine seedling growth three years after planting.

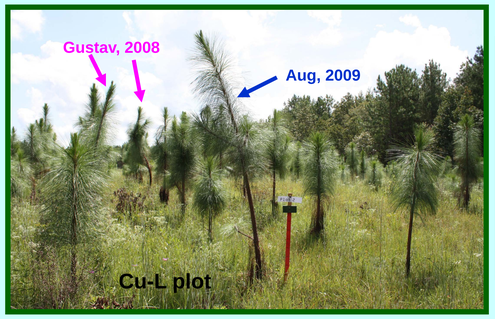




Cavity volume had significant effects on Ht growth for up to three years after planting (above left). Seedlings grown in the S cavities were the smallest for all three years. During the second year in the field, all L seedlings began accelerated Ht growth (i.e., stem bolting with a height of > 12 cm) whereas only 28% of M seedlings and none of the S seedlings bolted during the second year. During the third year, 84% and 69% of M and S seedlings bolted, respectively. Early height growth is critical for longleaf pine seedlings to compete with surrounding vegetation for resources such as light, water, and nutrients (Ramsey et al. 2003). Three years after planting, each of the S seedling components was significantly less in DW than its corresponding component in the L and M seedlings except for the adventitious root DW (above right). These results were similar to those reported by Sword Sayer (in press) for seedlings at planting and one year after planting.

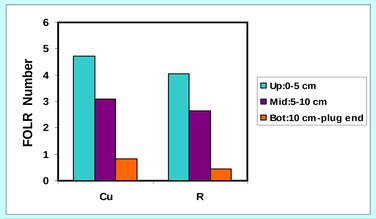
CONCLUSIONS

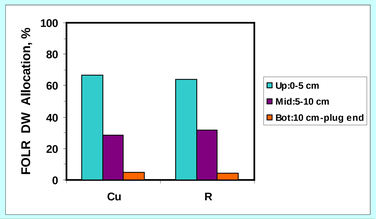
Copper root pruning treatment partially ameliorated lateral root deformity. Container cavity volume still affected seedling field performance three years after planting. However, the inherent characteristics of container stock such as limited taproot length and some lateral root deformity may still contribute to sapling stability in areas where strong wind events are not uncommon.



In 2008, Hurricane Gustav toppled several saplings in this study. A few seedlings from all container cavity treatments toppled or leaned in August 2009 when no strong winds were reported.

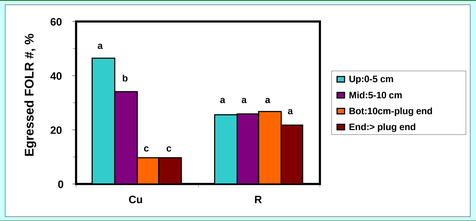
Copper root pruning treatment did not affect the number or DW allocation percentage of FOLR originating from each of the three root plug zones of the longleaf pine seedlings.



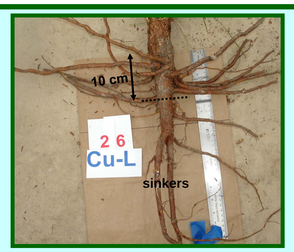


When FOLRs were grouped by their origination zones (top, middle, or bottom) on the taproots, cavity type did not change the number (above left) or DW allocation (%) (above right) of FOLRs in each root plug zone. The top root zone had the highest percentage of FOLR number and DW allocation followed by the middle root zone. Cavity volumes did not change FOLR originating pattern either (data not shown).

Copper root pruning treatment partially ameliorated lateral root deformity (e.g., spiraling, extending vertically instead of horizontally) imposed by the cavity wall.



Similar to FOLR originating patterns, FOLR egress patterns were not affected by cavity volume. However, Cu root pruning treatment changed the FOLR egress patterns significantly from that of the R seedlings (above). For R seedling, FOLR egress was evenly distributed among the four root plug zones, indicating that many FOLR were vertically trained. Within a Cu seedling root system, the top root plug zone had the highest percentage of FOLR egress followed by that of the middle zone. Both the bottom and the end root plug zones had the lowest percentages of FOLR egress in the Cu seedlings. These FOLR egress patterns remained similar to those reported by Sword Sayer et al. (in press) on younger seedlings. Although R seedlings had greater extent of FOLR spiraling within the root plug than the Cu seedlings, the latter still had some FOLR spiraling. These deformed FOLR may strangle each other or their taproots and further exacerbate the sapling stability problem.



A third year seedling from the large Cu cavity had most of its FOLR extending horizontally and root egress was mostly from the top 10 cm.

A third year seedling from the large regular cavity had some FOLR extending vertically or spiraling and root egress was mostly below the top 10 cm.