JUVENILE GROWTH OF PLANTED NORTHERN RED OAK: EFFECTS OF FERTILIZATION AND SIZE OF PLANTING STOCK

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Artificial regeneration of northern red oak *(Quercus rubra L.) is* presently difficult. Direct seeding will continue to be a risk until depredation by animals can be curtailed. While good survival can be obtained by using standard planting techniques, early growth is poor (Olson and Hooper 1968). In an effort to obtain rapid early growth of planted stock, we investigated the combined use of. fertilization and larger than average seedlings.

Methods

One-hundred-eighty seedlings were obtained from each of the following four sources in the 1964 seedling crop at Clinton Forest Nursery of the Tennessee Valley Authority.

Source	Description
1	500 seedlings from an average tree in Union County, Tenn.
2	500 seedlings from an average tree in Union County, Tenn.
3	500 seedlings from an average tree in Washington County, Va.
4	50,000 seedlings from a good stand in Monroe County, Tenn.

Ninety of the 180 seedlings were chosen randomly; the other 90 were the largest seedlings in each lot. Each lot of 90 seedlings was divided into 10 nine-tree replicates and planted in randomized docks early in 1965. Each nine-tree entry was planted in three rows of three trees each; spacing was 4 feet within rows and 8 feet between rows. The design prior to superimposition of fertilizer treatments was thus a randomized complete block with 10 replications of eight treatments.

The site was an abandoned forest nursery in Anderson County, Tenn., which had been in fescue sod for 5 years. It is characterized by an alluvial terrace soil (Waynesboro loam) with good drainage and is typical of old-field sites suitable for regeneration to high quality hardwoods.

Trees were planted in 6-inch-diameter post holes 1 foot deep. At planting, the following fertilizer treatments were superimposed on plots of randomly selected seedlings: A perforated plastic bag containing .26 pound of ammonium nitrate was placed in 6-inch-deep holes 1 foot from each tree in one of the three rows in each plot. Bags containing .43 pound of diammonium phosphate were similarly placed in a second randomly selected row. The third row of trees was untreated.

A second fertilizer treatment was superimposed on the test in May 1966, at the beginning of the second growing season. Ammonium nitrate at rates of 0, 25, 50, 100, 150 pounds of nitrogen per acre was broadcast on plots of both selected. and unselected seedlings. Each rate was applied to two randomly selected blocks.

The test was mowed between rows as needed during the growing seasons. Height was measured at planting and after the third and fourth years. At the end of the third growing season, 570 pounds per acre of commercial fertilizer (15:15:15) was broadcast over all the test except control blocks.

Results

Survival for the planting was 96 percent; distribution of mortality was random. Because of the way in which fertilizer treatments were applied, the study actually consisted of two split-plot experiments. Factors were tested at the .05 level of probability.

The first was a trial of broadcast and bag fertilization using randomly selected stock from the four sources. Selected stock was not evaluated since it did not receive bagged fertilizer at planting. The results are summarized (table 1). Response to both bag and broadcast fertilization was statistically significant. However, differences among broadcast treatments of 25 to 150 pounds per acre were small and nonsignificant. Ammonium nitrate applied in bags resulted in generally better growth than controls, but differences decreased at higher levels of

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TABLE 1.—*Three-year height (feet) of randomly selected northern red oak seedlings as influenced by fertilization*

Broadcast fertilization at beginning of second growing season Pounds N per acre	Fertilization treatment at planting		
	Control	Ammonium nitrate	Diammonium phosphate
0	1.7	2.6	1.8
25	2.4	3.2	2.9
50	2.4	2.7	2.6
100	2.6	3.2	3.0
150	2.7	3.3	3.3

broadcast fertilization. Diammonium phosphate applied in conjunction with the control level of broadcast fertilization did not stimulate growth; at higher levels of broadcast nitrogen, the response was similar to that effected by ammonium nitrate. Seed source effects were not statistically significant.

Seed bed selection, seed source, and broadcast fertilization were evaluated in the second test (table 2). At planting, selected stock was about twice as large as randomly selected material. Seedlings from Source No. 4 were twice as large as those from the other three sources, which did not differ in size. After 3 years' growth, effects of seed source and selection were still statistically significant. Trees from Source No. 4 were larger than those

TABLE 2.—*Height in feet of planted northern red oak seedlings as influenced by fertilization and selection*

Seed source	0 lb. N per acre		25 lb. N per acre		50 lb. N per acre		100 lb. N per acre		150 lb. N per acre	
	Random	Select	Random	Select	Random	Select	Random	Select	Random	Select
[HEIGHT AT PLANTING]										
1	0.9	1.5	1.0	1.6	0.8	1.6	0.7	1.5	0.8	1.5
2	0.8	1.5	0.7	1.6	0.8	1.5	0.7	1.5	0.8	1.6
3	0.9	1.5	0.9	1.4	0.7	1.4	0.8	1.7	0.9	1.5
4	2.0	3.1	1.5	3.0	1.1	2.9	1.0	2.9	1.2	3.0
Mean	1.2	1.9	1.0	1.9	0.8	1.8	0.8	1.9	0.9	1.9
[HEIGHT 3 YEARS AFTER PLANTING]										
1	1.4	2.6	2.5	3.5	2.6	3.5	2.6	4.0	3.2	4.3
2	1.5	2.3	2.3	3.7	2.8	3.5	2.6	3.4	2.5	3.9
3	1.5	2.3	2.2	3.0	2.1	3.5	3.0	3.9	2.7	3.9
4	2.4	3.5	2.7	4.0	2.2	4.1	2.4	4.1	2.3	4.5
Mean	1.7	2.7	2.4	3.6	2.4	3.6	2.6	3.8	2.7	4.2
[HEIGHT 4 YEARS AFTER PLANTING]										
1	2.4	3.0	4.9	5.3	4.3	4.7	4.6	6.0	5.2	6.5
2	2.2	3.2	3.4	6.2	4.0	4.8	4.4	4.4	4.0	5.8
3	2.2	2.9	4.0	4.8	3.4	5.1	4.8	5.7	4.5	6.4
4	3.0	4.3	4.2	6.1	3.2	5.7	3.4	5.9	4.2	6.5
Mean	2.4	3.4	4.1	5.6	3.7	5.1	4.3	5.5	4.5	6.3
[MEAN PERIODIC HEIGHT GROWTH]										
Growth period 1–3 years	0.5	0.8	1.4	1.7	1.6	1.8	1.8	1.9	1.8	2.3
4th year	0.7	0.7	1.7	2.0	1.3	1.5	1.7	1.7	1.8	2.1

from, other sources, although differences were relatively smaller than at planting. Both total height and 3-year height increment of selected seedlings were greater than that for random selections.

All fertilization rates produced significantly better growth than controls, but differences among rates were generally nonsignificant. Only the selected seedlings growing under 150 pounds of nitrogen per acre were larger than equivalent material under the three lower rates.

Height increment during the fourth growing season (after additional fertilization noted above) equaled the combined growth of the first 3 years. On fertilized plants, it occurred in two flushes, the second of which was in late June. At the end of the fourth season, selected seedlings were still significantly larger than run-of-the-bed trees, but effects of seed source were nonsignificant. The total range of tree-to-tree variation in the test was 1.6 to 9.0 feet. Treated and untreated trees are shown in figure 1.

Discussion and Conclusions

In contrast to previous reports on nitrogen fertilization of planted red oak (Curlin 1961; McComb 1949), distinctly beneficial effects were observed in this study. This response to fertilizer was largely responsible for dominance on the site by oak in 4 years. Both broadcast and bag applications were effective, but a combination of the two methods gave best results. On our site, little benefit accrued from broadcasting more than 25 pounds of nitrogen per acre 1 year after planting. Fertilization after the third growing season cannot be formally evaluated in the study, but the especially good fourth-season growth of treated plants suggests that it was beneficial.

Use of selected large seedlings was beneficial during the first 4 years after planting. The influence of selection within sources on total height at 4 years was about the same as average fertilization effects. However, the seed source effect faded out before plants were 5 years old. This suggests that some differences in initial height were related to seedbed effects, especially since seedlings for the test were reared in unreplicated source blocks.

Results of this study indicate that nitrogen fertilization, large planting stock, and weed control by mowing will produce good juvenile growth of red oak on an old-field site suitable for hardwoods. All three procedures appear warranted in establishing seed orchards or commercial plantations of high value stock.

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