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Full Length Research Paper

Needle-clipping of longleaf pine (*Pinus palustris* Mill.) can increase seedling survival while reducing transpiration and root growth potential

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Clipping needles of longleaf pine (*Pinus palustris* Mill.) prior to transplanting has been shown to increase seedling survival but the mechanism for this effect is not well documented. A greenhouse trial was conducted to examine the effect of clipping needles on transpiration, root-growth potential (RGP) and seedling survival. Clipping longleaf pine needles to a length of 5 cm reduced transpiration and reduced RGP but it increased seedling survival by 34% points. Clipping to a length of 15 cm had an intermediate effect on these variables. The results support the common practice of clipping needles in the nursery.

Key words: Nursery, container, reforestation, seedling quality.

INTRODUCTION

Needle-clipping of bareroot longleaf pine is practiced to increase the probability of survival after outplanting (South, 1998). Some studies have shown that clipping needles before transplanting into the field can increase survival by 13% points. South (1998) speculated that the increase in survival might be due to a reduction in transpiration. Although there have been numerous clipping studies with bareroot stock, there has been little research with clipping needles of container-grown stock. In one study, Barnett (2004) reported that clipping needles back to a length of 5 cm reduced both root growth and diameter growth in the nursery. Not allowing needles to grow longer than 8 cm in the nursery is an extreme treatment and is not operationally practiced.

Barnett and McGilvray (1997, 2000) suggest that needles should not be clipped shorter than 15 cm. In one study, he reported that a single clipping to 10 cm reduced shoot mass by 20 to 37%, but when seedlings were outplanted in stressful conditions in July, early survival was increased by 22% points (2 months after planting, no-clipping = 15%; clipped = 37%). However, clipping did not improve survival when seedlings were outplanted in cooler months when soil moisture was likely higher. The objective of this study was to examine if needle clipping affects transpiration, root-growth potential (RGP) and survival of non-transplanted seedlings in a greenhouse.

METHODOLOGY

Longleaf pine seedlings were grown in containers at the International Forest Company nursery in Moultrie, Georgia. The root plug was 12.1 cm long with a top diameter of 3.9 cm and a cavity volume of 121.9 cm^3. The potting media (Berger Peat Moss, Quebec, Canada), consisted of 80% coarse sphagnum peat moss, 15% coarse grade perlite and 15% vermiculite. Seedlings were cultured using standard nursery practices. Seedlings were transported to the greenhouse at Auburn University where they were removed from the shipping box and placed into plastic "Cone-tainers" (Ray Leach Cone-tainer Nursery, Canby, OR, USA). The study involved three clipping treatments: 28-NoClip = no clipping, 15-Clip = clipped to 15 cm, 5-Clip = clipped to 5 cm. For the transpiration phase of the study, each experimental unit included 10 seedlings and there were 10 replications of each treatment (that is, 100 total seedlings per treatment). Clipping was conducted on January 25, 2010. Ten seedlings per treatment were placed in an aluminum tray and each tray was submerged in water for 3 min. Seedlings were not watered for 28 days. During the first 17 days, trays were weighed daily at 1:30 pm. On February 22, seedlings were re-watered and survival of seedlings (still in the containers) was recorded on March 11. To compare treatments at the same level of water loss, a "time delay" was calculated for each of the two

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Table 1. The effect of needle clipping on needle length, needle mass, water loss (per seedling), Root growth potential (RGP) and survival.

Treatment	28-NoClip	15-Clip	5-Clip	Linear contrast	LSD (α=0.05)
Needle length (cm)	28	15	5	--	--
Top dry weight (g)	2.7	1.9	1.0	--	--
Water loss by day 5 (g)	37.0	26.6	21.2	0.0001	2.7
Water loss by day 17 (g)	64.3	60.4	53.7	0.0001	4.1
RGP (#)	10.9	5.9	0.7	0.0001	2.3
Seedlings with no RGP (%)	6.3	12.5	62.5	0.0200	8.2
Greenhouse survival (%)	8	19	42	0.0001	12.6

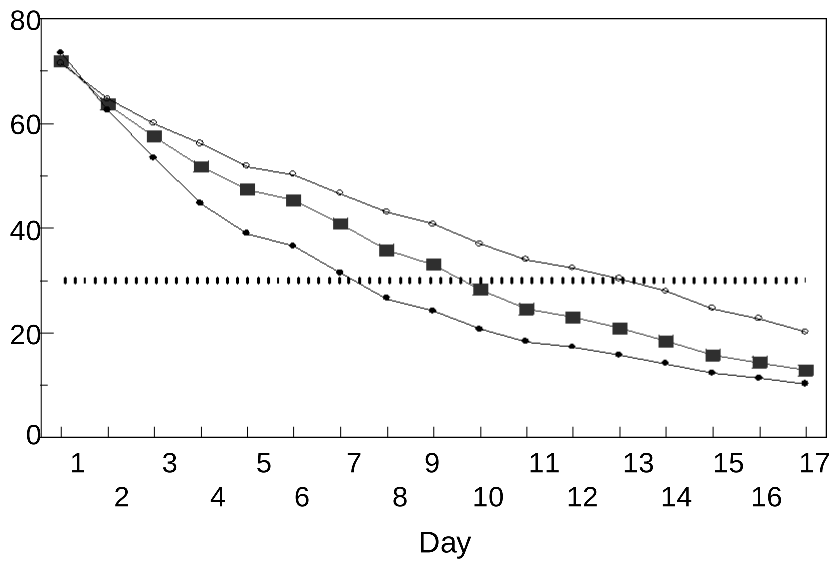

Figure 1. Effect of clipping treatment on water remaining in the media + seedling. 28-NoClip = bottom line, solid circle, 15-Clip = solid square, 5-Clip = top line, open circle

clipping treatments. To do this, an arbitrary stress level of 30 g of water per container was selected and then the date at which the seedlings reached the 30 g level was determined. A "gain in time" index was determined by subtracting the date obtained for the non-clipped seedlings from that for the clipped seedlings.

The root-growth potential (RGP) phase of the study was conducted simultaneously using 8 aquarium tanks (each representing one replicate). Each aquarium was aerated and contained 30 seedlings (that is, 10 seedlings from each treatment). After 44 days, the numbers of new white root tips (> 0.5 cm) were recorded.

Data obtained were subjected to analysis of variance using SAS computer software version 6.12. The experiment was arranged in a randomized complete block design with 3 treatments and either 8 or 10 replicates. Treatment effects were analyzed using a linear contrast test at α = 0.05 level of probability.

RESULTS AND DISCUSSION

The 15-Clip treatment removed about 30% of the shoot while the 5-Clip treatment removed about 63% (Table 1). As expected, the intact seedlings lost water more rapidly than that of clipped seedlings (P = 0.0001). The 15-Clip and 5-Clip treatments reduced water loss (by day 5) by 28 and 43%, respectively (Table 1). The 15-Clip treatment reduced RGP by 46% and the more extreme 5-Clip treatment reduced RGP by 94% (P = 0.0001). Clipping greatly reduced the number of seedlings that exhibited new root growth. Withholding water for 28 days killed many of the non-clipped seedlings. The 15-Clip treatment increased survival by 11% points and the extreme 5-Clip treatment increased survival by 34% points. The non-clipped seedlings reached the 30 g level on day 7.3 (Figure 1) while the 15-Clip and 5-Clip treatments reached this level on days 9.6 and 13.1, respectively. Daily water loss was initially greater for non-clipped seedlings (Figure 2).

Most of the loss in water occurred during the first 17

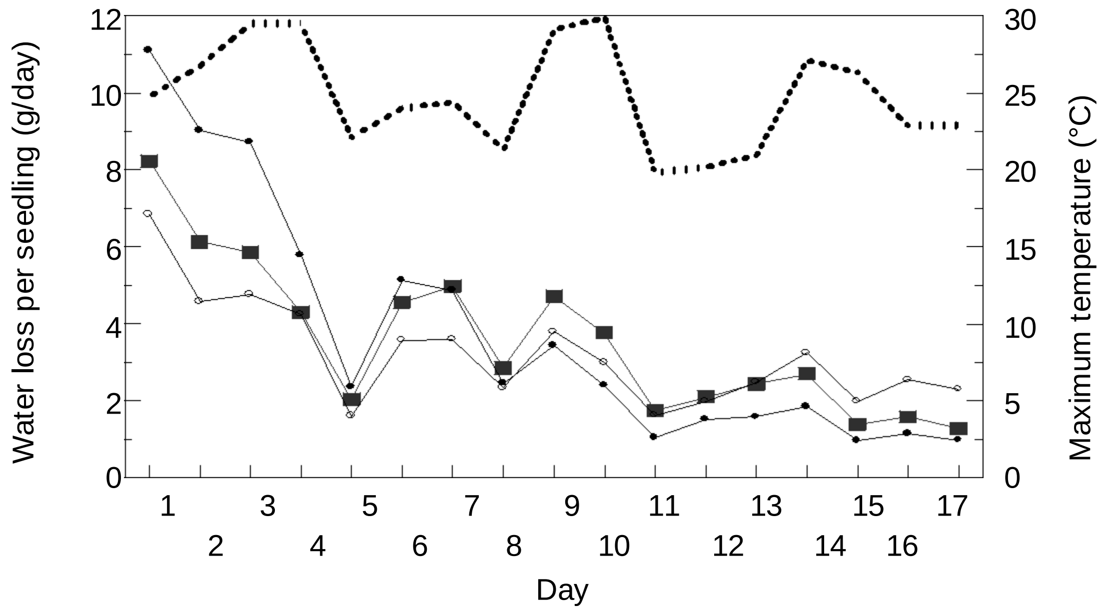

Figure 2. Water loss per seedling by day and clipping treatment. 28-NoClip = solid circle; 15-Clip = solid square, 5-Clip = open circle. Maximum daily temperature (dashed line) was highest on day 10.

days of the study. For each day, the amount of water loss appeared to be related to the maximum temperature for that day (Figure 2). The clipping treatments increased seedling survival, apparently by reducing the loss of water. The 5-Clip treatment increased survival in the greenhouse by 34% points even though RGP was reduced. In this study, the benefit of the clipping was apparently due to the reduction in transpiration. The "gain in time" index suggests the 15-Clip treatment reduced the onset of stress by an estimated 2.3 days. This supports the idea that needle-clipping longleaf pine seedlings may be beneficial to outplanting performance (South, 1998; Dumroese et al., 2009).

Results reported here support findings of an earlier trial established in 2008. In the 2008 study, needle clipping reduced both RGP and transpiration. The needles of longleaf pine were clipped to 20 cm and the seedlings (grown in trays) were placed either in a greenhouse or in a cool laboratory. After 3 days, control seedlings in the laboratory lost 250 g (per tray) while seedlings with clipped needles lost 140 g. Water loss was greater if seedlings were kept in the greenhouse (520 g for controls vs. 410 g for clipped seedlings). The trials demonstrate that needle clipping can reduce transpiration of longleaf pine seedlings. Researchers no longer have to presume that needle clipping reduces transpiration.

In both studies, RGP was reduced by clipping of needles. In the 2008 study, the RGP of longleaf pine seedlings was 29, 19, 6 and 0 for seedling that received (1) no clipping, (2) clip to 20 cm, (3) clip to 10 cm and (4) all needles removed, respectively. RGP decreased as more needle mass was removed with no RGP occurring when all needles were removed. Clipping seedlings to 20 cm reduced RGP by 34% (2008 study) while clipping to 15 cm (2010 study) resulted RGP by 46%. These findings support the statement that RGP of pines depends primarily on current photosynthesis. In these trials, RGP was of no benefit to the seedling since roots were prevented from growing into soil that contained moisture.

Other needle-clipping studies have been evaluated by outplanting seedlings into soil in the field. As a result, seedling stress may be minimized when rainfall keeps soil from drying out. Therefore, efforts by researchers to detect a difference in survival can be thwarted by a wet spring which minimizes stress. For this reason, some researchers plant seedlings in soil boxes where rainfall is eliminated by a roof or plastic tent. In this study, a quick stress treatment was imposed by (1) not planting the plugs into soil and (2) keeping both irrigation and rainfall from rewetting the plug. This treatment was able to kill some non-clipped seedlings after just 4 weeks of stress.

Barnett (1984) outplanted clipped container-grown seedlings in May, July and September. Clipping of small longleaf pine seedlings (average RCD 2.9 to 3.5 mm at planting) had little effect on survival in May (96% survival) or September (66% survival) when the seedlings were not under much stress. However, when outplanted in the hot month of July, survival (2 month) was 15% for non-clipped seedlings and 37% for seedlings clipped once (to 10 cm at week 13). This is a 22% point increase in initial survival of small container-grown seedlings. To increase the probability of survival, Dumroese et al. (2009) now recommend planting longleaf pine seedlings with a RCD ≥4.75 mm. Top-pruning of *Pinus taeda* and *Pinus elliottii* (at week 10) increased early survival (2 month) by 14% points (Barnett, 1984).

Although the 5-Clip treatment resulted in the greatest survival, this treatment is not recommended as an operational practice. First, results from this study are not directly applicable to the field, since (1) seedlings were not planted in soil and (2) growth after planting was not measured. Clipping needles short (to a 5 cm length and maintaining them at 5 cm) can reduce diameter growth in both the nursery and in the field (Barnett, 1984). Since longleaf pine is very sensitive to competition from weeds, it is important not to delay the time required to emerge from the grass stage.

An interesting aspect of this study involves the inverse relationship between RGP and survival. Seedlings with the most foliage had the highest RGP and the lowest greenhouse survival (Table 1). This suggests that under environments with limited and declining moisture availability, new root growth (within the plug) is not able to offset the loss of moisture through transpiration. In other words, new roots cannot extract moisture from the plug when transpiration has removed almost all the moisture. In contrast, new roots will likely be beneficial in studies where seedlings are transplanted into soil that contains moisture. For example, when a treatment reduces RGP, survival of bareroot longleaf pine seedlings planted in soil may be reduced (South and Loewenstein, 1994).

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