SURVIVAL AND GROWTH OF PLANTED WHITE PINE ARE RELATED TO SEEDLING SIZE AND SEEDBED DENSITY

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Seedbed density in the nursery affects seedling quantity and quality. And seedling quality has an important effect on the survival and growth of planted seedlings. Wakely (1954) states that a given amount of bed space will produce a given amount of plant material. Decreasing seedbed density spreads growth over fewer stems, thus increasing the size of individual seedlings. Many investigators have shown that survival and growth of some species are directly related to the size and balance of the planting stock. Chapman (1948) found that large shortleaf pine seedlings survive and grow better than smaller ones; Curtis (1955) found the same thing to be true for red pine; and others have discovered the same relation for various species.

White pine has long been a popular species for reforestation and in recent years has been planted extensively on some of the better old-field sites in southern Indiana. In 1960 this study was started to find out what size white pine seedling survives and grows best in southern Indiana, and what nursery seedbed density will produce the greatest number and proportion of this most desirable size seedling.

In May 1960 sections of a 1-0 white pine seedbed at the Forest Service Nursery near Vallonia, Indiana were thinned to 10, 20, 30 and 46 (bed run) seedlings per square foot. And in June 1960, sections of a newly germinated seedbed were thinned to the same densities. The 2-0 seedlings used in the study plots were selected from these seedbeds. Large seedlings were selected from the low-density beds; and small seedlings, from the high-density beds.

In both 1961 and 1962, graded seedlings were planted at two locations: A field on the Paoli Experimental Forest that had produced hay three years before planting, and a broomsedge field on the Hoosier National Forest near Bedford, Indiana.

Seedling Size Varied

The Paoli plantings included three stem-diameter classes; 4/32, 6/32, and 8/32 inches, measured at the root collar; and two height classes; 5 to 8 inches and 8 to 11 inches. Combinations of the three diameter classes and the two height classes provided six seedling sizes. Each year 96 seedlings from each size class were planted in a 6 x 6 Latin square at a 6 x 6 foot spacing.

Not enough seedlings were available from the thinned seedbeds to provide two height classes in each diameter class for both planting areas so size classes for the plantings near Bedford were based on stem diameter only. Four diameter classes, 2/32, with 5 to 8 inch tops and 4/32, 6/32 and 8/32 with 8 to 11 inch tops were planted in 1961; and three diameter classes, 4/32 with 5 to 8 inch tops and 6/32 and 8/32 with 8 to 11 inch tops were planted in 1962. In 1961 each size class was represented by 100 seedlings planted in a 4 x 4 Latin square and in 1962 75 seedlings planted in a 3 x 3 Latin square.

Field Survival and Growth

The survival and growth of all seedling sizes included in the study are acceptable (table 1). However, large seedlings survived better and grew faster than small seedlings.

At Paoli, fourth year survival of the 1961 plantings ranges from 83 percent for the tall 4/32-inch seedlings to 95 percent for the tall 8/32-inch seedlings. And 4-year height ranges from 2.1 feet for the 4/32-inch seedlings to 3.4 feet for the tall 8/32-inch seedlings. On these particular plots seedling height did not affect survival or growth, probably because these seedlings were top-pruned during the second year in the nursery.

Table 1.--Survival and Height of White Pine Seedlings by Planting Site and Size Class

Year Planted and Location	Height Class	Diameter Class	Survival 1964	Total Height 1964
	Inches	Inches	Percent	Feet
1961 Paoli	5-8	4/32	89	2.1
	8-11	4/32	85	2.3
	5-8	6/32	94	2.7
	8-11	6/32	92	2.7
	5-8	8/32	95	3.2
	8-11	8/32	95	3.4
1962 Paoli	5-8	4/32	83	1.6
	8-11	4/32	93	2.1
	5-8	6/32	90	2.2
	8-11	6/32	94	2.4
	5-8	8/32	96	2.5
	8-11	8/32	98	2.7
1961 Bedford	5-8	2/32	85	1.8
	8-11	4/32	91	2.4
	8-11	6/32	89	3.0
	8-11	8/32	98	3.6
1962 Bedford	5-8	4/32	92	2.0
	8-11	6/32	97	2.6
	8-11	8/32	100	3.2

Third year survival of the 1962 Paoli planting ranges from 83 percent for the smallest seedlings to 98 percent for the largest seedlings. Three-year height ranges from 1.6 feet for the short 4/32-inch seedlings to 2.7 feet for the tall 8/32-inch seedlings. These seedlings were not top-pruned and the taller seedlings grew faster than the short ones.

Fourth year survival for the 1961 planting near Bedford ranges from 85 percent for the small seedlings to 98 percent for the large ones. Four-year height ranges from 1.8 feet for the 2/32-inch seedlings to 3.6 feet for the 8/32-inch seedlings.

Although only three size classes were planted near Bedford in 1962, third year survival and height growth follow the same pattern as in the other plantings. Survival ranges from 92 percent for the small seedlings to 100 percent for the large ones. The 8/32-inch seedlings are now 1.2 feet taller, on the average, than the 4/32-inch seedlings.

Results from the four plantings show that as seedling size increases, survival and growth increase. Although survival of all sizes studies was acceptable -- 83 percent or better -- the 3 and 4-year old trees grown from 8/32-inch seedlings were more than a foot taller than those grown from 4/32-inch seedlings. Both 1961 and 1962 were good growing seasons in southern Indiana. Under more adverse conditions it is reasonable to assume that differences in stock size would have greater impact on survival and growth. Since poor growing seasons cannot be predicted, nurserymen should strive to produce a high percentage of seedlings larger than 4/32 inches.

Seedbed Density

Seedbed density had a decisive effect on seedling size (Table 2). Low-density seedbeds yield a small number but a high proportion of seedlings larger than 4/32 inches. Seedbeds or higher density yield a greater number but a smaller proportion of seedlings larger than 4/32 inches. In seedbeds thinned to 10 seedlings per square foot, 41 percent of the seedlings were larger than 7/32 inches and 83 percent were larger than 5/32 inches. In the unthinned beds only 5 percent were larger than 7/32 inches and only 42 percent were larger than 5/32 inches.

Limstrom (1963) recommends that if less than 75 percent of the planting stock shipped from the nursery fails to meet minimum standards, the stock should not be accepted by the planter. According to the 5/32-inch minimum standard for white pine seedlings planted in the Central States (U.S. Forest Service, R-9, 1962), only those seedlings grown at 10 per square foot would be acceptable as bed-run stock. The minimum standards could also be met by culling at the nursery but unless other management practices are altered to increase seedling size much of the production from high-density beds would have to be culled. According to Stoeckeler and Jones (1957) nursery cull normally ranges from 5 to 20 percent. To stay within acceptable cull limits and fully utilize bed space the nurseryman should sow to produce 20 to 30 seedlings per square foot.

Table 2.--Size of 2-0 White Pine Seedlings at Various Seedbed Densities

Seedbed Density (Seedlings per sq. ft.)	Height Class	Diameter Class 2/32	4/32	6/32	8/32	10/32	12/32	Total	
	(inches)				(percent)				
10	2-5	4	8	3	0	0	0	15	
	5-8	0	4	22	9	1	0	36	
	8-11	0	1	16	21	5	0	43	
	11-14	0	0	1	3	2	0	6	
	Total	4	13	42	33	8	0	100	41% Larger than 6/32"
									83% Larger than 4/32"
20	2-5	2	7	1	0	0	0	10	
	5-8	1	18	26	4	0	0	49	
	8-11	0	2	23	13	1	0	39	
	11-14	0	0	0	0	1	1	2	
	Total	3	27	50	17	2	1	100	20% Larger than 6/32"
									70% Larger than 4/32"
30	2-5	2	9	1	0	0	0	12	
	5-8	2	22	19	2	0	0	45	
	8-11	0	6	28	8	0	0	42	
	11-14	0	0	0	1	0	0	1	
	Total	4	37	48	11	0	0	100	11% Larger than 6/32"
									59% Larger than 4/32"in
46	2-5	4	8	0	0	0	0	12	
	5-8	4	23	12	0	0	0	39	
	8-11	1	18	23	4	0	0	46	
	11-14	0	0	2	1	0	0	3	
	Total	9	49	36	5	0	0	100	5% Larger than 6/32"
									42% Larger than 4/32"

The proper density also depends on a number of factors that have not been mentioned -- cost of seed, for example. High seedbed density, with a correspondingly high cull percent, wastes seed. So if expensive hybrid seeds are used, bed density should probably be reduced to 10 to 20 seedlings per square foot. This density will assure a high percentage of premium-quality seedlings that will survive better and grow faster.

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