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IMPROVING GERMINATION OF NUTTALL OAK ACORNS

R. L. Johnson¹

SOUTHERN FOREST EXPERIMENT STATION

Under simulated field conditions the best treatment for germination of acorns of Quercus nuttallii Palmer was a combination of sowing 1 inch below soil surface, under litter, and in partial shade. Supplemental watering was also advantageous. The most important factor was depth of sowing.

Nuttall oak, an important commercial species in low, wet areas in the South, and especially in the lower Mississippi Valley, has heavy seed crops every 3 or 4 years.² Plentiful seed does not ensure good stands of reproduction, however, for unfavorable site conditions may seriously hamper germination.

Acorns fall from early October to mid-December, with the peak usually in late November. The seeds frequently remain under water for 3 or 4 months during winter and spring. Long-term soaking at low temperatures does not decrease viability³ and may help break

dormancy. While acorns will germinate when submerged, it is doubtful that seedlings become established. Once the water leaves, lack of moisture appears to limit germination and seedling establishment. Since good seedling stands often occur in depressions beneath crowns of Nuttall oak, it appears that shade, moisture, and possibly litter accumulation are important factors. A study was accordingly undertaken to test various seedbed conditions, with a view to discovering a combination favorable to seedling establishment.

METHODS

Several hundred Nuttall oak acorns that had been under water since December were collected on April 19, 1964. On the 20th and 21st of April, 20 sound acorns (as judged by close visual examination) were sown in each of 72 blocks of Sharkey clay soil. The blocks, measuring 1 foot square and 6 inches deep, were

¹ Stationed at the Southern Hardwoods Laboratory, which is maintained at Stoneville, Miss., by the Southern Forest Experiment Station in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group.

² Morris, R. C. Nuttall oak (*Quercus nuttallii* Palmer). In *Silvics of Forest Trees of the United States*, pp. 593-595, illus. U. S. Dep. Agr., Agr. Handbook 271. 1965.

³ Briscoe, C. B. Germination of cherrybark and Nuttall oak acorns following flooding. *Ecology* 42: 430-431. 1961.

dug from the Delta Experimental Forest, near Stoneville, and enclosed with wooden slats on the sides and burlap underneath. The soil was relatively undisturbed during lifting.

Blocks were arranged in the nursery of the Southern Hardwoods Laboratory in a split-plot design, with three replications, to test all combinations of:

Two light treatments—full sunlight and partial shade from a snow fence placed about 1 foot above the soil surface. Snow fence slats were oriented east-west.

Two moisture treatments—natural rainfall and a minimum of 1 acre-inch of water per week through a combination of rain and supplemental watering.

Two seedbed conditions—mineral soil and about 1 inch of partially decomposed litter present when the blocks were dug.

Three sowing depths—on the surface of the mineral soil, with top of acorn even with surface of mineral soil, and with top of acorn 1 inch below surface of mineral soil.

The four light-moisture combinations constituted the major plots.

In the expectation that moisture and temperature would be important to germination, measurements were taken of: 1.—Moisture contents of one or two acorns per soil block weekly from May through July (but no more than 10 acorns were removed from any replication). 2.—Moisture contents in the surface inch of soil in shaded and unshaded mineral and littered soil blocks during one 7-day period. 3.—Temperatures on and 1 inch below the surface of mineral and littered soil both in full and partial sunlight throughout the summer.

RESULTS

Germination ranged from 0 to 100 percent, depending on treatment (table 1). Percentages were based on the 10 seeds per soil block left after 10 had been removed for moisture-content determinations. Germinating seeds were counted throughout the growing season. More than 95 percent of the seeds that germinated did so by June 16. A few acorns at all depths turned black and spongy during the first week. The number found in this condition increased weekly, and by July 1 few were sound at any depth.

Table 1.—Germination of Nuttall oak acorns by treatments

Planting depth and seedbed condition	Light		Shade	
	Rainfall	Rainfall and watering	Rainfall	Rainfall and watering
----- Percent -----				
Surface				
Bare soil	13	0	0	0
Litter	3	13	3	0
Even with surface				
Bare soil	3	3	7	20
Litter	43	13	60	50
Inch below surface				
Bare soil	33	83	73	97
Litter	77	90	80	100

Analysis of germination percentages showed significant differences (0.05 level) among several variables.

Sowing depth affected germination more than any other factor. Germination averaged 5 percent for all surface-sown acorns, 25 percent for even-with-the-surface acorns, and 79 percent for acorns 1 inch below the surface. Most acorns had a moisture content of 50 to 70 percent when sown. Those placed on the soil surface were immediately exposed to 100° F. for several hours at a time; as a result, most seedcoats burst and the embryos dried. Acorns sown 1 inch deep maintained a high moisture content.

Germination was 39 percent in blocks given supplemental water and 33 percent in blocks receiving only rain. From April 21 through June 16 (8 weeks), watered blocks received 9.8 inches of water. Natural rainfall during this time was 6.6 inches, and was reasonably well distributed. In early May, 7 days after a supplemental watering, soil moisture in the surface inch of the blocks was 2 to 3 percentage points higher under shade than in the open and 2 or 3 percentage points higher under litter than in bare soil. Soil moisture averaged 5 to 6 percentage points higher in shaded, littered blocks than in open, unlittered blocks.

There was a significant interaction between watering and sowing depth. Where water was added, germination averaged 92 percent for deep-sown acorns, 3 percent for those on the surface, and 21 percent for those sown even with the surface. Corresponding percentages for acorns exposed only to rain were 66, 5, and 28. The additional water was of substantial

benefit only to deep-sown acorns, but the data do not reveal the reason.

Shade from the snow fence cut light intensity by about 50 percent, according to readings taken on July 2 and August 16. Overall, shaded acorns had 41 percent germination, as compared to 31 percent for acorns in full sunlight. The interaction of light $\times$ planting depth was not significant.

Litter was about 1 inch thick in most boxes, but ranged from $\frac{1}{2}$ to 2 inches. Germination was 44 percent with some litter and 25 percent without any litter.

From May 5 through June 16, temperatures near the acorns varied with treatment (table 2). On the surface of bare soil, temperatures of 70-90° (probably the best range for germination) prevailed only 27 percent of the time in full sunlight and 61 percent in shade, while for 13 percent of the time in the sun and 7 percent in the shade the acorns were exposed to 100-130° (too high for germination). Germination was best among acorns sown 1 inch below the soil surface, under litter, and under shade in temperatures that never exceeded 90° and ranged between 70-90° for 93 percent of the time.

DISCUSSION

One inch of soil over the acorns was the most beneficial single treatment. It probably acted as a buffer against extremely high temperatures. Soil moisture (which is closely associated with temperature) and moisture content of acorns were both higher, and thus better for germination, an inch below the soil surface. Litter, partial shade, and supplemental watering all helped create an even more desirable environment by further reducing temperature and conserving soil moisture.

In the forest, seedbed conditions like those of the best treatment can probably be obtained by plowing furrows during autumn. Acorns would either fall naturally or could be thrown into the furrows and then covered with 1 to 2 inches of soil. Leaf fall during the winter would provide litter. Records at Stoneville show that the soil an inch below the surface usually does not reach 70° under full shade until June or even later. By opening the stand somewhat, it may be possible to raise soil temperature to 70-90° in late April, May, and early June, when soil moisture is normally high. Apparently, few Nuttall acorns will germinate after July 1, even if soil moisture is adequate.

Table 2.—Percent of total time recorded from May 5 through June 16 in each of nine temperature classes

Location of sensing unit	Temperature class (° F.)								
	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	121-130
	----- Percent -----								
Surface of bare, unshaded soil	4.6	28.7	19.1	16.2	11.1	7.4	8.6	3.7	0.7
Surface of bare, shaded soil	0	0	21.0	42.7	18.1	11.3	6.7	.2	0
One inch below surface of bare, unshaded soil	0	0	17.5	42.7	26.8	12.4	.7	0	0
One inch below surface of littered, unshaded soil	0	0	23.4	54.1	21.6	.9	0	0	0
One inch below surface of bare, shaded soil	0	0	10.2	56.3	28.0	5.5	0	0	0
One inch below surface of littered, shaded soil	0	0	6.6	86.0	7.3	0	0	0	0