Re[illegible]ted from the JOURNAL OF FORESTRY, Vol. 59, N[illegible], May 1961

Effect of Seed Size on Germination, Growth, and Survival of Slash Pine

Eugene Shoulders

SEED SIZE influences germination of many coniferous seeds or the initial growth of the resulting seedlings (*1, 2, 3, 4, 5, 6, 7*). Often both are affected. In general, large seeds have been found to germinate faster and more completely than small seeds and to produce seedlings whose initial growth is greater. The growth advantage has usually disappeared after a few years; but some authors believe the initial advantage persists, so that seedlings from large seeds usually form the dominant trees in the stand.

This article reports a study in which slash pine (*Pinus elliottii* Engelm.) seedlings were grown from a single lot of seed that had been sorted into size classes. Briefly, sorting did not impart any important benefits. Small seeds produced smaller seedlings and fewer plantable seedlings than medium and large seeds, but the overall performance of the lot was the same whether seed was sown mixed in the nursery bed, or separated into size components and sown.

Study Methods

The lot consisted of approximately 500 pounds of slash pine seed collected in Georgia in 1955. Prior to sorting, the seed had been thoroughly cleaned. Cutting tests revealed it was 89 percent sound. It averaged about 16,000 seeds per pound. Sorting was done on a commercial seed cleaner; Table 1 shows sizes of circular screen apertures used to separate the seeds, the proportion of the lot in each size class, and the average number of seeds per pound in each class. An unsorted portion was reconstructed by thoroughly mixing proportional amounts (by weight) of small, medium, and large seed.

Laboratory tests were conducted with the sorted seed to determine the effects of seed size on germination.

Sorted and unsorted seed was sown in the nursery in a randomized block design on April 10, 1957. Plots were 4- by 484-foot nursery beds. Sowing rates were calculated to produce a uniform stocking of 40 seedlings per square foot at lifting time. None of the seed was stratified.

The beds were sampled on May 23 and 24, 1957, to determine germination of seed and actual seedling catches. During July, four permanent sample plots were randomly located in each bed. These were hand weeded and thinned to a density of 40 seedlings per square foot.

Final stocking of the beds was estimated by counting all seedlings on the permanent sample plots. The center 25 seedlings from each plot were used to determine size and grade of planting stock, and a sample of the remaining seedlings, with injured and diseased individuals discarded, was planted on two different sites in central Louisiana on January 24, 1958. Seed size treatments were replicated three times on each site. Individual plots contained 50 seedlings. After planting, the seedlings were classified as plantable or cull; morphological grades 1 and 2 (*8*) were considered plantable and grade 3 cull.

Survival and growth of plantable and bed-run seedlings were evaluated after one year in the field. Only seedlings free from disease or insect injury were included in these appraisals. It was necessary to identify and exclude diseased and insect-injured seedlings because of a high incidence of southern fusiform rust (*Cronartium fusiforme* Hedgcock and Hunt) in the nursery in 1957 and an attack on one of the test plantings by Texas leaf-cutting ants (*Atta texana* Buckley). Results from the two sites were quite similar and have been combined in this paper.

Results

Germination. — Small, medium, and large seed germinated equally well in the laboratory, gross germination in 44 days averaging 75 percent. Germination was rapid and seed of the various sizes germinated at similar rates. Fifty-nine percent of the small seed, 60 percent of the medium seed, and 61 percent of the large seed germinated in 8 days, and germina-

TABLE 1.—CLASS LIMITS, NUMBER OF SEEDS PER POUND, AND PROPORTION OF SEED LOT IN SMALL, MEDIUM, AND LARGE SIZE CLASSES

Class of seed	Size of aperture		Proportion of seed lot in each class		Seeds per pound
	Passed by	Retained by	By weight	By number	
	Inches		*Percent*		*Number*
Small	10/64	.....	24.1	30.7	20,800
Medium	12/64	10/64	52.0	50.7	15,900
Large	.....	12/64	23.9	18.6	12,700
Unsorted[1]	.....	.....	.....	.....	16,300

[1]This separate was reconstructed from proportioned amounts (by weight) of small, medium, and large seed.

THE AUTHOR is with the Southern Forest Expt. Sta., Forest Service, U. S. Dept. Agric., New Orleans, La.

tion of all sizes equaled or exceeded 72 percent in 21 days.

Germination in the nursery was slightly lower than in the laboratory—70 percent of the unsorted seed germinated and the weighted average germination of small, medium, and large seed was also 70 percent. Nursery germination ranged from 64 percent for small seed to 73 percent for medium seed, but the differences were not statistically significant.

Stocking and survival in the nursery.—Initial stocking in the nursery bed, 44 days after sowing, ranged from 45.6 seedlings per square foot for small seed to 54.2 for medium-sized seed. Beds sown with large and with unsorted seed averaged 53.8 and 51.2 seedlings per square foot, respectively. Stocking from small seed was significantly lower than stocking from medium, large, or unsorted seed, but other differences were not significant. Part of the difference in stocking resulted from errors in sowing rates (the drill did not sow the exact weights of the various separates of seed calculated to produce the desired stand), and part was due to the lower germination of small seed, even though germination percents, themselves, were not significantly different.

Variations in density between size classes were corrected by thinning all sample plots to 40 seedlings per square foot in July. Subsequent mortality, principally from hand weeding, reduced stocking considerably below this level. By lifting time, stocking averaged 32.7 seedlings per square foot for small seed, 36.2 for medium seed, 36.0 for large seed, and 31.5 for unsorted seed. These differences in stocking were not statistically significant. Thus, survival in the nursery bed was independent of seed size.

Yield and size of seedlings.—No consistent trends in size of seedlings or yield of plantable seedlings were associated with seed size (Table 2). Small seed produced significantly fewer plantable seedlings than either medium, large, or unsorted seed, but differences in yields from medium, large, and unsorted seed were not significant. Sorting the seed did not produce any increase in the total weighted yield of plantable seedlings. The 73 percent plantable production from beds seeded with unsorted seed was 2 percentage points higher than the weighted average plantable production when the three sizes of seed were sown separately. In other words, seedlings from various sizes of seed grew just as well in mixture as when kept separate.

The inferior performance of small seed in the nursery is also reflected in the average size of bed-run and plantable stock (Table 2). Bed-run seedlings from small seed were 0.05 to 0.15 foot shorter than those from the other size classes and were 1/64 to 2/64 inch smaller in root collar diameter. Plantable seedlings from small seed were also smallest, but the differences were less pronounced. Medium-size seed produced bigger stock, both bed-run and plantable, than large and unsorted seed. In this respect, unsorted seed was superior to large seed.

Field survival.—Field survival at the end of the first growing season was generally good. With both graded and bed-run stock, survival increased as the size of seed decreased (Table 3). Unsorted seed had the lowest survival of all seed lots. Differences in survival of plantable seedlings from small, medium, large, and unsorted seed were not significant, and the maximum range was only 4 percentage points. The maximum range in survival of bed-run seedlings from mixed and sorted seed was 9 percentage points; analysis of variance showed the differences to be statistically significant, but of little practical importance.

The weighted average survival of plantable seedlings from sorted seed was 95 percent as compared to 92 percent for stock from unsorted seed. With bed-run seedlings, the averages were 91 percent for sorted seed and 87 percent for unsorted seed. Thus, the maximum benefit derived from sorting was only 4 percentage points with bed-run seedlings.

Unpublished data from a somewhat similar study at the Southern Institute of Forest Genetics[1] substantiated the observation that seed size has no notable effect on survival of outplanted slash pine seedlings.

As mentioned previously, site quality had no important influence on field survival under the favorable weather of 1958-1959 in central Louisiana.

Growth.—During the first season in the field, seedlings from medium-size seed lost much of the superiority in height that they had gained in the nursery. Whereas bed-run nursery stock from me-

TABLE 2.—YIELD AND SIZE OF SLASH PINE SEEDLINGS BY SIZE OF SEED

Class of seed	Total seedlings per sq. foot of nursery bed at lifting		Size of bed-run stock		Proportion plantable	Size of plantable stock[1]	
	Desired	Actual	Root-collar diameter	Ht.		Root-collar diameter	Ht.
	Number		*Inches*	*Feet*	*Percent*	*Inches*	*Feet*
Small	40.0	32.7	8/64	0.51	59	10/64	0.55
Medium	40.0	36.2	10/64	.66	78	11/64	.69
Large	40.0	36.0	9/64	.56	73	11/64	.58
Unsorted	40.0	31.5	10/64	.61	73	11/64	.64

[1]Morphological grade 1 and 2 seedlings combined.

TABLE 3.—SEEDLING SURVIVAL AND HEIGHT AFTER ONE YEAR IN THE FIELD

Class of seed	Bed-run stock		Plantable stock	
	First-year survival	Avg. height of survivors	First year survival	Avg. height of survivors
	Percent	*Feet*	*Percent*	*Feet*
Small	96	0.95	96	1.04
Medium	90	1.04	94	1.14
Large	88	.96	94	1.04
Unsorted	87	1.01	92	1.12

[1]Allen, R. M.

dium seed averaged 0.10 and 0.15 foot taller than stock from large and small seed, the advantage had diminished to 0.08 and 0.09 foot one year after planting. The difference between seedlings from medium and unsorted seed had also diminished. None of the differences are statistically significant, and all will probably disappear after two or three years. In the study at the Southern Institute of Forest Genetics seed size did not significantly affect height one and two years after planting.

Bed-run seedlings from unsorted seed averaged 1.01 feet in height one year after planting (Table 3). The mean height of bed-run seedlings from sorted seed, weighted by the proportion of the total number of seed in each class, was 1.00 foot. Thus, the seedlings continued to develop at similar rates whether grown from sorted or unsorted seed.

Discussion and Conclusions

As nearly as can be determined the slash pine seed used in this study produced the same numbers of plantable seedlings when sown as a composite as when small, medium, and large size components were sown separately and a weighted average was computed. Plantable seedlings from all separates survived about equally well, and the differences in survival of bed-run seedlings from sorted and unsorted seed were too small to indicate any real advantage from sorting. Growth of survivors during the first year eliminated much of the height difference present when the stock was lifted from the nursery. As previously noted, laboratory and nursery germination were not influenced by seed size.

The most striking experimental result was the superior initial growth of seedlings from medium seed. With other species, large seeds have usually produced the largest seedlings. This and the other relationships between seed size and initial growth of slash pine are of interest to research workers who sometimes must evaluate differences in heights of very young seedlings. These considerations, however, should not obscure the fact that differences are small and will probably disappear after two or three years. The practicing nurseryman or forester may continue to use unsorted slash pine seed with confidence.

Literature Cited

1. BALDWIN, H. I. 1942. Forest tree seed of the north temperate region with special reference to North America. 240 pp. Illus. Chronica Botanica Co., Waltham, Mass.
2. FOWELLS, H. A. 1953. The effect of seed and stock sizes on survival and early growth of ponderosa and Jeffrey pine. Jour. Forestry 51: 504-507. Illus.
3. HOUGH, A. F. 1952. Relationships of red pine seed source, seed weight, seedling weight, and height growth in Kane test plantation. U. S. Forest Service Northeastern Forest Expt. Sta. Sta. Paper 50. 14 pp. Illus.
4. LANGDON, O. G. 1958. Cone and seed size on south Florida slash pine and their effects on seedling size and survival. Jour. Forestry 56: 122-127. Illus.
5. RIGHTER, F. I. 1945. Pinus: the relationship of seed size and seedling size to inherent vigor. Jour. Forestry 43: 131-137. Illus.
6. SPURR, S. H. 1944. Effect of seed weight and seed origin on the early development of eastern white pine. Jour. Arnold Arboretum 25: 457-480.
7. TOUMEY, J. W., and C. F. KORSTIAN. 1942. Seeding and planting in the practice of forestry. Ed. 3, 520 pp. Illus. John Wiley & Sons, Inc., N. Y.
8. WAKELEY, P. C. 1954. Planting the southern pines. U. S. Dept. Agric. Agric. Monog. 18. 223 pp. Illus.