Seedling Size and Lifting Date Effects on Root Growth Potential of Loblolly Pine From Two Arkansas Nurseries

John C. Brissette and Terrence C. Roberts[1]
Nursery and Tree Improvement Specialist, USDA Forest Service, Southern Region, Jackson, Miss.; and Nursery Supervisor, International Paper Co., Blenheim, S.C. (formerly Reforestation Manager, Arkansas Forestry Commission)

Loblolly pine seedlings lifted in March had greater new root growth than stock lifted in November or January, and large seedlings had more new root growth than medium or small seedlings for two of the lifting dates.

The ability of newly outplanted seedlings to become established depends on their physiological readiness to produce new roots. Root growth potential (RGP) is a measure of new root growth determined after lifted seedlings are potted and grown for a specified time in a growth chamber or greenhouse. In the Western United States and in Canada, RGP has been used to evaluate physiological quality of seedlings in research tests and operational outplantings (1, 3). Relatively higher RGP generally indicates greater seedling quality than lower RGP.

In most species studied thus far, RGP is cyclic and appears related to the terminal bud dormancy cycle (3). Typically, RGP increases during the autumn and winter months, peaks in late winter or early spring, and declines rapidly just before bud burst. Because it is cyclic, RGP is affected by the timing of various nursery cultural treatments. Lifting date, for example, has major impact on RGP.

For the past several years, marked differences in average size and apparent vigor have been observed between loblolly pine (*Pines taeda* L.) seedlings grown at the two Arkansas Forestry Commission nurseries. This study was initiated to determine if differences in RGP existed between stock from the two nurseries and among seedlings from each nursery. A secondary objective was to investigate whether any differences measured in RGP related to differences in first-year field performance.

Materials and Methods

Nursery A is located near the geographic center of Arkansas on a silt loam soil of alluvial origin from the Arkansas River. This nursery has been in operation since the mid-1950's. Established about 1940, nursery B is in the southwest part of the State on a sandy loam Coastal Plain soil.

Seedlings from the same seedlot were not available at both nurseries. At nursery A, seedlings were grown from open-pollinated seeds collected in an unrogued clonal seed orchard consisting of selections from the northern half of Arkansas. Stock at nursery B was grown from seeds collected in a similar seed orchard of southern Arkansas origin.

The seedlings used in this study received no special treatment while in the nursery. Stocks at each nursery were top pruned in late July. They were also undercut and laterally root pruned in October.

Seedlings for this study were hand-lifted in 8-week intervals from both nurseries on November 24, 1981, and January 19 and March 16, 1982. Because of the size differences, seedlings from each nursery were subdivided into three classes-large, medium, and small. These classes approximated the root collar diameter specifications of the morphological grades for loblolly pine seedlings described by Wakeley (4). They differed, however, because it was difficult to identify grade 3 seedlings at nursery A or grade 1 seedlings at nursery B.

After lifting, the seedlings were protected from heat and exposure and brought to the greenhouse at nursery A within 30 hours. Any new, white root growth was clipped off. The seedlings were potted in 1-gallon (4.5 liter) containers using a commercial 1 :1 :1 peat, vermiculite, and perlite medium. They were grown in the heated greenhouse, which varied from about 55° F (13° C) at night up to 80° F

[1]The authors wish to thank the Arkansas Forestry Commission for providing facilities and assistance for this study.

(26° C) on some days. The seedlings were grown under natural photoperiods for 28 days. They were watered as necessary to maintain the medium at near field capacity.

Among the seedlings lifted in November, each treatment (size class by nursery) was represented by five replicates of four trees. Because variability within treatments was high, the number of replicates was increased to 10 for the January- and March-lifted treatments.

After the 28-day growing period, the seedlings were removed from the pots and soil was carefully washed from the roots. All new root growth was measured and the total recorded to the nearest centimeter.

Seedlings lifted at the same time as those used for the RGP evaluation were outplanted in an unused portion of nursery A within 48 hours of lifting. Seedling size was not an experimental factor in the field plantings. Each treatment (nursery by lifting date) was represented by a 25-tree plot planted in four replications. Survival and total height were measured after the first growing season.

Results and Discussion

Root growth potential varied considerably among the various treatments (table 1). In each treatment, some seedlings did not exhibit any RGP. However, the new root growth of some seedlings was astonishing. One of the large seedlings lifted in March from nursery A had new root growth after 28 days totaling 23.7 feet (7.2 m) from approximately 360 growing points.

Table 1—*Root growth potential of graded loblolly pine seedlings from two Arkansas Forestry Commission nurseries, 1981–82*

Lifting date	Seedling size	Average new root growth		
		Nursery A	Nursery B	Mean
		Cm		
Nov. 24	L	9.7	3.0	6.4
	M	5.1	4.5	4.8
	S	5.4	7.3	6.4
	Mean	6.7	4.9	5.8
Jan. 19	L	96.7	44.9	70.8
	M	39.9	28.3	34.1
	S	36.3	11.4	23.8
	Mean	57.6	28.2	42.9
Mar. 16	L	108.6	38.9	73.8
	M	54.9	54.5	54.7
	S	51.2	22.6	36.9
	Mean	71.6	38.7	55.1

Among all the seedlings in the greenhouse study, mortality was 7.3 percent. The mortality occurred among seedlings from both nurseries and from each size class on at least one lifting date. The worst mortality in the greenhouse (22.5 percent) was among the small seedlings lifted in January from nursery B.

Nursery effects. Seedlings from nursery A consistently had greater RGP than seedlings from nursery B (table 1). Although the November RGP difference between stock from the two nurseries was not significant ($p = 0.05$), those differences in January and March were highly significant ($p = 0.01$). However, these results do not indicate a clear contrast between nurseries because the same seedlots were not available from both nurseries. Therefore, it was not possible to separate RGP differences between nurseries from seed source effects. A subsequent experiment is now underway to determine those differences.

Seedling size effects. Seedling size had a marked impact on RGP. In general, larger seedlings had greater RGP than smaller seedlings (table 1). Although this relation-

ship did not occur among stock lifted in November, there were no significant ($p = 0.05$) differences in RGP for that lifting date. When averaged for both nurseries and all three lifting dates, the large seedlings had significantly ($p = 0.05$) more RGP than the small size class. Differences between large and medium seedlings, and between medium and small seedlings were not significant.

The positive relationship between seedling size and RGP was also reversed for medium and large seedlings lifted in March at nursery B (table 1). RGP declines rapidly just before bud break, which may explain why the large seedlings had lower RGP than the medium seedlings in that case. The buds of the large seedlings may have been more physiologically active than buds of the smaller size classes, thus accounting for the lower RGP. Such an anomaly to the general trend did not occur among March-lifted trees from nursery A but bud burst would be expected first at nursery B because it is farther south.

No attempt was made to measure root area, mass, or volume of the seedlings used in this study. From observations, however, the larger seedlings appeared to have bigger root systems and therefore more sites for new root growth RGP may also be related to food storage capacity; ial11gef seedlings have more stored. Carbohydrate reserves to use for producing new snots before the needles can supply sufficient photosynthate for rapid growth (2) .

Much of the contrast in RGP between the nurseries may be attributed to seedling size. From nursery A, medium and small seedlings respectively approximated the size of large and medium seedlings from nursery B. The similarities in RGP among these four size classes for the January and March lifting dates would indicate that seedling size had a more direct effect on RGP in this study than did nursery site. However, because larger seedlings were grown at nursery A, the effects of nursery site and culture on seedling size, and consequently on RGP, were important.

Lifting date effects. The greatest differences in RGP were among the three lifting dates (table 1). The November-lifted seedlings had very low average RGP (5.8 cm). The January-lifted trees had over 700 percent more average new root growth (42.9 cm) than seedlings lifted earlier. The March-lifted seedlings averaged an additional 28 percent greater RGP (55.1 cm) compared to seedlings lifted in January. The differences in RGP between the November-lifted seedlings and the two later lifting dates were significant ($p = 0.05$) The RGP difference between January and March lifting was not significant.

We chose the three lifting dates to be what is generally considered early optimum and late. The RGP of seedlings lifted in midwinter (i.e., mid-December through mid-February) could typically be expected to be high and rather stable. However, before and after this period, RGP would be less predictable and vary considerable from year to year. RGP in this study averaged higher among March-lifted seedlings than January-lifted stock indicating that the seedlings had not yet initiated bud break. The date of bud burst varies greatly depending on the weather; and in another year, RGP of stock lifted in mid-March might be very low Possibly, RGP may have peaked sometime between the latter two lifting dates and was declining when the seedlings were lifted in March.

Together, lifting date and seedling size had a dramatic impact on RGP (fig. I). The greatest RGP was from urge seedlings from the last lifting date. in both January and March, the medium seedlings had RGP intermediate between large and small seedlings. In November, ail of the size classes had very low RGP.

RGP and field performance. Those seedlings that were outplanted in an unused and nonirrigated portion of nursery A were left unattended. They encountered severe grass competition, but otherwise growing conditions were excellent. Over all first-year survival was 89 percent, with the highest survival from the January

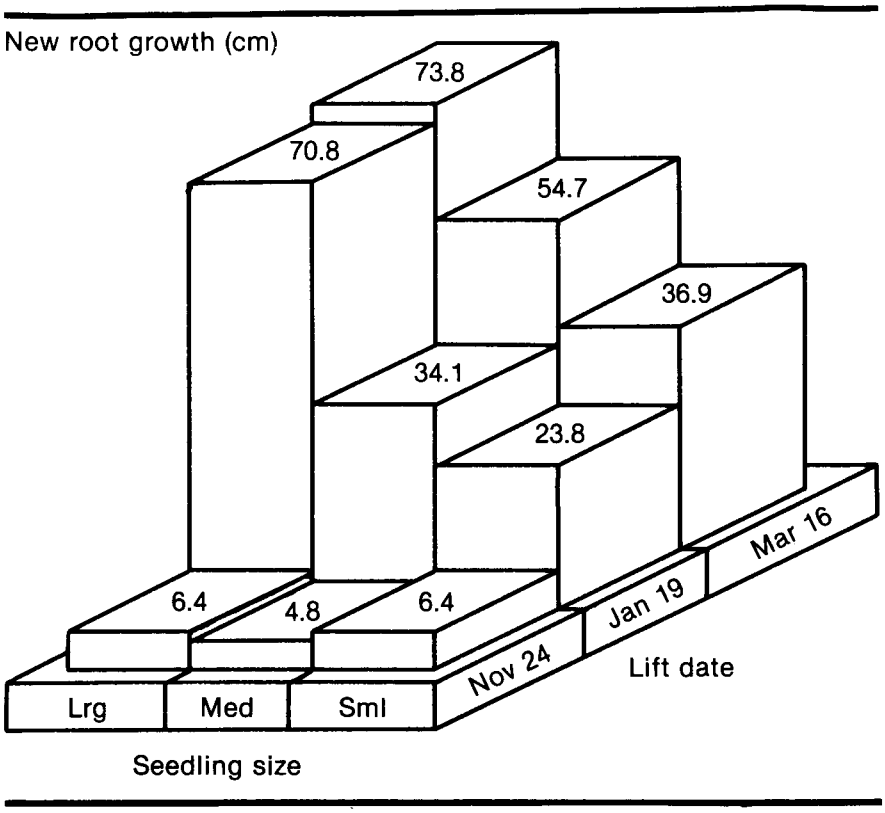

Figure 1—*Root growth potential (cm) of graded loblolly pine seedlings averaged for two Arkansas Forestry Commission nurseries for three lifting dates in 1981–82.*

tion between RGP and average seedling total height was somewhat better (r=0.26), but still not significant. These relationships may have been stronger if the seedlings had encountered more stressful conditions during the first growing season.

Although RGP did not correlate strongly with field performance in our study, it has proved to be a good predictor of field performance in other experiments. In their review, Ritchie and Dunlap (3) cite numerous studies with several species, including loblolly pine, in which RGP had positive, good-to-strong correlations with field survival. Only with three hardwood species did they cite no correlation or an inverse correlation.

Implications for Nursery Management

Evaluating RGP offers many benefits to nursery managers who have even a simple greenhouse available for growing seedlings.

planting date (table 2). Nursery A seedlings were taller than stock from nursery B when planted and retained that height advantage after one growing season. The tallest seedlings from both nurseries were those planted in November (table 2).

The correlation between average RGP and arc sine transformed survival was low (r = 0.14) and not significant (p = 0.05). The correla-

Table 2—*First-year survival and total height of loblolly pine seedlings lifted on three dates from two Arkansas Forestry Commission nurseries*

Lifting date	Nursery A		Nursery B		Mean	
	Survival	Total height	Survival	Total height	Survival	Total height
	%	*Cm*	%	*Cm*	%	*Cm*
Nov. 24	95	31.0	67	28.3	81	29.9
Jan. 19	99	29.5	100	27.2	100	28.4
Mar. 16	81	33.1	92	23.4	87	28.2
Mean	92	31.2	86	26.3	89	28.8

The greatest benefit comes when RGP is evaluated for various dates over several lifting seasons. The optimum range of lifting dates, or the best "lifting window," can then be determined for a particular nursery. The technique can also be used to evaluate the effects of nursery site, seed source, and various cultural practices on new root growth.

In British Columbia, a modified version of the RG P test, taking only 7 days, is used to evaluate the quality of batches of nursery stock (1). More research is needed before the technique will have a real value in predicting field performance of southern pine seedlings because of the time now needed to conduct the test and the variability among seedlings. The greatest value of RGP testing is therefore in improving the quality of future crops by quantifying the effects of present nursery practice.

A side benefit we gained while conducting this study was a better understanding of pine seedling physiology. Observing and measuring the roots of many seedlings and analyzing the results provided the opportunity to study root growth in detail. The study has given us a better appreciation for seedling growth and the impacts that nursery management can have on seedling quality.

Literature Cited

1. Burdett, A. N. New methods for measuring root growth capacity: their value in assessing lodgepole pine stock quality. Can. J. For. Res. 9: 63-67; 1979.
2. Hay, Ronald L.; Woods, Frank W. Carbohydrate relationships in root systems of planted loblolly pine seedlings. In: Van Eerden, Evert; Kinghorn, James M. eds. Root form of planted trees: Proceedings of the symposium; 1978 May 16-19; Victoria, BC. Joint Report No. 8. Victoria, BC: British Columbia Ministry of Forests/Canadian Forestry Service; 1978: 73-84.
3. Ritchie, G. A.; Dunlap, J. R. Root growth potential: its development and expression in forest tree seedlings. New Zealand J. For. Sci. 10(1): 218-248; 1980.
4. Wakeley, Philip C. Planting the southern pines. Agric. Monog. No. 18. Washington, DC: U.S. Department of Agriculture, Forest Service; 1954. 233 p.