THE EFFECTS OF SEED AND SEEDLING SIZE ON SURVIVAL AND GROWTH OF LOBOLLY PINE

After 15 years, loblolly pine (Pinus taeda L.) trees from large seeds were shorter than those from medium seeds; trees from select seedlings survived better and were taller than those from average seedlings.

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In studies of morphological grades of slash and longleaf pine seedlings, Wakeley (*9*) found that large seedlings tended to grow faster than small seedlings but survival was lower. Many small seedlings survived and grew well. The physiological condition of the seedlings was more important than the morphological grade. In a study with loblolly pine seedlings (*10*), large seedlings grew faster than the smallest grade and survived better. By age 34 years, seedlings of the largest grade had produced twice as much volume per unit area. Other studies with loblolly pine in Texas have shown that a large planting stock maintains a growth advantage over small stock for several years (*5, 6, 7*)

A logical extension of grading seedlings by morphology is to select the outstandingly tall seedlings usually produced in nursery beds and compare subsequent growth with control seedlings. Studies using this approach have shown that growth differences established early may persist for 10 years, but phenotypic selection is not particularly accurate for predicting long-term growth on an individual tree basis (*3*).

Separating pine seeds into size or weight classes has been tested to control variation in seedling size. For eastern white pine (*8*) and white spruce (*2*), seedling size was positively correlated with seed weight, but the correlation disappeared after only a few years of field growth.

In loblolly pine, seedlings from large and medium seeds differed little in size, but seedlings from small seed did tend to be smaller (*1*).

Studies reported in the literature have dealt separately with seedling size and seed size. But these two variables must be studied jointly if their relationship to wood volume production is to have commercial significance. A study established in 1954 was designed to test the effects of seed and seedling size and their interaction on survival and growth of planted loblolly pine. Results indicate that seed and seedling size each has an independent effect as well as interacting effects on survival and growth. The results also suggest some refinements in study design to produce a more definitive analysis of effects and interaction.

Methods

A bulk lot of loblolly pine seeds from a North Carolina source were separated into medium and large seed and sown in the nursery. One year later seedlings from each seed-size class were lifted and graded into average and select classes.

The two seed sizes and two seedling sizes made up a 2 x 2 factorial of 4 treatment combinations. Seedlings from the four treatments were planted in 1954 in a randomized block design with three replications. Two plots of each treatment were planted in each replication at a spacing of 10 by 10 feet (3.04 x 3.05 m). Plot size was 20 trees in blocks 1 and 2, and 25 trees in block 3.

Measurements have included survival and height at age 3 years and survival, height, and diameter at age 15 years. Data from the two plots of each treatment replicated within the blocks were averaged for analysis. Randomized block analyses, including factorial effects, were performed.

Results and Discussion

Differences among the treatments were significant for survival at age 3, and height and volume/ ha at age 15 (table 1). Height differences at age 3 were not significant, but the variation pattern conforms to that reported in the literature. Select seedlings at planting were still tallest at age 3, and trees from large seeds averaged taller at age 3 than those from medium seeds. By age 15, however, the height variation pattern had changed. Both treatments with large seed averaged shorter than the two treatments with medium seed. The beneficial effects of select seedlings on height continued to be evident. Also, seed size had little apparent effect on survival but select seedlings survived better than average seedlings. At age 15, survival differences remained closely correlated with survival at age 3 (table 2). Volume per hectare at age 15 was correlated with both survival and height at age 3 and was, therefore, affected by treatments in much the same manner. In no trait, however, was the effect of select seedlings as great in combination with large seeds as in combination with medium seeds.

Survival differences among the treatments were well established by age 3. Early mortality probably was associated with planting failure. Fusiform rust infections seldom kill loblolly pine seedlings soon after planting; and rust infection at age 15 did not differ among treatments.

Table 1.—*Average data at ages 3 and 15 years.* [1]

Seed size	Seedling size	Age 3 Survival	Age 3 Height	Age 15 Survival	Age 15 Height	Age 15 D.b.h.	Age 15 Volume/ha
		percent	*m*	*percent*	*m*	*cm*	m^3
Medium	Average	52.3 b	2.17a	47.3 a	14.29 a-b	23.9 a	114.2 c
	Select	75.5 a	2.38 a	62.2 a	15.00 a	22.9 a	144.9 a
Large	Average	63.3 a-b	2.32 a	54.5 a	13.68 b	23.6 a	120.8 b-c
	Select	64.2 a-b	2.39 a	55.5 a	14.11 a-b	24.6 a	137.3 a-b
Mean		63.8	2.31	54.9	14.27	23.7	129.3

[1]Seedlot averages without a letter in common are different at the 5-percent level, according to Duncan's New Multiple Range test.

Table 2.—*Correlations among the different traits at ages 3 and 15 years*

Age	Trait	Age 3 Survival	Age 3 Height	Age 15 Survival	Age 15 Height	Age 15 d.b.h.	Age 15 Volume/ha
3	Survival		0.85	0.991	0.55	-0.56	0.90
	Height			0.87	0.18	-0.06	0.87
15	Survival				0.53	-0.52	0.912
	Height					-0.57	0.63
	d.b.h.						-0.25

[1] Significant at the 0.01 level.

[2] Significant at the 0.10 level. There were only 2 degrees of freedom in the correlations, requiring an extremely high correlation to be significant.

Factorial effects more clearly show the independent and interacting effects of seed and seedling size (table 3). Seed size had no effect on survival at age 3, but seedling size apparently did (significant at the 10 percent level). Select seedlings on the average had 12 percent better survival than average seedlings. There was an apparent interaction between seed size and seedling size on third year survival. Select seedlings from large seed had lower than expected survival considering the performance of select seedlings from medium seeds. Seed and seedling size had no significant effect on average height at age 3 years or on survival at age 15 years. Both seed size and seedling size apparently affected average height at 15 years. Trees from large seeds averaged 0.74 m shorter than trees from medium seed. Trees planted as select seedlings, however, were 0.57 m taller than those planted as average seedlings. Average d.b.h. at age 15 was not affected by seed or seedling size. Seed size had no significant effect on volume per hectare at age 15, but trees planted as select seedlings produced on the average 23.6 ml per hectare more than those planted as average seedlings.

A comparison of the main factorial effects on the different traits at the different ages shows a similar pattern in survival effects at age 3 and 15, and volume per hectare at age 15 (table 3). The use of large seeds as opposed to medium seeds had little effect except to produce shorter trees at age 15. Select seedlings survived better, were taller at age 15, and produced considerably more volume of wood than did average-sized seedlings. The effect of seedling size is greater than that of seed size for all traits except d.b.h., in which neither factor had a strong effect.

The interaction between seed and seedling size is shown in fig. 1. As seen in table 3, interaction approaches significance only for survival at age 3. All the interactions shown in fig. 1, however, point out that in all traits measured except d.b.h. the combination of large seeds and select seedlings tended to be unfavorable. For example, using large seeds increased third-year survival of average seedlings by 11 percent, but decreased survival of select seedlings by 11 percent. Conversely, using select seedlings increased third-year survival of seedlings from medium seed by 23 percent, but had no effect on survival of seedlings from large seed.

The combined effects of large seeds and select seedlings-that is, selecting the largest seedlings produced by the large seed-were to produce seedlings that had some kind of survival and growth disadvantage. However, since this experiment was done with a bulk seedlot, the seed and seedling size effects could have been confounded by maternal and single-parent genotypic effects. The literature clearly shows that separating bulk lots of seed by size or weight would tend to separate them by mother tree, specifically eastern white pine (8), white spruce (4), and loblolly pine (1). Grading the seedlings from each seed size lot could very well involve another separation by mother tree or half-sib family. Research done with bulk seed lots therefore was probably not free from confounding effects of genotype. Much of the treatment effects in this study, particularly the interactions, could have been the result of genotype differences brought about by grading the seeds and seedlings.

Additional work of this type should be done to determine if these findings have consistence or are unique to the particular lot of seed used in this study. The effects of seed size and seedling size may be more precisely defined by using three size classes for each factor, and using several seedlots of known parentage so parental effects can be partitioned.

Table 3.—*Summary of factorial effects.* [1]

	Trait measured					
	Age 3 years		Age 15 years			
Factor[2]	Survival	Height	Survival	Height	d. b. h.	Volume/ha
	percent	*m*	*percent*	*m*	*cm*	*m*[3]
A	-0.17 ns.	0.08 ns.	0.25 ns.	-0.74*	0.79 ns.	-0.52 ns.
B	12.00 a	0.14 ns.	7.92 ns.	0.57 a	0.05 ns.	23.61**
AB	-11.17 a	0.07 ns.	-6.92 us.	0.15 ns.	1.04 ns.	-7.12 ns.

[1] ** = Significant at the l-percent level.
* = Significant at the 5-percent level.
a = Significant at the 10-percent level.
ns. = Nonsignificant.

[2] A =The effect of large seed compared to medium seed.
B =The effect of select seedlings compared to average seedlings.
AB = Interaction, or failure of the treatment effects to combine additively.

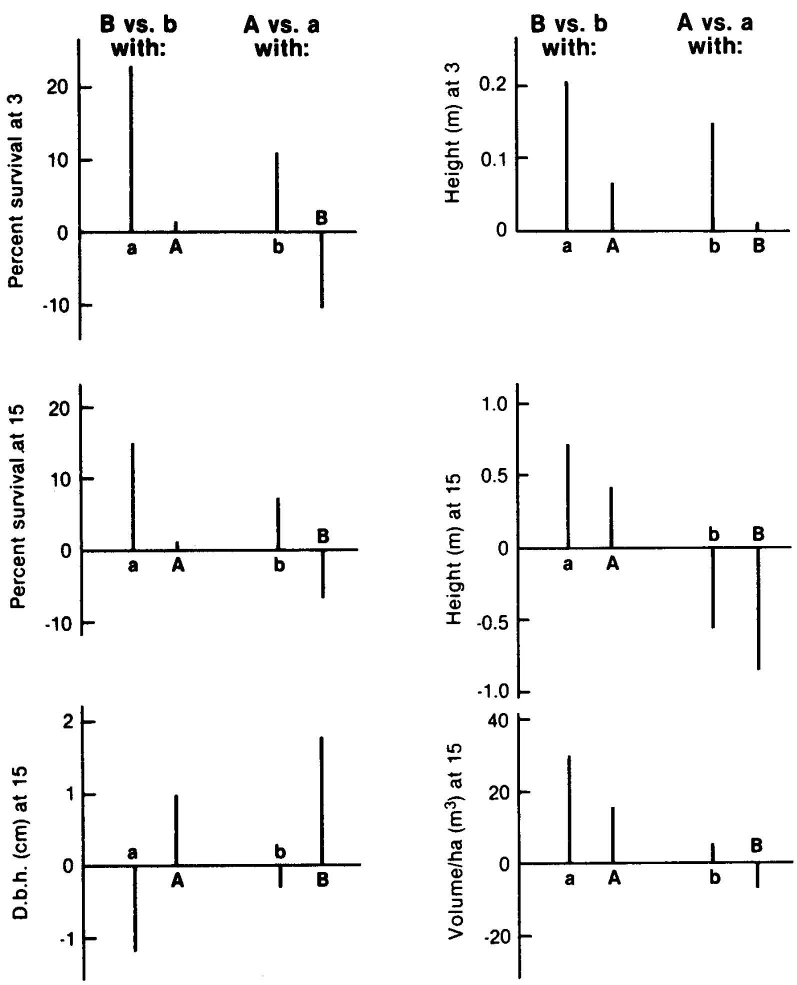

Figure 1.—*Interactions between seed size and seedling size effects. a, medium seed; A, large seed; b, average seedlings; B, select seedlings. "A vs. a with" or "B vs b with" is the effect of the high level of that factor combined with the indicated level of the other.*

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