Auburn University
Southern Forest
Nursery Management
Cooperative

RESEARCH REPORT 01-1

ONE OR TWO-ROW BELT-LIFTERS AFFECT SEEDLING SURVIVAL

by
David B. South and William A. Carey

INTRODUCTION

Lifting method can make a significant difference in outplanting survival. For example, Rowan (1987) increased outplanting survival by 6% in one year and 11% in another year when he carefully hand-lifted seedlings. His data suggests that operational lifted seedlings had 44% fewer small roots than carefully hand-lifted seedlings. Stripping these fine roots can reduce RGP and seedling survival. Unfortunately, it was not clear if the operational seedlings tested by Rowan were lifted by hand after undercutting with an agitating lifter (e.g. Fobro), or were lifted using a chain-lifter (e.g. Grayco), or with a one-row belt-lifter (e.g. Mathis) or with an 8-row belt-lifter (e.g. Whitfield or Love). Nursery mangers know that a great deal of seedling damage can result when harvesters are operated at relatively fast forward speeds or if the belts are improperly adjusted (Xydias 1981). In New Zealand, all forest tree nurseries lift seedlings by hand.

Prior to 1950, most pine seedlings in the South were lifted by hand after the soil was loosened using a lifting-blade. Langdon (1954) pointed out that even when using a simple lifting blade, survival could be reduced if the lifter blade was not sharp or if the tractor was traveling too fast. He reported 60% survival for shovel-lifted seedlings and 41% survival for seedlings lifted with the aid of a lifting blade. Langdon concluded that many feeder rootlets were lost if the lifting blade was not operated correctly.

Modified potato diggers were introduced in the early 1950's and reduced the time required to lift seedlings (Clifford 1954). Later, harvesters with shaker chains were specifically designed for tree nurseries (McDonald 1976). Harvesters manufactured by the Grayco Company were in use in the South during the 1970's. However, seedlings removed from this lifter were usually in a disarray and required additional labor to reorient the seedlings (Darby 1962). Belt-lifters do not have this

problem.

Lifting studies conducted by Barnard and others (1980) found that machine lifting decreased survival in 3 out of 4 nurseries in Florida (Table 1). Although confounding with nursery location exists, the data suggest injury was less when using an 8-row belt lifter instead of a 1- or 2-row lifter. Xydias (1981) reported no effects from machine lifting when seedlings were outplanted on nine Coastal Plain sites. However, he reported a 6 to 8% decrease in survival when seedlings were lifted with a single-row belt-lifter and transplanted on Piedmont sites. He indicated this difference, due to soil type in the field, should be explored in more detail.

Trials by Mead Coated Board suggest that belt-lifters are affecting seedling quality at some nurseries (Greene and Danley 1999). Feedback from nursery managers also suggest that injury might increase when lifting larger "morphologically improved" seedlings. These concerns prompted the following preliminary research.

Table 1. Effects of machine lifting on survival of pine seedlings.

Lifter	Planting Site	Hand	Machine	Difference	Reference
fixed-blade	FL	60	41	-19	Langdon 1954
2-row	FL	88	71	-17	Barnard et al. 1980
2-row	FL	52	45	-7	Barnard et al. 1980
1-row	FL	91	83	-8	Barnard et al. 1980
8-row	FL	73	71	-2	Barnard et al. 1980
2-row	FL	85	34	-51	Barnard et al. 1980
2-row	FL	73	53	-20	Barnard et al. 1980
1-row	FL	82	59	-13	Barnard et al. 1980
8-row	FL	32	42	+10	Barnard et al. 1980
1-row	GA	99	93	-6	Xydias 1981
1-row	GA	91	84	-7	Xydias 1981
1-row	SC	95	88	-7	Xydias 1981
Grayco	VA	97	89	-8	Xydias 1981
Grayco	VA	87	81	-6	Xydias 1981
1-row	GA	97	95	-2	Xydias 1981
Grayco	VA	88	88	0	Xydias 1981
8-row	GA	95	92	-2	Greene and Danley 2001
2-row	GA	90	84	-6	Greene and Danley 2001
8-row	AL	95	91	-4	South and Carey
8-row	AL	92	90	-2	South and Carey
2-row	AL	30	18	-12	South and Carey

Note: Xydias found no significant difference in survival in 10 (data not shown) out of 15 operational comparisons.

METHODOLOGY

Operational trials were installed at three loblolly pine nurseries during the 1999 lifting season. Two nurseries grew seedlings at low seedbed densities (12 and 18/ft^2 for Nursery A and B, respectively) while Nursery C grew seedlings at 29/ft^2. Seedling genotype was different for each nursery. Seedlings were lifted on 2/9/99 at Nursery A (located in Georgia), on 1/12/99 at Nursery B (located in South Carolina) and on 1/10/99 at Nursery C (located in the Coastal-Plain of South Carolina). A Mathis 2-row lifter was used at Nursery A while a Love 8-row lifter was used at the other nurseries.

Five plots within a single seedbed were selected at each nursery and seedlings were first lifted by hand with the aid of shovels. Subsequently, the machine harvester was employed and samples from the same bed were removed from the lifter at locations adjacent to hand-lifted plots. Seedlings were then transported to Auburn, Alabama for analysis and planting. Samples of seedlings were measured for root-collar diameter (RCD) and height and oven-dry-weights of shoots and roots. Root-weight ratios were determined by dividing root dry weight by seedling dry weight.

Seedlings from Nurseries B and C were planted 1/20/99 on a Piedmont site North of Auburn. A Piedmont site was selected because Xydias (1981) indicated Coastal Plain sites were less likely to show differences in survival. The study design was a randomized complete block design with five replications. Each plot contained 49 seedlings (7 rows of 7 trees per row) and the trees were planted on a 4 x 4 foot spacing. Seedlings were hand planted using KBC bars and each replication was planted by a different individual. Seedlings from Nursery A were outplanted (using a KBC bar) by a single tree planter three weeks later (2/9/99). All plots were treated with a herbicide (sulfometuron methyl 3 oz a.i./acre) in April. An overall transplant stress index (TSI) was determined for each treatment (South and Zwolinski 1997). Each nursery was considered a separate test. Except for TSI, all measured variables were tested with an analysis of variance (using an error term with 4 degrees of freedom).

RESULTS

Prior to transplanting, no significant treatment effects were detected for seedlings from Nursery A and B (Table 2). There was a trend for machine-lifted trees at Nursery A to have larger RCDs, but this occurred because the two-row drill lifted rows 1 and 5. Therefore, half of the machine-lifted seedlings came from the outside drill while none of seedlings from drills 1 or 8 were included in the hand-lifted samples. At the 10% level of probability, shoot weights were lower at Nursery C. This might have resulted from removal of needles by belts as seedlings were lifted from the seedbed.

For this study, seedlings from Nursery A were intentionally grown larger than normal. As a result, damage from the 2-row lifter was noticed and recorded. About 2% of the seedlings had bark removed all around the stem and 7% had torn bark half away around the stem. Approximately 91% exhibited little or no stem damage.

Table 2. Morphological characteristics for loblolly pine after lifting. Numbers in parentheses indicate probability of a greater F-value.

Nursery	Lifting method	RCD (mm)	Height (cm)	Root (g)	Shoot (g)	Root weight ratio
A	Hand	9.0	45.9	5.4	16.2	0.26
	2-row lifter	10.5	45.7	7.0	15.1	0.29
		(0.10)	(0.84)	(0.24)	(0.61)	(0.16)
B	Hand	6.2	20.2	1.9	5.5	0.27
	8-row lifter	6.4	21.6	2.0	5.0	0.27
		(0.57)	(0.16)	(0.60)	(0.62)	(0.97)
C	Hand	6.2	21.2	2.5	5.9	0.30
	8-row lifter	6.5	21.7	2.5	4.4	0.36
		(0.39)	(0.69)	(0.95)	(0.07)	(0.06)

Survival varied from 95% (hand-lifted seedlings from Nursery C planted in January) to 18% (2-row lifter seedlings from Nursery A planted in February). The exact reason for low survival of hand-lifted seedlings from Nursery A is not known but we believe the problem is related to an inadequate planting tool. The planting hole was too small for the massive root system (5-7 g dry weight average). Even with the KBC bar, planting large roots was difficult in the rocky and clay soil. As a result, many lateral roots remained exposed after planting since they were too large to fit in the planting hole. In addition, we wonder if survival was reduced by planting tall seedlings that were not top-pruned. Short, hand-lifted seedlings from Nursery A (those less than 28 cm after planting had 68% survival while seedlings taller than 43 cm had 21% survival.

At the 10% level of probability, machine-lifting appears to have reduced survival at Nursery A, GLD at Nursery B, and heights at Nurseries B and C (Table 3). Although the effect of harvesting with an 8-row lifter was statistically significant for growth, the biological significance appears relatively small. We are pleased to know that our planting design and protocol was good enough to detect a 4 cm difference in height growth in two studies.

As expected, negative TSI values were observed for Nurseries B and C. Machine-lifted seedlings had more negative TSI values than hand-lifted seedlings. Due to low survival (< 75 tree per treatment), TSI values are not reported for Nursery A. South and Zwolinski (1997) recommend that TSI values not be calculated for samples with less than 100 seedlings.

Regardless of lifting method or soil texture, some fine roots will be lost during harvesting of bare-root seedlings. In some cases, 50% or more of the fine-roots are stripped during lifting. In theory, the loss in survival potential increases as more fiberous roots are removed. Therefore, if machines are operated at fast speeds (with no lifting bar in place) to meet high production goals, the survival potential may be reduced. Regardless of the type of machine-lifter used, it is important to keep an eye on the operation of the belts and beaters as well as the speed. When lifting large-diameter

seedlings, it will be very important to make sure the belts are adjusted to reduce the stripping of bark. Greene and Danley (2001) indicate that some of the potential gains obtained from large-diameter seedlings can be lost when these seedlings are lifted with a 2-row lifter. Barnard and others (1980) concluded "It will do you no good to grow a quality seedling if you beat it to death in lifting and handling."

Table 3. Field performance of loblolly pine seedlings after one year in the field. Numbers in parentheses indicate probability of a greater F-value.

Nursery	Lifting method	After Planting		First year			
		GLD (mm)	Height (cm)	GLD (mm)	Height (cm)	Survival (%)	TSI
A	Hand	7.8	36.9	9.0	46	30	
	2-row lifter	8.0	36.1	9.0	46	18	
		(0.69)	(0.62)	(0.96)	(0.99)	(0.06)	
B	Hand	6.4	21.9	11.4	54	92	-0.5#
	8-row lifter	6.4	21.9	10.9	52	90	-0.6*
		(0.86)	(0.95)	(0.007)	(0.09)	(0.52)	
C	Hand	5.6	21.1	11.0	57	95	-0.7**
	8-row lifter	5.6	21.3	10.6	53	91	-0.9**
		(0.94)	(0.13)	(0.11)	(0.03)	(0.22)	

Note: Due to poor survival (< 75 trees/treatment), TSI values were not reported for Nursery A. Due to deeper planting for replication #1, only 4 replications were used to calculate TSI values from Nurseries B and C.

= significantly different from zero at the 10% level of probability
* = significantly different from zero at the 5% level of probability
** = significantly different from zero at the 1% level of probability

MANAGEMENT IMPLICATIONS

One- and two-row belt-lifters are often operated at higher speeds than 8-row belt-lifters. Due to operational experience, a number of nursery managers have stopped using the single or double-row lifters and have switched to 8-row lifters (with higher hourly production rates). Although no direct comparisons with 2-row belt-lifters are available, many believe that more fine roots are harvested when using 8-row belt lifters with an undercutter blade that lifts the soil prior to the belts contacting the seedlings. Future harvester studies should compare different lifters at the same nursery.

Nursery managers who produce low-density seedlings should consider lifting these large-diameter

seedlings by hand, or with a Fobro lifter, or with a Grayco lifter. When transplanting large-diameter seedlings (9-10 mm RCD), regular planting bars will likely be insufficient for making a proper planting hole. These trees should be either machine planted or, when planted in Piedmont soils, should be planted using shovels in ripped areas.

REFERENCES

Barnard, E.L., C.A. Hollis and W.L. Pritchett. 1980. A comparative evaluation of seedling quality in commercial forest nurseries in Florida. p. 34-41. In: Proceedings of the 1980 Southern Nursery Conference; 1980, September 2-4; Lake Barkley, KY.

Clifford, E.D. 1956. Use of a potato digger for lifting nursery stock. Tree Planters' Notes 24:9-10.

Darby, S.P. 962. The Georgia seedling harvester. Tree Planters' Notes 53:1-6.

Greene, T.A. and S.T. Danley. 1999. Effect of lifting methods on first-year growth of loblolly pine seedlings. pp. 334-338 In. Proc. Tenth Biennial Southern Silvicultural Research Conference. USDA Forest Service General Technical Report SRS-30.

Greene, T.A. and S.T. Danley. 2001. Hand-lifting improves field performance of loblolly pine seedlings. South. J. Appl. For. (In press).

Langdon, O.G. 1954. Skillful lifting technique increases seedling survival. Southern Lumberman 18:153-154.

McDonald, S.E. 1976. Mechanization reduces lifting labor costs 70 percent at the Coeur d'Alene Nursery. Tree Planters' Notes 27(2):6-7.

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

South, D.B. and Zwolinski, J.B. 1997. Transplant stress index: a proposed method of quantifying planting check. New Forests 315-328

Xydias, G.K. 1981. Plantation survival studies of continental forest industries. Pp. 8-15 In. Proc. First Biennial Southern Silvicultural research Conference. USDA Forest Service General Technical Report S0-34.