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Planting Northern Red Oak Acorns: Is Size and Planting Depth Important?

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Abstract

A study was conducted in northern Pennsylvania to determine whether predation by small mammals and insects is related to the size of red oak acorns. Three sizes of acorns were used along with two planting techniques and three levels of overstory shading. Three-year results indicated that acorn size is not a factor in mammal and insect predation. Acorn size did not affect 3-year survival. Although total height growth was statistically different after 3 years, the differences were too small for practical use.

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Introduction

Due to the wide geographic range of oaks, acorn seed crops vary greatly in the quantity and size of acorns that are produced for the same species. Average acorn size in one portion of the range may be twice as large as large seed from another portion of the range (Tourmey and Korstian 1947). Does acorn size really matter? Is there some advantage to selecting smaller or larger acorns for artificial regeneration of oaks? Does the size of an acorn influence seed germination or seedling survival? Similar questions can be asked about acorn consumption and predation. Do small mammals or insects prefer smaller or larger acorns?

There are a number of available publications indicating that acorn seed size or weight has a positive relationship with such factors as germination, seedling survival, and seedling height. Other information indicates acorn size has little or no effect. Some researchers conclude that genetic differences are more significant than acorn seed size. Early literature reported that there was considerably more information on seed size and weight of agricultural and garden seeds than of seeds of forest trees (Cummings 1914; Korstian 1927; Schmidt 1924).

When using acorns for artificial regeneration, we often pick the larger, heavier, "better looking" acorns. Realistically, larger acorns presumably have greater quantities of stored nutrients (food reserve), implying larger, more vigorous seedlings with a better chance of early survival. Thus, seed weight (size) should play an important role in the selection of forest-tree seeds.

European foresters have long recognized that heavier and larger seed results in higher germination and seedling survival. The concern is, then, how long does this advantage persist? Clements et al. (1929) indicated a height-growth advantage that tended to be cumulative. Tree seedlings that are able to quickly get their crowns above the competition usually are more favorably situated to continue to be competitive (McComb 1934; Korstian 1927). Hauch (1923) and Tourmey and Korstian (1947) indicated that the variation in tree size and vigor persists throughout the life of oaks. Cieslar (1896) indicated the early height-growth advantage for oaks from larger acorns persisted for 18 growing seasons.

However, much of the information in the literature is based on 1- to 2-year studies. Korstian (1927) reported that larger acorns of northern red oak (*Quercus rubra* L.), black oak (*Q. velutina* L.), chestnut oak (*Q. prinus* L.), and scarlet oak (*Q. coccinea* L.) should provide additional germination and greater seedling vigor. Seedlings from large chestnut oak acorns had significantly more extensive roots (McComb 1934). Conversely, Tecklin and McCreary (1991) reported that root length for blue oaks was not affected by acorn size. Larger acorns result in greater weights of seedling roots and tops (Korstian 1927; Matsuda and McBride 1986; McComb 1934; Tecklin and McCreary 1991). Also, acorn size can be an important factor influencing the extent of the range of plant species

that expanded or whose range shifted following climatic changes. Aizen and Patterson (1990) reported a positive correlation between acorn size and the geographic range of oaks in Eastern North America (large-seeded oaks have a greater geographic range than smaller seeded oaks). Also reporting positive results when evaluating larger versus smaller acorns were Eytingen (1915), Cummings (1914), Kiesselbach and Helm (1917), Renich (1921), and Baranski (1975).

Some investigators have reported that size or weight of red oak acorns was not as significant as previously indicated. In France, Aissa (1983) found that large *Q. ilex* acorns had no advantage of root size during germination. In reviewing several studies, Bonner (1988) suggested that the advantage of seed size may not persist, and that genetic factors may be more important.

Predation of red oak acorns by mammals and insects was reported by Korstian (1927) who found in a North Carolina study that acorns were destroyed by animals (56.5 percent) and insect larvae (24.2 percent). Similar comparisons were reported for acorns from white, chestnut, and black oak. Acorns provide highly nutritious food for numerous species of wildlife and constitute both a fall and winter food source. In a Michigan study, Verne (1957) found that white, black, and scarlet oak acorns were most preferred by chipmunks (*Tamias striatus*) and white-footed mice (*Peromyscus leucopus*). Red oak acorns were least preferred.

Methods

The objective of this study was to determine the effect of size of northern red oak acorns on populations of small mammals and insects, germination and seedling survival, and height growth. Other treatments superimposed on the acorn-size treatments were depth of planting and overstory density.

Three acorn-size treatments and two sowing depths were evaluated. Acorn sizes were small, medium, and large. Acorn green weights for each size class were large, more than 5.5 grams; medium, 3.5 to 5.5 grams; and small, less than 3.5 grams. Acorns were float-tested and examined for weevil infestation prior to sowing; only sound, uninfected acorns were used. The acorns were sown in early November to two soil depths--on the soil surface and 1 inch beneath the soil surface. For each acorn-size plot there were three rows of surface-sown acorns and three rows of subsurface-sown acorns. Each row contained 14 acorns. The acorns were planted 4 inches apart and rows were 1 foot apart. The subsurface acorns were pushed 1 inch into the mineral soil. For the surface-sown acorns, the current year's litter was pulled back and acorns were pressed into the top of the previous season's litter. All acorns were covered with an amount of the current year's litter that was representative of the treatment plot. During the first year, acorns were examined three times to determine viability or causes of mortality and thereafter checked annually to trace seedling development. In this paper we report 3-year survival.

Study Area

The study was conducted in north-central Pennsylvania on the unglaciated Allegheny Plateau on the Moshannon State Forest in commercial-size northern red oak stands. Elevations ranged from 1,700 and 2,300 feet. Precipitation averaged nearly 4 inches per month during the growing season. The region's climate is cool and moist, with a growing season of approximately 130 days. The average air temperature during the growing season is 60°F, though late freezes are common through June. Because of ample rainfall, cool summer temperatures, and extensive cloud cover, soil moisture usually remains plentiful until late in the growing season. Snow cover prevails from December through mid-March. Each study area consisted of three 4-acre stands (12 acres total). All 36 acres were fenced to exclude deer.

Each study area was characterized by uniform, gently rolling topography. Although soils varied among areas, none has important physical limitations for the development of red oak or production of acorns. Soil textures range from sandy loam to silty clay loam; the effective soil depth ranges from about 24 to 30 inches. Humus types are duff mull. Each of the even-aged stands originated after clearcutting and is dominated by northern red oak in the overstory. Site index for red oak at age 50 ranges from 63 to 75 among the three areas. Common associated species are red maple (*Acer rubrum* L.), sugar maple (*A. saccharum* Marsh.), black cherry (*Prunus serotina* Ehrh.), white oak (*Quercus alba* L.), and white ash (*Fraxinus americana* L.). Along with northern red oak, these species make up 95 percent of the stand basal area.

The basic experimental units within each study area are three 4-acre cutting plots with installations located only in plots that are fenced (electric) to protect acorns from deer predation. The overstory in each 4-acre plot was treated with one of three relative-density levels: 100 percent (no cutting), 60 percent, and 40 percent. Within each 4-acre plot, four acorn-size plots (14 x 14 feet) were established. Two of these plots were protected from pilferage of seed by small mammals and two were left unprotected. Acorn-size plots were located in areas that were representative of the level of overstory light that reached the forest floor beneath the different overstory levels. These small-acorn plots always were located well away from the perimeter of the larger 4-acre plot to avoid edge effects. Data were analyzed using chi-square analysis and analysis of variance split/split/split plot techniques with significant differences tested at the 1-percent level. All treatments were assigned at random.

Results

Small-Mammal Predation

Acorn size did not affect predation and consumption of acorns by small mammals in the unprotected plots. There was no preference for acorns of different size that were readily available on the soil surface or for the less conspicuous acorns located 1 inch beneath the surface (Table 1). Placement beneath the soil simulates caching by

small mammals and helps protect the acorn from insect attacks and desiccation, and may reduce pilferage by small mammals. Small mammals consumed about 91 percent of the acorns that were placed on the surface and about 34 percent of those beneath the surface. When the study was installed, it was a good acorn crop year; otherwise, we would have expected more acorns to have been consumed. Observations suggest that the major predators were chipmunks and white-footed mice. Consumption of acorns by gray squirrels (*Sciurus carolinensis*) and red squirrels (*Tamiasciurus hudsonicus*) was minor, probably because of their low population levels in 1989 when the acorns were sown.

There were no significant differences in small-mammal preferences for acorns of different size among the three overstory densities. This was true for acorns placed on the soil surface and beneath it.

Table 1.—Acorns destroyed by small mammals by size and placement method^a

Acorn size	Acorn placement			
	Surface		Subsurface	
	Number	Percent	Number	Percent
Small	696	92	271	36
Medium	708	94	246	33
Large	655	87	249	33

^aMaximum number of acorns available for predation was 756 per treatment; plots not protected from small mammals.

Insect Infestation

There were no significant differences in insect infestation rates that were attributed to acorn size for either surface or subsurface placed acorns (Table 2). Insects infested about 40 percent of the acorns on the surface and about 25 percent of the acorns beneath the soil surface. Insect infestation was primarily from ground weevils (*Conotrachelus posticus* Buheman) and to lesser extent from nitidulids (*Stelidota octomaculata* (Say)), which collectively accounted for 97 percent of all damage.

Insect infestation of northern red oak acorns by weevils and nitidulids is nearly always fatal. Of the 4,536 acorns that were sampled in this part of the study, 1,405

Table 2.—Acorns destroyed or infested with insects by size and placement^a

Acorn size	Acorn placement			
	Surface		Subsurface	
	Number	Percent	Number	Percent
Small	291	38 ^b	176	23 ^b
Medium	299	40	187	25
Large	306	40	146	19

^aMaximum number of acorns available for predation was 756 per treatment; plots protected from small mammals.

^bNo significant differences among acorn-size treatments.

(31 percent) became infested. None of the infested acorns produced a seedling. Thus, regardless of size, virtually all acorns that become infested with insects die. Insect infestation of small, medium, or large acorns was unaffected by light levels resulting from the overstory treatments.

Thirty-five percent of the subsurface acorns were infested with insects; an average of 23 percent of these planted acorns were lost to predation by small mammals. This means about 50 percent of the subsurface acorns would be available for germinating seedlings.

Seedling Survival

Too many surface acorns (90 percent) were destroyed by chipmunks and mice in the unprotected small-mammal treatment areas and too many surface acorns (39 percent) were lost to insects in the protected treatment for meaningful statistical analysis. Therefore, the effects of acorn size were analyzed only for the protected subsurface treatments.

Acorn size did not significantly affect seedling survival during the first and third years after germination (Fig. 1). For the 2-year data, survival was significantly higher for the larger acorns compared to medium or small ones.

However, this trend was not evident in the 3-year data. Also, seedling survival was not affected by initial acorn size for the three overstory density levels.

Total Height Growth

Height data were used only for subsurface acorns that were protected. In all, 2,268 of these acorns were available for analysis.

There were small increases in seedling height with acorns of increasing size (Fig. 2). These increases were similar over all light levels and were consistent during each of the 3 years. At the end of 3 years, the maximum difference in the annual gain in seedling height growth of increasingly larger acorns was 0.5 foot among the small, medium, and large acorns at any time during the study period. Although these differences are statistically significant, the actual differences in height are so small that they are of little practical value.

Seedling growth was slightly better in the 40-percent relative-density plots where more light reached the forest floor. Total seedling height after 3 years ranged from about 1 foot in the 40-percent plots to about 0.5 foot for higher densities. During the third growing season, seedling height decreased slightly in the higher density plots, primarily due to dieback of the terminal shoot, a common characteristic of

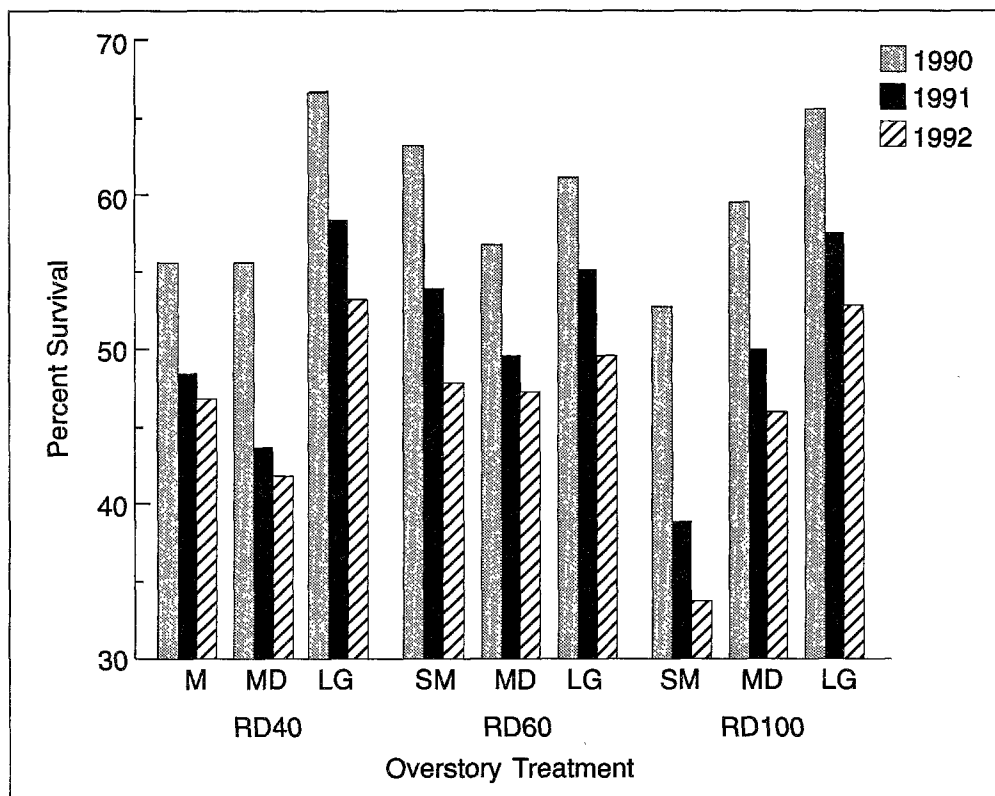


Figure 1.--Percent red oak seedling survival (3-year) as related to acorn size and overstory relative density in plots fenced (electric) to protect acorns from predation by deer.

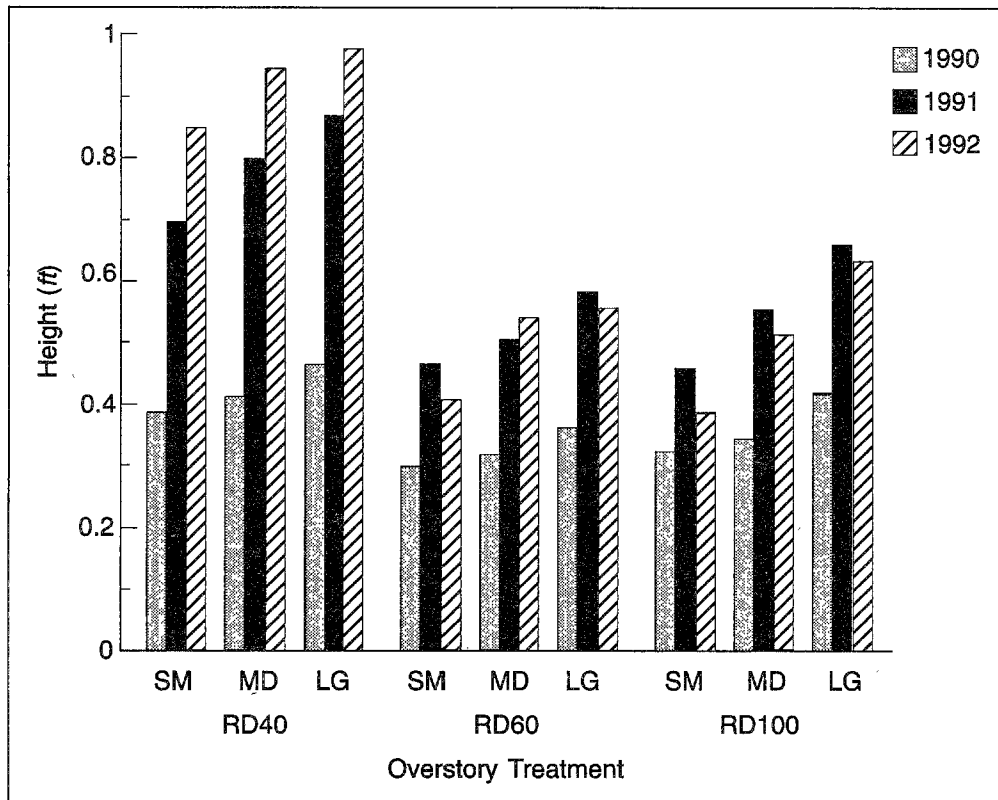


Figure 2.--Total height of red oak seedlings as related to acorn size and overstory relative densities in plots fenced (electric) to protect acorns from predation by deer.

small oak seedlings growing under a shade canopy. These effects were unrelated to initial acorn size.

Summary and Conclusions

Results of this study indicate that initial size of acorns has little influence on small-mammal predation, insect infestations, or seedling survival. Although total seedling height increased significantly with an increase in acorn size, after 3 years, these differences were too small for practical use. The following are specific results from the study.

- Size does not affect acorn predation by small mammals, in this case, chipmunks and mice.
- Acorn size did not influence insect infestations.
- There was significantly less acorn insect damage and small-mammal predation of buried acorns compared to acorns planted on the soil surface (study installed during good acorn crop year).
- No insect-infested acorns produced a seedling.
- After 3 years, acorn size did not affect seedling survival.
- There was a small increase in seedling height growth with increased acorn size. These increases were consistent for all light levels.
- Predation of acorns on the soil surface was nearly three times that of acorns below the surface (91 to 34 percent). Acorn predation was mainly by chipmunks and mice.
- Planting acorns to a depth of 1 inch resulted in a loss of about 50 percent to small mammals and insects. Thus, about half of the acorns were available for germinating seedlings.
- Between 19 and 40 percent of all acorns were infested with insects.

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Keywords: Northern red oak; predation; germination; seed crops



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