Auburn University
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NURSERY LIFTER OPERATION AFFECTS ROOT GROWTH POTENTIAL OF PINE SEEDLINGS

by
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INTRODUCTION

Nurseries take many precautions to minimize seedling injury during the lifting and shipping process. These include extra care to minimize root exposure following lifting, reducing the time in packing shed, spraying roots with acrylic-based gels, storing seedlings in a cooler, to shipping in refrigerated semi-trucks which have all been shown to have a positive effect on outplanting performance. Despite these precautions, seedling roots are still injured and damaged during the lifting process. Rowan (1987) found that lifting of bareroot seedlings can remove 35% to 77% of the small roots. Although there have been modifications made to seedling lifters by both manufactures and nurseries, examining the nursery bed behind any lifter today will still reveal numerous fine roots remaining in the soil. The purpose of this study was to determine what affect a lifter had on root growth potential (RGP), root biomass and morphology of seedlings lifted with either a 2-row or full-bed lifter run at 2 different speeds.

METHODOLOGY

Three bareroot nurseries located within the coastal plain region of the southern US were chosen for this study. At nursery A, slash pine were lifted on December 15, 2010 using a Mathis 2-row lifted and a Love full-bed lifter. At nursery B and C, loblolly pine was lifted on February 9 and February 23, 2011, respectively, using a Love full-bed lifter. Specific nursery information as to seedling densities, soil moisture and texture are presented in Table 1. Each lifter at each nursery was operated at two speeds; the normal speed used during lifting and then a faster speed that could be used by the nursery (Table 2). At each nursery, 80' of bed row was flagged for seedling sampling. Within the 80' section, each lifter was operated at the 2 different speeds which allowed for the collection of approximately 50 seedlings for each speed. This procedure was repeated at 4 locations at each nursery. Hand lifted seedlings, designated as control seedlings, were carefully

lifted from drill 3 using a shovel in each 80' plot at each nursery. Seedling parameters measured for each lifter at each nursery were root collar diameter (RCD), height, seedling biomass, root weight ratio, root morphology criteria and the number of white root tips >1/2 cm which is a measure of root growth potential (RGP).

RESULTS AND DISCUSSION

Nursery A used both a Mathis 2-row and a Love full-bed lifter. The 2-row lifter at normal speed was operated 6 times faster than the full-bed lifter at normal speed (Table 2). The 2-row lifter at normal speed also left an average 27% more fine roots in the soil compared to hand-lifted seedlings (Table 4). In addition, the root weight ratio, RGP, average root length and number of root forks (a rough estimate of mycorrhizae) all were significantly less for the 2-row lifter at normal speed compared to the hand-lifted seedlings (Table 3, 4). There was no difference for any root parameters between the normal and fast speed of the 2-row lifter (Table 3, 4). This indicates that increasing the speed did not affect seedling root characteristics for the 2-row lifter. Most nurseries have stopped using the 2-row lifter due to concerns which include the amount of fine roots left in the soil following lifting (Carey & South, 2001). Seedling survival in the Carey & South (2001) study reported survival of 2-row lifter seedlings was reduced by 40% compared to the hand-lifted controls.

The full-bed lifter at Nursery A had significantly less average root length, fewer root tips, forks and white root tips when compared to the hand-lifted seedlings. The reduction in both number of root tips and the number of white root tips can have a significant impact on outplanting performance. The removal of fine roots by the lifter is similar to root stripping which is sometimes conducted in the field by tree planting contractors. A single root stripping can reduce RGP by 47% (South and Stumpff, 1990). A measure of potential outplanting performance, RGP, in this study showed a reduction of 35% and 39% from the 2-row and full-bed lifted seedlings, respectively, compared to the controls (Table 3).

At Nursery B there was no significant differences between the full-bed lifter at normal speed and hand-lifted (control) seedlings for root biomass, root weight ratio, number of white root tips or root volume (Table 5, 6). The hand-lifted seedlings had significantly longer roots, more root tips and forks than the full-bed lifter operated at normal speed. These same root parameters were significantly greater for the full-bed lifter operated 18% faster than at the normal speed. Several factors may explain this; 1) that Nursery B had the wettest soil (10%) compared to other nurseries and the higher moisture level may have resulted in more root damage to the seedlings during lifting, and 2) it is possible that the optimum speed for this lifter may actually be greater than what is normally used.

Nursery C was the only nursery in the study that used a seedling lifter (undercutting) blade (Figure 1) on the full-bed lifter (Table 2). The only differences at this nursery was the full-bed lifter at normal speed had significantly more white root tips than either the hand-lifted seedlings or the seedling from the full-bed lifter operated at a higher speed (Table 7). However, when the faster speed was used at Nursery C, proper separation of the seedlings coming up the belt was not achieved, forcing us to "tear" the seedlings apart, injuring the roots which may explain the reduced RGP.

Figure 1. Love full-bed lifter seedling lifter bar in raised (unused) position.

When comparing root morphology for machine lifted and hand-lifted seedlings at Nursery A and B, the machine lifted seedlings had significantly shorter roots and less number of root forks than the hand-lifted seedlings (Table 4, 6). This may be an indication of the amount of tearing of the roots that occurred at Nursery A and B. However, at Nursery C there was no significant difference for the average root length and number of forks between the machine lifted and hand-lifted seedlings (Table 8). The use of the seedling lifting blade on the lifter at Nursery C may have allowed recovery of more roots on seedlings and reduced root damage.

MANAGEMENT IMPLICATIONS

One or two row seedling lifters should not be used to lift seedlings for outplanting due to their associated root damage to pine seedlings. Even if these lifters were operated at a slower speed, the repeated passes over the same bed still do not warrant their use.

Prior to lifting season, most nurseries overhaul and calibrate their full–bed lifter each year. Since lifter calibration and adjustments are specific to one speed, caution should be used when increasing tractor speed without adjusting the corresponding belts and/or beater bar speeds on the lifter. Without matching the two (belt and beater bar), seedling root damage can occur.

Some nurseries have modified the lifter for their specific soil type to facilitate the lifting operation. Nursery modifications of the lifter may allow speed changes without sacrificing seedling quality. Critical monitor of the seedling quality should be done when faster speeds that normal are used.

Separation of the seedlings coming up the belt is important. The use of the seedling lifter blade on the lifter was beneficial at nursery C. Some nurseries chose to make a separate undercutting

pass with a separate tractor just prior to lifting a bed to accomplish what the seedling lifter blade did at nursery C. The use of the lifter blade may also be beneficial on other soils/fields when lifting conditions are not optimum.

In the south, roots continue to grow throughout the winter. Therefore, nurseries should consider multiple lateral pruning's of the seedlings when the lifting season is spread over several months.

REFERENCES

Rowan, S.J. 1987. Nursery seedling quality affects growth and survival in outplantings. Georgia Forestry Commission, Georgia Forest Research Paper # 70. 15 p.

South, D.B. and N.J.Stumpff. 1990. Root stripping reduces root growth potential of loblolly pine seedlings. Southern Journal of Applied Forestry 14:196-199.

South, D.B. and W.A. Carey 2001. One or two-row lifters affect seedling survival. AUSFNMC Research Report 01-1. 6p.

Table 1. Nursery, species, seedling density, date lifted and nursery soil characteristics of the three nurseries examined.

Nursery	Species	Seedling Density	Date Lifted	Soil Moisture	%		
					Sand	Silt	Clay
A	Slash	21/sq ft	12/15/2010	7.1%	84	9	7
B	Loblolly	23/sq ft	2/9/2011	10.1%	83	9	8
C	Loblolly	21/sq ft	2/23/2011	6.4%	74	15	11

Table 2. Lifter type and lifting speed used to remove seedlings from nursery beds.

Nursery	Lifter	Lifter Blade Used?	Normal Speed	Fast Speed
A	Mathis 2-row	-	1.50 mph	2.00 mph
A	Love Full-bed	No	0.25 mph	0.50 mph
B	Love Full-bed	No	0.33 mph	0.39 mph
C	Love Full-bed	Yes	0.50 mph	0.70 mph

Table 3. A comparison of statistical contrast means for root biomass, root weight ratio and number of white root tips for Nursery A.

	Root biomass (g)	Root Wt. Ratio	# White Root Tips
	Contrast	**Contrast**	**Contrast**
Contrast	**Means**	**Means**	**Means**
2-row normal vs hand-lifted	0.75 vs 0.91 (0.041)[a]	0.14 vs 0.16 (0.054)	51.0 vs 78.1 (0.010)
2-row normal vs 2-row fast	0.75 vs 0.76 (0.931)	0.14 vs 0.15 (0.875)	51.0 vs 53.8 (0.779)
Full-bed normal vs hand- lifted	0.87 vs 0.91 (0.542)	0.15 vs 0.16 (0.120)	47.5 vs 78.1 (0.004)
Full-bed normal vs full-bed fast	0.87 vs 0.86 (0.889)	0.15 vs 0.15 (0.863)	47.5 vs 88.0 (0.0003)

[a] Number in parantheses below means is the significance level. *Alpha = 0.05.*

Table 4. Statistical contrasts for root morphology for Nursery A.

	Root Volume (cm3)	**Average Root Length (cm)**	**# root tips**	**# forks**
	Contrast	**Contrast**	**Contrast**	**Contrast**
Contrast	**Means**	**Means**	**Means**	**Means**
2-row normal vs hand-lifted	1.68 vs 2.30 (0.0037)[a]	215 vs 293 (0.002)	746 vs 814 (0.480)	894 vs 1488 (0.0007)
2-row normal vs 2-row fast	1.68 vs 1.66 (0.938)	215 vs 202 (0.541)	746 vs 582 (0.106)	894 vs 886 (0.947)
Full-bed normal vs hand-lifted	1.96 vs 2.30 (0.076)	240 vs 293 (0.021)	593 vs 814 (0.036)	945 vs 1488 (0.001)
Full-bed normal vs full-bed fast	1.96 vs 2.04 (0.672)	240 vs 254 (0.484)	593 vs 585 (0.930)	945 vs 1101 (0.257)

[a] Number in parantheses below means is the significance level. *Alpha = 0.05.*

Table 5. Statistical contrasts for root biomass and root weight ratio for Nursery B.

	Root biomass (g)	**Root Wt. Ratio**	**# White Root Tips**
Contrast	**Contrast Means**	**Contrast Means**	**Contrast Means**
Full-bed normal vs hand-lifted	0.96 vs 1.11 (0.222)[a]	0.23 vs 0.24 (0.640)	61.1 vs 63.5 (0.770)
Full-bed normal vs full-bed fast	0.96 vs 1.22 (0.054)	0.23 vs 0.23 (0.852)	61.1 vs 74.0 (0.157)

[a] Number in parantheses below means is the significance level. *Alpha = 0.05.*

Table 6. Statistical contrasts for root morphology for Nursery B.

	Root Volume (cm3)	**Average Root Length (cm)**	**# root tips**	**# forks**
Contrast	**Contrast Means**	**Contrast Means**	**Contrast Means**	**Contrast Means**
Full-bed normal vs hand-lifted	2.2 vs 3.8 (0.899) [a]	206 vs 352 (0.0001)	466 vs 742 (0.001)	907 vs 1916 (<0.001)
Full-bed normal vs full-bed fast	2.2 vs 17.8 (0.246)	206 vs 253 (0.035)	466 vs 602 (0.020)	907 vs 1225 (0.010)

[a] Number in parantheses below means is the significance level. *Alpha = 0.05.*

Table 7. Statistical contrasts for root biomass and root weight ratio for Nursery C.

	Root biomass (g)	Root Wt. Ratio	# White Root Tips
Contrast	**Contrast Means**	**Contrast Means**	**Contrast Means**
Full-bed normal vs hand-lifted	1.39 vs 1.03 (0.060) [a]	0.25 vs 0.23 (0.200)	45.2 vs 34.2 (0.0007)
Full-bed normal vs full bed fast	1.39 vs 1.29 (0.547)	0.25 vs 0.24 (0.400)	45.2 vs 26.5 (<0.0001)

[a] Number in parantheses below means is the significance level. *Alpha = 0.05*.

Table 8. Statistical contrasts for root morphology for Nursery C.

	Root Volume (cm3)	Average Root Length (cm)	# root tips	# forks
	Contrast	**Contrast**	**Contrast**	**Contrast**
Contrast	**Means**	**Means**	**Means**	**Means**
Full-bed normal vs handlifted	3.79 vs 3.72 (0.912)[a]	383 vs 441 (0.289)	727 vs 847 (0.153)	1845 vs 2402 (0.110)
Full-bed normal vs full-bed fast	3.79 vs 3.79 (0.999)	383 vs 431 (0.373)	727 vs 776 (0.531)	1845 vs 2058 (0.500)

[a] Number in parantheses below means is the significance level. *Alpha = 0.05*.