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Robert C. Lommasson
University of Nebraska-Lincoln

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RED OAK GERMINATION AND SEEDLING SURVIVAL IN PRAIRIE HABITATS

Robert C. Lommasson

School of Biological Sciences
University of Nebraska–Lincoln
Lincoln, Nebraska 68588-0118

A seed germination test was made on 50 of over 350 red oak acorns. Acorn weights ranged from 2 g to over 9.5 g, and their sizes ranged from 19.4-25.5 mm diameter. Roots first appeared from a hole in the bottom of a planting pot 17 days after planting and continued to 64 days after planting. Root germination by weight class of acorns was: those under 5.5 g 31%, 5.5 to 6.5 g 76%, and those over 6.5 g 100%. Shoots first emerged 27 days after planting, and the last emerged 65 days after planting. Production of emergent above-ground shoots for the same weight classes of acorns was: 23%, 64%, and 60%. Of 300 acorns planted into a tall, warm-season prairie sod an estimate of considerably fewer number of above-ground shoots was seen in the field than the 52% found in the greenhouse germination test. After four seasons of growth no seedlings of red oak could be found in the tall warm-season prairie area. Of the 24 seedlings from the germination test only 11 were barely surviving after five years of growth in a cool-season grass sod of mostly smooth brome.

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INTRODUCTION

The presence of mature red oaks, *Quercus rubra* L., on the outskirts of Lincoln, Lancaster County, Nebraska, is not shown in the distribution maps of Little (1971) and Stevens (1973). This suggested that it might be worth while trying to grow these trees from seed in an area of woodland-grassland juncture. The Reller Natural History Research Area of the University of Nebraska–Lincoln, which is located in Lancaster County, provided an available area for a long-term experiment having such an interface. Petersen (1923) and Winter (1936) both have stated that the red oak is the second most common oak in the State with its principal distribution in the southeastern part of Nebraska along the Missouri River and its tributaries.

Jensen (1977) studied seven species of the genus *Quercus*, subgenus *Erythrobalanus*. Of the 36 variables studied, 12 concerned those of the nut and the cup. His collections of *Quercus rubra* were obtained from six States, eight different collecting areas, and thirteen different collections. On the whole his collection from Tennessee was fairly typical of the species with a few exceptions.

Since woody plants often invade grasslands in this area, the objective of this study was to determine if red oak acorns could germinate and grow in tall warm-season grassland, and if seedlings of red oak could develop in cool-season grassland such as smooth brome without the relief from competition that is usually provided for introduced seedlings in the form of a prepared transplant bed or an area denuded by herbicides.

MATERIALS AND METHODS

On May 31, 1977, Professor Walter T. Bagley provided over 350 stratified red oak acorns of Tennessee origin. On June 1, 1977, 50 acorns were removed from the lot for a germination test. Each acorn was weighed and measured before planting. Acorns were placed in half-gram categories and assigned a number from 1 to 50. Each acorn was then measured with a vernier caliper to obtain its approximate diameter (Table 1). Acorns were then separately planted in small plastic pots with coarse vermiculite in the bottom and a mixture of sand and

TABLE 1. Weight, size and days from planting to root appearance, and days from planting to shoot emergence from the soil of 50 red oak acorns.

Rank	Weight[1]	Size[2]	Root[3]	Shoot[4]	Rank	Weight	Size	Root	Shoot
1	2-2.5	20.1			26	6-6.5	21.6	22	65
2	2-2.5	20.7			27	6-6.5	22.3	22	42
3	3-3.5	19.8			28	6-6.5	22.4		
4	3-3.5	22.0			29	6-6.5	22.5		
5	3.5-4	19.4	42	65	30	6-6.5	24.3		
6	3.5-4	20.3			31	6.5-7	23.4	64	
7	3.5-4	20.6			32	6.5-7	21.7	41	
8	4-4.5	23.5			33	6.5-7	22.2	64	
9	4.5-5	20.0	24	36	34	6.5-7	23.1	22	36
10	4.5-5	20.0			35	7-7.5	23.3	22	65
11	5-5.5	20.6	41		36	7-7.5	22.1	17	27
12	5-5.5	20.8	41	41	37	7.5-8	22.9	41	
13	5-5.5	22.9			38	7.5-8	23.3	42	65
14	5.5-6	20.5	24	41	39	7.5-8	23.5	22	29
15	5.5-6	21.9	24	36	40	8-8.5	22.1	22	36
16	5.5-6	21.2	17		41	8-8.5	22.3	64	
17	5.5-6	21.1	22	65	42	8-8.5	24.0	41	
18	5.5-6	21.6	41		43	8-8.5	23.7	17	36
19	5.5-6	21.7	24	36	44	8-8.5	23.2	22	36
20	5.5-6	21.4	22	36	45	8-8.5	23.7	64	
21	6-6.5	21.4	27	27	46	8-8.5	22.1	41	
22	6-6.5	21.3	41	36	47	8-8.5	23.2	17	36
23	6-6.5	22.4	27	41	48	8.5-9	23.7	27	42
24	6-6.5	21.7	17	36	49	8.5-9	24.2	24	65
25	6-6.5	22.8			50	9.5-10	25.5	22	65

[1] Weight of acorns in half-gram categories.

[2] Size of acorns to a tenth of a mm for the less than maximum diameter as measured with a vernier caliper.

[3] Number of days from planting of acorns to the appearance of a root at or through one of the four holes in the bottom of a small plastic pot.

[4] Number of days after planting to the emergence of the shoot from the soil.

fine vermiculite surrounding the acorn. The 50 pots were placed in a greenhouse of moderate temperature to germinate. As root germination was observed through holes in the bottom of the pots, the acorns were transferred separately to 12.5 cm clay pots in a soil medium. The young plants which developed shoots were retained in the greenhouse until next spring.

On June 1 and 2, 1977, the remaining 300 acorns were planted in a warm-season tall-grass prairie area at Reller Natural History Research Area (RNHRA). The site is a re-established grassy area planted in 1970 to five common prairie grasses: Indian grass *(Sorghastrum avenaceum* [Michx.] Nash), big bluestem *(Andropogon gerardii* Vitman), little bluestem *(Andropogon scoparius* Michx.), switch grass *(Panicum virgatum* L.), and side oats grama *(Bouteloua curtipendula* [Michx.] Torr.). Earlier, on May 7, 1977, the area had been burned for the first time since its planting to grass in 1970. The acorns were planted in a 3 m grid in an area 30 m wide by 81 m long, with 11 acorns in each of 27 rows. Observations of plants in this area were made in early September 1977, and again in late May of 1978 to detect seedling establishment.

On May 29, 1978, 24 red oak seedlings which remained from the acorn germination test were planted into mostly smooth brome grass sod which had encroached from a nearby road at RNHRA. These seedlings with the whole ball of soil from each pot were planted directly into the sod without establishing a planting bed or the use of herbicides to kill existing vegetation. Seedlings were planted 4 m apart in four rows which were 6 m apart. Observations of the seedlings were made twice a year, around the end of May and the beginning of September from 1978 to 1983.

OBSERVATIONS AND RESULTS

For the 50 acorns used in the germination test much of the information on acorn size, weight, date of root appearance and date of shoot emergence from the soil is contained in Table 1.

The size of the acorns varies considerably, and they are much larger in diameter than those of other oaks in the subgenus as studied by Jensen (1977). Thirty of the 50 acorns in this germination study are larger than the maximum diameter given for acorns in his study. Also the density of these acorns varies considerably as indicated by comparing the diameters of acorns numbered 4 and 8 (Table 1) with acorns numbered below and above them. Acorn number 35 in the 7-7.5 g weight class appears to be 1.5 g heavier than similar-sized acorns.

One week after being planted several acorns were removed and upon examination showed that the radicle had extended 2 to 3 mm outside of the shell, and the shell itself had split up the side about half-way. In another week and a half, five of the acorns showed roots coming out of the bottom of the plastic pots. After another week ten more acorns had similarly shown root germination, and by the end of one month, 23 acorns or 46% had germinated. Five weeks after planting, 14 acorns (28%) showed above-ground shoots. Acorns continued to germinate into August or as much as 65 days after being planted. In all, 37 of the 50 acorns (74%) root germinated within 64 days and none germinated after that. Only 26 of 50 acorns (52%) produced above ground shoots within 65 days.

The germination rate of the 300 acorns planted in tall warm-season grass was undoubtedly not as great as in the test run in the greenhouse, but there was a noticeable amount of germination during the first summer before the warm-season grasses became too rank. As late summer and fall came on, the grasses smothered the small seedlings. As usual, in the first season of growth after a burn, the grasses became very tall with inflorescences at a height of about 2 m in the higher end of the plot and about 2.2 m in the lower, more moist end, particularly on big bluestem and Indian grass. At the time of the spring survey, the few red oak seedlings found were very small. Later searches for red-oak seedlings showed that they were not competing with the grasses. In April 1981, when it was time for the next management burn of that area, no red oaks were to be seen after the four growing seasons, yet sprouts of elm, bur oak, black walnut and ash were scattered through the area.

Seedlings from the germination test growing in 12.5 cm clay pots in soil were kept in the greenhouse until May 29, 1978, when 24 surviving seedlings were planted into mostly brome grass sod near a road at the RNHRA. By September 1978, it was obvious that the oak seedlings had not prospered, and the severe grasshopper invasion was destroying most of the leaves on the young seedlings. Five of the seedlings were considered dead at that time. Some of those had been clipped off near the ground by rabbits or squirrels. In May 1979, one more or six were dead and several others were very small and spindly. By September 1979, two more had died but one thought to be dead in May had sprouted from the base of the stem during the summer. In May 1980, the area had a severe freeze, killing off the leaves on all of the trees of the area except the elms. By the end of 1980, ten seedlings had died and by September 1981, eleven seedlings had died. At the end of the five-year study, 13 seedlings had died leaving 11 of 24 seedlings (46%) still alive but not looking like the thriving saplings they should be in that span of time.

SUMMARY AND CONCLUSIONS

A test on germination rate run on a sample of acorns in the greenhouse was to determine the degree of viability of the stratified acorns. An overall 74% germination rate for the 50-acorn sample suggested that a good number of seedlings might appear in the area where the 300 acorns were planted, but only a few were found. From the presence of squirrels and other rodents in the area, we could expect a decrease in the number of the seedlings produced. Microorganisms in the soil may have actually decreased the germination rate by destroying the embryo of some seeds.

In this study the smaller and lighter acorns showed fewer acorns germinating. Only 4 of 13 acorns (31%) weighing under 5.5 g germinated while 13 of 17 acorns (76%)between 5.5 g and 6.5 g germinated, and all 20 acorns (100%) over 6.5 g germinated. However, the percentages which produced above-ground shoots are different in these same three weight groups, being respectively 3 of 13 for 23%, 11 of 17 for 64%, and 12 of 20 for 60%. This means that in the heavier acorns 40% were able to produce a root but failed to produce an emergent shoot. For the 5.5 to 6.5 g acorns only 12% were unable to follow through with above-ground shoots, and in the lighter acorns under 5.5 g only 8% were unable to produce a shoot after producing roots.

Since the acorns in the study by Jensen (1977) were smaller than those in this study, it may be that smaller acorns are better able to survive in nature. Acorns were in vermiculite during the root germination process, and they were in soil while forming the emergent-shoot system in the test acorns. Microorganisms in the soil may have destroyed some seedlings after root germination, which could account for fewer seedlings producing above-ground shoots than those producing roots.

In the field-planted acorns, the microorganisms in the soil had a longer period in which to act, thus accounting for a lower germination and a resultant fewer than expected seedlings than were obtained in the germination test.

It is difficult to determine why 30 of 50 acorns (60%) in this study were larger than the largest acorns in the study made by Jensen (1977), since his collections included Tennessee sources also.

The differences in density of the 50 acorns in the germination study may have been due to differences in acorn-shell thickness, differences in the hydration of the shell in the stratification process, or differences in the hydration of the seed

within the acorn as it approached the stage of germination. Each of these possibilities should be subjected to further study.

Most of the acorns which took the maximum time to produce an emergent shoot were in the heaviest weight group, over 6.5 g (4 of 6 acorns) with one in each of the other weight groups. In all, 26 of the 50 acorns (52%) in the germination test produced emergent shoots and 24 of these grew for about a year before they were planted into smooth brome sod at RNHRA.

The competition the red oak seedlings experienced from growing in smooth brome sod was severe during first growing season, but the added stress from the grasshopper invasion that fall led to the death of some of the seedlings. The May freeze of 1980 caused a severe set back in the vigor of the seedlings. The largest seedling became a little over 60 cm tall but thereafter was attacked by deer and rabbits so that it died before the end of the observations in the fall of 1982. Eleven of 24 seedlings were still living at the end of the period of observations, but definitely were not competing well in the environment.

The mature red oaks native in the Lincoln area are growing on steep banks allowing good drainage, and young red oak trees nearby having trunk diameters of 5 cm are growing in more sparse vegetation than occurs in grasslands. This condition may arise from the rocky soil in which they were growing.

Red oak acorns will germinate in tall warm-season grasslands, but their seedlings cannot compete with the smothering grass canopy. Introduced seedlings can grow in smooth brome sod but do not develop into trees as do the native bur oaks.

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