Effects of Seedbed Density and Fertilization on Root-Pruned 2-0 White Oak Nursery Stock

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Average seedling caliper of white oak increased as seedbed density decreased and as fertilization increased. Seedling height increased with fertilization but was not affected by seedbed density. Percent of culls increased as density increased but was not affected by fertilization.

Nursery practices may affect the growth and survival of white oak seedlings after outplanting. Because larger seedlings appear to have a greater potential for good growth than smaller seedlings (1,2), Johnson (1) recommended a minimum size of 8 millimeters (10/32 in) in caliper at 2.54 centimeters (1 in) above the root collar and a shoot length of 50 centimeters (20 in). Under conditions at Vallonia Nursery, white oak (*Quercus alba*) seedlings take 2 years to reach this acceptable size. The purpose of this study was to measure the effects of seedbed density and fertilization on the growth of root-pruned 2-0 white oak seedlings.

Methods

The white oak acorns used in this study were collected from various sources in southeastern Indiana and thoroughly mixed before sowing so that the study results would represent the seed sources normally sown at Vallonia. The acorns were sown by hand in October 1981 in five 1-inch-deep drills spaced 8 inches apart on a standard 4-foot-wide nursery bed. The acorns were covered with $^1/_2$ to 1 inch of soil and mulched with hydromulch.

Treatments consisted of 3 seedbed densities of 4, 8, and 12 seedlings per square foot, and 3 top-dress fertilizer rates of 0, 400, and 800 pounds per acre of 12-12-12 fertilizer at each seedbed density. The study was a 3 by 3 factorial arranged in a randomized complete block design having 3 replications. The 9 treatment combinations were assigned randomly to each replication with 4-by-4-foot plots.

Except for root pruning, these seedlings were grown under the same conditions as described for 1-0 white oak by Wichman and Coggeshall (3). All fertilizer treatments were applied during June and July of the first growing season.

The seedlings were root-pruned in early April of 1983, just as they were beginning to grow new shoots. A standard horizontal root-pruner was used at a depth of 6 to 8 inches. The roots were pruned to limit tree size and also to increase root fibrosity, which has been shown to enhance field performance (2).

In December 1983, 3,867 seedlings were lifted and measured to determine height, caliper (diameter at 1 inch above the root collar) and percent cull. A cull was defined as a seedling with a caliper of 5 millimeters (6/32 in) or less. Height, caliper, and percent of cull were subjected to analyses of variance, and percent of cull data was transformed by using arc sin v (percentage) transformation.

Results and Discussion

Seedbed density and fertilizer significantly influenced seedling caliper (table 1). Seedling caliper increased from 6.0 millimeters at a seedbed density of 12 to 7.8 millimeters at a seedbed density of 4

Table 1—*Analysis of variance of caliper, height, and cull seedling percentage for 2-0 root-pruned white oak*

Source of variation	df	Mean square for		
		Caliper	Height	Seedlings culled
		mm	*cm*	*Arc sin* $\sqrt{\%}$
Blocks	2	1.1626*	26.9478	106.7811
Seedbed density (D)	2	7.7615**	20.6144	948.9811**
Fertilizer (F)	2	2.5848**	86.5433**	99.1033
D x F	4	0.0715	7.5994	14.1044
Error	16	0.2230	12.6149	33.1969

*Significant at p = .05 level

**Significant at p = .01 level

(table 2). Average caliper increased from 6.2 millimeters at 0 pounds per acre of top-dress fertilizer to 7.3 millimeters at 800 pounds per acre of 12-12-12 (table 2). For individual treatment combinations, caliper varied from 5.4 millimeters at a seedbed density of 12 and 0 fertilizer to 8.4 millimeters at a seedbed density of 4 and fertilizer of 800 pounds per acre. This combination of low seedbed density and high levels of fertilizer produced the largest caliper seedlings.

Wichman and Coggeshall (3) reported that fertilization did not significantly affect caliper of 1-0 white oak seedlings. The different response of 1-0 and 2-0 white oak to fertilization could be due to several factors. Because 2-0 seedlings were much larger than the 1-0 trees, they needed more soil nutrients. Also, the root-pruning cut many of the deep roots (more than 8 inches below the surface) established during the first growing season. The nutrients in deeper soil layers could therefore not be tapped for several weeks until deep roots were re-established.

Seedbed density had no effect on seedling height (table 1). Wichman and Coggeshall (3) reported that neither seedbed density nor fertilizer influenced the height of 1-0 white oak seedlings. For 2-0 white oak, seedling height was influenced by fertilization (table 1). Average height increased from 34.8 centimeters at 0 pounds per acre to 40.5 centimeters at 800 pounds per acre of 12-12-12 fertilizer (table 2). Nutrients apparently became a limiting site factor during the second growing season, because when fertilized, seedlings responded to the improved site conditions by growing taller.

Percent cull was influenced by seedbed density but not by fertilizer (table 1). Average cull percent increased from 16.1 at a seedbed density of 4 to 48.1 per-

Table 2—*Average caliper, height, and cull seedling percentages by seedbed density and fertilizer treatments for 2-0 root-pruned white oak*

Source of variation		Caliper	Height	Seedlings culled
		mm	*cm*	%
Seedbed density				
4 seedlings/ft²		7.8a[1]	39.6a	16.1a
8 seedlings/ft²		6.7b	38.8a	33.3b
12 seedlings/ft²		6.0c	36.7a	48.1c
Fertilizer				
0 lb/acre		6.2c	34.8c	37.6a
400 lb/acre		6.9b	39.8b	32.3a
800 lb/acre		7.3a	40.5a	27.5a
Seedbed density (D)x Fertilizer (F)				
D	F			
4	0	7.2	36.9	20.0
4	400	7.8	40.5	17.8
4	800	8.4	41.4	10.6
8	0	6.2	36.5	35.6
8	400	6.8	39.8	34.3
8	800	7.1	40.1	30.0
12	0	5.3	31.0	57.4
12	400	6.2	39.0	44.8
12	800	6.4	40.0	42.0

[1]Means within a column, within a treatment, not followed by a common letter are significantly different at the $p = .05$ level.

cent at a seedbed density of 12 (table 2). For individual treatments, percent cull varied from 10.6 percent at 4 seedlings per square foot and 800 pounds per acre of fertilizer, to 57.4 percent at 12 seedlings per square foot and 0 fertilizer (table 2). The former combination of density and fertilizer is therefore best for producing the greatest number of shippable seedlings.

In this study, seedlings were not culled on the basis of height because nearly all seedlings were at least 20 centimenters tall. In fact, most of the seedlings approached 35 centimeters in height. At high seedbed densities, the seedlings apparently grew in height at the expense of diameter growth.

Studies with white oak and many other tree species have shown that large seedlings are more likely to grow at an acceptable rate after field planting (1, 2). If this criterion is applied to the trees in this study, a seedbed density of 4 with 800 pounds per acre of top-dress 12-12-12 fertilizer would be the best practice for producing large, high quality, 2-0 root-pruned white oak. This combination would also minimize the number of cull seedlings.

Seedlings from each treatment in this study will be outplanted and compared with the 1-0 seedlings described by Wichman and Coggeshall (3). Results from this outplanting phase will show how seedling age and nursery culture affect field performance of white oak seedlings in Indiana.

Literature Cited

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