The Effects of Seedbed Density and Fertilization on 1-0 White Oak Nursery Stock

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Average seedling caliper for white oak increased as seedbed density decreased. Fertilizer treatments did not influence seedling caliper. Seedling height was not influenced by density or fertilizer. Percentage of culls increased as seedbed density increased, but was not influenced by fertilizer.

White oak (*Quercus alba*) is one of our most valuable tree species for both timber and wildlife. Interest in planting white oak has increased over the past decade as the value of white oak timber has increased. Although more trees are being planted, many of these plantings have not been successful (*2*).

Information on the best nursery cultural practices to produce high-quality white oak seedlings is not available. For oaks in general, recommendations for seedbed density range from 10 to 30 seedlings per square foot (*5*).

The purpose of this study is to measure the effects of seedbed density and fertilizer treatments on height, caliper, and percentage of cull for 1-0 white oak nursery stock. A second objective of this study is to measure the effects of the density and fertilizer treatments on growth and survival after the trees have been planted in the field. Results from this part of the study will be reported at a later date since this information will not be available until the trees have been in the field for a period of time.

Methods

The seedbed area used for this study was treated according to stardard nursery practices for growing hardwoods at the Vallonia Nursery. The soil type was an Alvin sandy loam. In May 1980, a cover crop of Sorghum-Sudan was sown and fertilized with 1,000 pounds per acre of 12-12-12 fertilizer. In May 1981, the residue from the cover crop was plowed under and the area fertilized with 800 pounds per acre of 6-24-24. The area was maintained in a fallow condition until August 1981, when it was fumigated with 450 pounds per acre of methyl bromide.

White oak seeds were collected in southeastern Indiana from a wide variety of sources and thoroughly mixed before sowing so that the results from the study would be applicable to a wide range of seed sources. The seed was sown by hand in October 1981 in five 1-inch-deep drills spaced 8 inches apart on a standard 4-foot-wide nurserybed. The seed was covered with ½ to 1 inch of soil and mulched with 2,000 pounds per acre of hydromulch.

Treatments consisted of three seedbed densities of 4, 8, and 12 seedlings per square foot and three top-dress fertilizer rates of 0, 400, and 800 pounds per acre of 12-12-12 fertilizer at each level of seedbed density. The study was designed as a 3-by-3 factorial arranged in a randomized complete block design having three replications. The nine treatment combinations were assigned at random to each replication and were represented by a 4-by 4-foot plot.

Density treatments were sown at 12, 24, and 36 seeds per square foot assuming a survival percentage of 33 percent. All plots were thinned to the correct density in June 1982. Fertilizer treatments were applied by hand in June and July 1982 in 400-pound-per-acre increments and at 2-week intervals.

In January 1983, the seedlings were lifted and measured to determine height, caliper (diameter 1 inch above the root collar), and percentage of cull. A cull was considered to be any seedling with a caliper of less than 1/8 inch (3.2 mm) and a height of less than 6 inches (15.2 cm). The data were subjected to an analysis of variance. Percentage of cull data was transformed by the arcsin percentage transformation before the data were analyzed. Measurements were made on 3,750 seedlings.

Results and Discussion

Seedbed density significantly influenced seedling caliper (table 1). Average seedling caliper increased from 3.1 millimeters at a seedbed density of 12 seedlings per square foot to 4.1 millimeters at 4 seedlings per square foot (table 2 and fig. 1). Average caliper at 12 seedlings per square foot was slightly less than the minimum size for a shippable seedling (3.2 mm or 1/8 in); whereas at a seedbed density of 4, the average caliper was well above the minimum size. Although the average caliper at 12 seedlings per square foot was less than 3.2 millimeters, only 28 percent of these trees were in the cull category. The explanation for this apparent contradiction was that the caliper of the culls was so small that it lowered the average (mean) caliper for the treatment to 3.1 millimeters (table 2). Also, many of the non-cull seedlings were only slightly larger than the minimum size for a cull. Studies with other species have shown that large-caliper seedlings are more likely to survive and grow when outplanted (*3, 6*). If this holds true for white oak, the large caliper seedlings grown at low seedbed densities would be better planting stock. Barham (*1*) studied the effects of seedbed density on cherrybark oak *(Quercus falcata* var. *pagodaefolia)* and recommended a seedbed density of 4 seedlings per square foot for producing the maximum number of high-quality seedlings.

Table 1.—*Analysis of variance of caliper, height, and cull seedling percentage for 1-0 white oak*

Source of variation	df	Mean square for: Caliper	Height	Cull seedling percentage
		Mm	*Cm*	*Arcsin √percent*
Blocks	2	0.2107	4.7660	22.6248
Density (D)	2	2.3652**	7.6515	273.6415**
Fertilizer (F)	2	.0363	4.1160	28.4193
D *X* F	4	.0285	2.1981	15.9504
Error	16	.0582	5.6384	12.2361

** = significant differences at $P \leq 0.01$.

Table 2.—*Average caliper, height, and cull seedling percentage by seedbed density and fertilizer treatments for 1-0 white oak*

Treatments	Caliper	Height	Cull seedling percentage
	Mm	*Cm*	*%*
Density (seedlings/ft^2)			
4	4.1a[1]	25a	13a
8	3.4b	24a	19b
12	3.1c	23a	28c
Fertilizer (lb/acre)			
0	3.4a	24a	21a
400	3.5a	25a	21a
800	3.6a	24a	17a

[1]Means within a column not followed by a common letter are significantly different at $P \leq 0.01$.

In contrast to seedbed density, fertilizer treatments did not affect seedling caliper (tables 1 and 2). Apparently the nursery soil was able to supply the nutrient requirements of white oak without the need for additional fertilizer. The white oak seedlings had a large, deeply penetrating root system, which may have been able to extract nutrients from a large volume of soil.

For seedling height, neither seedbed density nor fertilizer treatments had any significant influence (tables 1 and 2). Shipman (4) studied the effects of seedbed density on height growth of 1-0 white oak and also found that density did not influence height growth.

The cull seedling percentage was significantly influenced by seedbed density, but not by fertilizer treatments (tables 1 and 2). The percentage of culls increased from 13 percent at 4 seedlings per square foot to 28 percent at 12 seedlings per square foot (table 2). The effect of seedbed density on percentage of culls relates

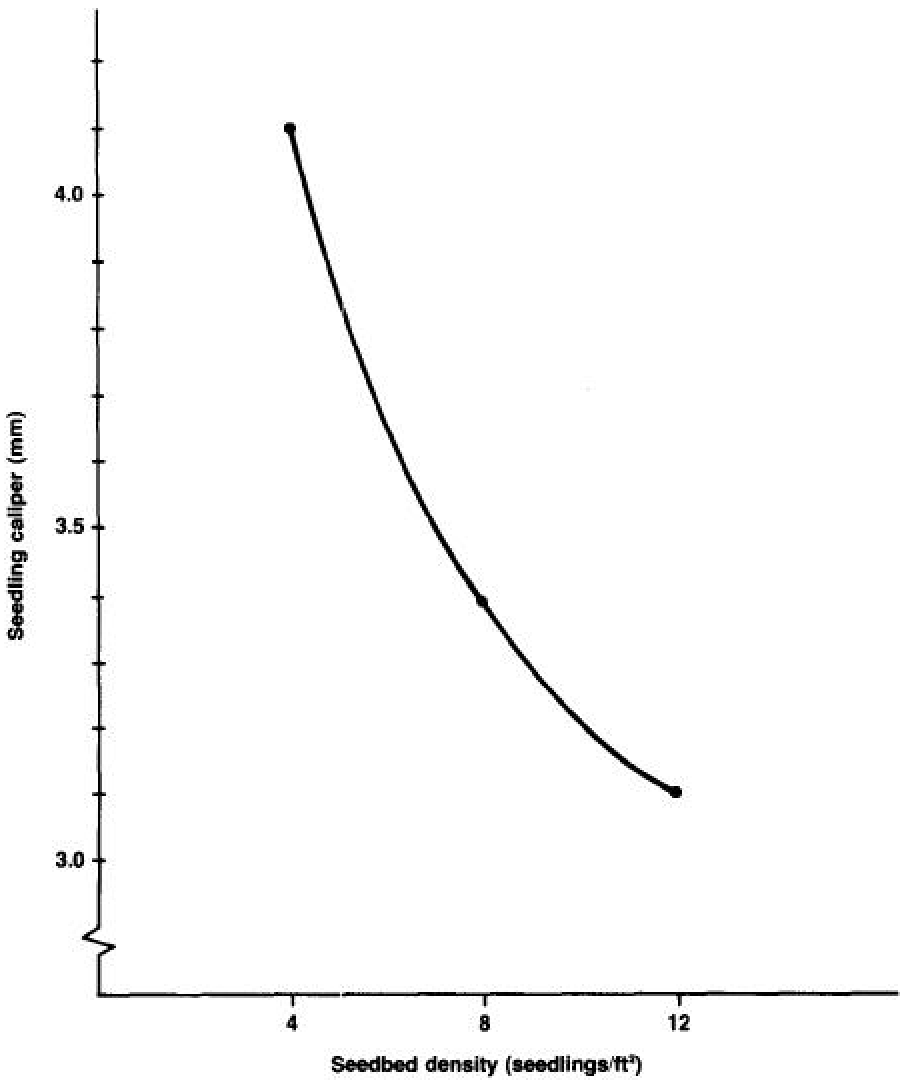

Figure 1.—*The relationship between seedling caliper and seedbed density for 1-0 white oak.*

directly to costs of growing seedlings in the nursery. Table 3 shows the estimated cost for bedspace and seeds for producing white oak at the Vallonia Nursery. Costs are shown in units of dollars per 1,000 shippable seedlings. Bedspace cost included fumigation, tillage, and fertilization and the labor for these presowing operations. Bedspace cost was estimated at $0.04 per square foot. Seed cost included all seed collection costs and was estimated at $20 per 1,000 ungraded seedlings.

Seed cost increased as seedbed density increased because the percentage of culls increased. Bedspace cost decreased as seedbed density increased because more seedlings were grown per square foot (table 3). For total cost, a seedbed density of eight seedlings per square foot resulted in the lowest cost. However, cost at the three densities did notdiffer greatly. If the large white oak seedlingsare more likely to survive and grow when planted in the field as noted previously, then the larger seedlings could be grown at low seedbed densities without significantly increasing production cost.

When seed is scarce (a frequent situation), low bed densities will produce the maximum number of shippable seedlings per unit of seeds. The relationships shown in table 3 would change if different values for seed or bedspace cost were used.

Table 3.—*Bedspace, seed, and total cost for 1-0 white oak as related to seedbed density and cull seedling percentage*

Seedbed density	Cull seedling percentage	Bedspace cost	Seed cost	Total of bedspace and seed cost
Seedlings/ft²	*%*	*Dollars per 1,000 shippable seedlings*		
4	13	11.60	23.00	34.60
8	19	6.20	24.70	30.70
12	28	4.60	27.80	32.40

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