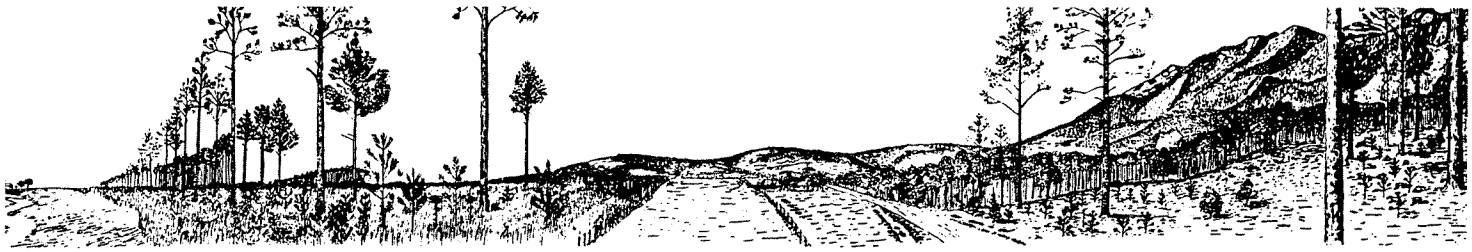

U. S. Forest Service Research Note SE-90 March 1968

NORTHERN RED OAK SEEDLING GROWTH VARIES BY LIGHT INTENSITY AND SEED SOURCE

Abstract. --Northern red oak seedlings from each of three seed sources were subjected for one growing season to one of four intensities of light: full light, 70 percent light, 37 percent light, and 8 percent light. Seedlings grown in the open were taller than those grown in the shade and had more, generally heavier leaves. Height and leaf growth decreased as the amount of light reaching the plants decreased. Seed source, another important factor affecting growth, was related to height growth, number of leaves per seedling, acorn weight, and percent of multiple stems. Forty-one percent of the seedlings from one source had multiple stems, while only 11 percent and 4 percent of the seedlings from the other two sources had multiple stems.

In seeking to determine light requirements for seedlings of northern red oak (*Quercus rubra* L.), we found that seedlings exposed to open sunlight grew taller in the first year than did those subjected to varying degrees of shade. At a time when many forest landowners are shifting to even-age management and its associated heavy harvest cuts, it is reassuring to observe red oak seedlings growing well in the open. This phenomenon does not preclude the possibility that under certain conditions the temperature or soil moisture associated with shade might improve growth. Nevertheless, the study results show that shade itself is not necessary to the growth of northern red oak.

To determine whether light requirements varied according to seed source, acorns were collected from three widely separated northern red oaks (table 1). All acorns were stored in moist sand at 40° F. Before they were planted on March 15, 1966, the acorns were cleaned and weighed so that any correlation between acorn weight and growth could be observed.

Table 1.--Description of seed source trees

Tree	Age	Merchantable height	Diameter	Site elevation	Average acorn weight
	Years	Feet	Inches	Feet	Grams
1	150	16	9	5,000	5.5
2	200	40	30	3,300	10.4
3	70	24	16	2,700	7.1

Seedlings from each of the three seed sources were subjected to one of four intensities of light: 8 percent sunlight (heavy shade), 37 percent sunlight (medium shade), 70 percent sunlight (light shade), and full sunlight (no shade). Light intensity was

regulated on each plot by plastic screens which controlled the amount of light reaching the plants (fig. 1).[1]

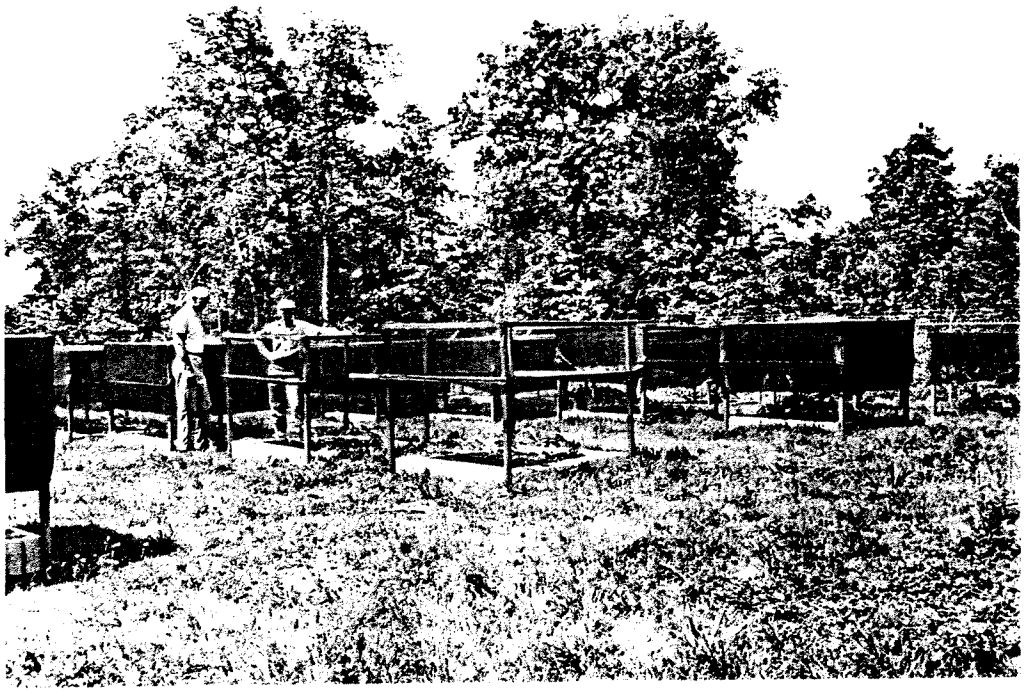

Figure 1.--Study layout showing shade apparatus and seedlings.

On April 29, when the spring foliage in the adjacent forest began to cast a significant amount of shade, the plastic screens were set in place. These screens were removed on October 12, a date roughly corresponding with the annual fall leaf drop. During the growing season, the seedlings were watered frequently to prevent variation in soil moisture between treatments from becoming a major factor affecting growth. The seedlings grown in the open, in particular, dried quickly.

Near the end of the growing season the number of leaves and stems per seedling were counted. At the same time, two disks of leaf tissue were taken from each seedling. The disks from each plot were grouped by seed source, ovendried, and weighed. At the end of the growing season seedling height was measured. In the case of multiple stems, the height of the tallest stem was recorded.

RESULTS

Regardless of seed source, those seedlings grown in open sunlight were considerably taller, had more and thicker leaves, and were generally healthier than those grown in the shade (tables 2, 3, and 4). As the amount of sunlight reaching the plants decreased, height and leaf growth also decreased. Seedlings receiving a low intensity of light (8 percent), comparable to the light under a natural mature oak stand, were only 60 percent as tall as seedlings grown in the open and 84 percent as tall as seedlings receiving

[1]Because future plans for the study include determining the effect of release from shade on seedling growth, more replicates of the various shade treatments were set up than of the full sunlight treatment. This disproportion in the number of plots for the shaded and unshaded seedlings prevented our subjecting the data to an analysis of variance.

a medium intensity of light (37 percent). Seedlings receiving a low intensity of light had about half as many leaves as did seedlings grown in the open and, based on the ovendry weight of the respective leaf disks, only 80 percent of the leaf weight per unit area.

Table 2.--Height of northern red oak seedlings in relation to light treatment and seed source

Seed source	Treatment				Average
	Full light	70 percent light (light shade)	37 percent light (medium shade)	8 percent light (heavy shade)	
	Inches				
Tree 1	6.77	5.03	5.17	4.94	5.48
Tree 2	9.40	7.58	7.23	5.80	7.50
Tree 3	11.40	8.87	7.25	5.72	8.31
Average	9.19	7.16	6.55	5.49	7.09

Table 3.--Average number of leaves per northern red oak seedling by light treatment and seed source

Seed source	Treatment				Average
	Full light	70 percent light (light shade)	37 percent light (medium shade)	8 percent light (heavy shade)	
	Number				
Tree 1	10	7	7	6	7
Tree 2	14	12	11	8	11
Tree 3	13	11	8	6	10
Average	12.3	10	8.7	6.6	9.3

Table 4.--Ovendry weight of leaf disks per seedling by light treatment and seed source

Seed source	Treatment				Average
	Full light	70 percent light (light shade)	37 percent light (medium shade)	8 percent light (heavy shade)	
	Milligrams				
Tree 1	11.49	10.48	9.97	9.26	10.30
Tree 2	10.74	12.07	9.78	8.28	10.21
Tree 3	10.75	11.88	9.45	8.78	10.21
Average	10.99	11.14	9.73	8.77	10.24

Seedling response also varied according to seed source. Acorns from tree 3 produced seedlings $1\frac{1}{2}$ times as tall as seedlings produced from tree 1 (table 2). A high correlation also exists between seed source and number of leaves per seedling (table 3). The large number of leaves per seedling shown for seedlings from tree 2 can be partially explained by the high number of multiple stems produced by acorns from that tree. Forty-one percent of the seedlings from tree 2 had multiple stems as compared with 11 percent of the seedlings from tree 3 and 4 percent of those from tree 1.

Another factor associated with seed source is the average weight of acorns. Acorns from tree 1 averaged only 5.5 grams while those from tree 3 averaged 7.1 grams, and those from tree 2 averaged 10.4 grams. It is possible, therefore, that some of the differences in seedling response associated with seed source were due to acorn size.

Weight variation of acorns from a single tree, however, was not generally associated with variation in seedling height growth. Regressions of seedling height on acorn weight were computed for each of the 12 treatment-seed source combinations; only two of these regressions had b coefficients significant at the 5-percent level.

DISCUSSION

Perhaps the best lesson to be learned from this study and other published results is that the various oak species vary in their response to light, and each must be studied and managed on an individual basis. Kramer and Kozlowski[2] have stated that, generally, high light intensities increase root-shoot ratios, leaf thickness, number of stomata, and cell wall thickness. Kozlowski[3] found that seedlings of overcup oak (Quercus lyrata Walt.) are shorter but heavier when grown in full sunlight than when grown in the shade. Jarvis[4] found that for sessile oak (Quercus petraea (Matt.) Liebl.) shading increased height, leaf area, leaf area ratio, and chlorophyll content but decreased leaf thickness, root weight, root-stem ratio, net assimilation rate, and relative growth rate.

Data from this study show rather conclusively that northern red oak seedlings do not require shade during their first year. The 2- to 4-inch average height advantage of seedlings grown in the open over shaded seedlings may in some cases be of no practical importance. On the other hand, there may be cases where an extra 2 inches would be the key to survival by keeping such seedlings just above competing growth.

The variation in response for seedlings produced from different trees may also have practical significance. Producers could grow better oak seedlings by separating acorns according to source and eliminating from future collection those trees that produced seedlings with poor growth or multiple stems. The same selectivity should be maintained for direct seeding. Germination tests could be run on a few acorns from potential parent trees before the acorns were seeded; subsequent acorn collection could then be confined to the best trees.

Much work remains to be done before forest biologists can be confident that they know the environmental requirements for the various oak species. The study reported here is part of a comprehensive study of the light requirements and response to release of northern red oak.

---

[2]Kramer, P. J., and Kozlowski, T. T. Physiology of trees. 642 pp. New York: McGraw-Hill Book Co. 1960.

[3]Kozlowski, T. T. Light and water in relation to growth and competition of Piedmont forest tree species. Ecol. Monogr. 19: 207-231. 1949.

[4]Jarvis, P. G. The adaptability to light intensity of seedlings of Quercus petraea (Matt.) Liebl. J. Ecol. 52(3): 545-571. 1964.

Charles E. McGee, Silviculturist
Asheville, North Carolina

☆ U. S. GOVERNMENT PRINTING OFFICE: 1972 — 745-563 / 5032. REGION NO. 4