Collection Procedures Affect Germination of Northern Red Oak (*Quercus rubra* L.) Acorns

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*Specifics of acorn collection procedures affect germination in northern red oak (*Quercus rubra *L.) and can be important in obtaining a sufficient acorn supply. Tree-collected acorns had better germination than ground-collected acorns. Acorns that sank during water flotation had a high germination percent regardless of whether they were tree or ground collected. Tree-collected floaters did not significantly lower germination than either tree- or ground-collected sinkers. Ground-collected floaters had the lowest germination. The original position of acorns in the tree crown had no significant effect on germination. Water flotation is recommended for all acorn collections.* Tree Planters' Notes 37(3):812; 1986.

Acorn crops differ greatly from tree to tree, from location to location, and from year to year (8). Add to this the problems of long-term storage for red oak acorns (10), and the specifics of acorn collection become important in obtaining an acorn supply sufficient for forestry purposes.

We studied the viability of acorns collected from the ground and from the tree in one study and from several positions within a tree in another. We also tested water flotation as a method of determining viability. Our findings should be helpful to foresters and nurserymen who wish to propagate oak, particularly in poor seed years.

Although mature acorns are most commonly collected from the ground after they fall, they can be collected after manual or mechanical shaking or they can be picked off the tree from a hydraulic lift. After collection, acorns are commonly tested for soundness by water flotation (1, 6, 7). Floating acorns are usually considered unsound and discarded. Although this simple float test has been used for years, to our knowledge it has not been tested experimentally.

Materials and Methods

Experiment 1. On September 28, 1982, we collected acorns from a single northern red oak tree in Oneida County near Rhinelander, WI. Acorns were mature and were beginning to fall from the tree. We collected newly fallen acorns from the ground, and then spread tarpaulins under the tree and shook acorns from the branches. Acorns were segregated into lots according to collection procedure and tested by water flotation. The presence of intact acorn cups was also noted. Not all acorns collected from the tree had intact cups; all acorns collected from the ground with cups intact floated in water. Five categories were recognized:

1. Ground-collected floaters with cups (GFC).
2. Ground-collected floaters without cups (GF).
3. Ground-collected sinkers (GS).
4. Tree-collected floaters (TF).
5. Tree-collected sinkers (TS).

Acorns were rinsed in captan fungicide to retard mold and then their surfaces were air dried. Lots of 50 acorns were stored in 4-mil polyethylene bags at 4 °C for 95 days, because red oak acorns require cold stratification to break embryo dormancy (5). Acorns were then removed from the cooler, allowed to warm to room temperature, and soaked in water overnight.

Germination was determined in January 1983 in a greenhouse bench filled with a 3:1 mixture of coarse perlite and sand (about 10 centimeters deep). Acorns were planted about 2 centimeters deep at 7.5 by 10 centimeters spacing, and the seedbed was maintained at 40 percent moisture content (ovendry basis) at 22 °C. Artificial light (150-watt flood lamps) was provided daily from 8 a.m. to 4 p.m.

Experiment II. On September 7, 1983, we collected acorns with the aid of a hydraulic lift from another northern red oak tree near Rhinelander, WI. Acorns were collected from branches at four different heights in a 16-meter-tall tree: 1) 16 meters (top), 2) 12 meters, 3) 8 meters, and 4) 4 meters (bottom). Acorns from each stratum were kept separate and then floatation-tested. All sinking acorns were bagged and stored as in experiment I for 118 days.

Acorns were planted in January 1984 as in experiment I. The germination bed was lighted artificially for 16 hours per day from 6 a.m. to 10 p.m. and was watered with an intermittent mist system (i.e., 2-second misting every half hour).

Germination. Emergence of the epicotyl from the seed bed was used as an indicator of germination (3, 5). (Emergence percent is considered an indicator of germination percent throughout the paper.) Germinating acorns were counted and recorded three times a week for 6 to 7 weeks. Germination percent and peak value were used to quantify germination success. Peak value was proposed by Czabator (4) to express both the speed and completeness of seed germination. Peak value (PV) is equal to the maximum cumulative germination percent divided by the number of days from sowing.

Because germination percent data do not usually exhibit a normal distribution, these data were transformed with arcsine v % for analysis (9). Peak values were not transformed. Analyses of variance were conducted on transformed data in the case of germination percent and on raw data for the peak values. Linear contrasts (9) were used to compare treatments at weekly intervals over the duration of the experiment (table 1).

Table 1—*F-tests of significance of linear contrasts from analysis of variance of percentage germination data from northern red oak acorns at 5 weeks after planting (experiment I)*

Source of variation	Degrees of freedom	F-test	Significance[1]
Treatments	4	31.4	0.01
Ground-collected vs tree-collected acorns	1	6.4	0.05
Ground-collected sinkers vs floaters	1	17.8	0.01
Tree-collected sinkers vs floaters	1	2.0	NS
Cups vs no cups	1	99.2	0.01

[1] Transformed percentage germination data.

Table 2—*Germination rates of northern red oak acorns collected in 1982 and 1983 in Oneida County, WI*[1]

Treatment	Peak value ± SE
Experiment I	
Tree-collected sinkers	4.1 ± 0.4 a
Ground-collected sinkers	3.4 ± 0.5 a
Tree-collected floaters	3.3 ± 0.5 a
Ground-collected floaters	1.6 ± 0.3 b
Ground-collected floaters w/cups	0.1 ± 0.1 b
Experiment II	
16-m-high branches	1.9 ± 0.3 a
12-m-high branches	1.9 ± 0.2 a
8-m-high branches	1.6 ± 0.1 a
4-m-high branches	1.8 ± 0.2 a

[1]Peak values calculated according to the methods of Czabator (*4*) and Bonner (1984). Peak values for each experiment followed by the same letter are not significantly different at the .05 probability level.

Results and Discussion

Germination percentages of northern red oak acorns varied greatly with acorn collection procedures and with water flotation (fig. 1). After 5 weeks, germination in experiment I had stabilized and ranged from 2.5 to 85.0 percent. Tree-collected acorns had a significantly higher germination percent than ground-collected acorns (table 1). But "sinkers" had a high germination percent regardless of where they were collected. Although tree-collected sinkers had the highest germination percent, the difference in germination percentage was not significantly different from ground-collected sinkers (fig. 1). Tree-collected sinkers did, however, have a peak value higher than the ground-collected sinkers (table 2), indicating that they germinated more rapidly (4).

Surprisingly, the germination rate of tree-collected floaters was over 70 percent and was not significantly different than the rates for ground-collected sinkers or tree-collected sinkers. Ground-collected floaters had a germination percent and peak value much lower than the ground-collected sinkers and

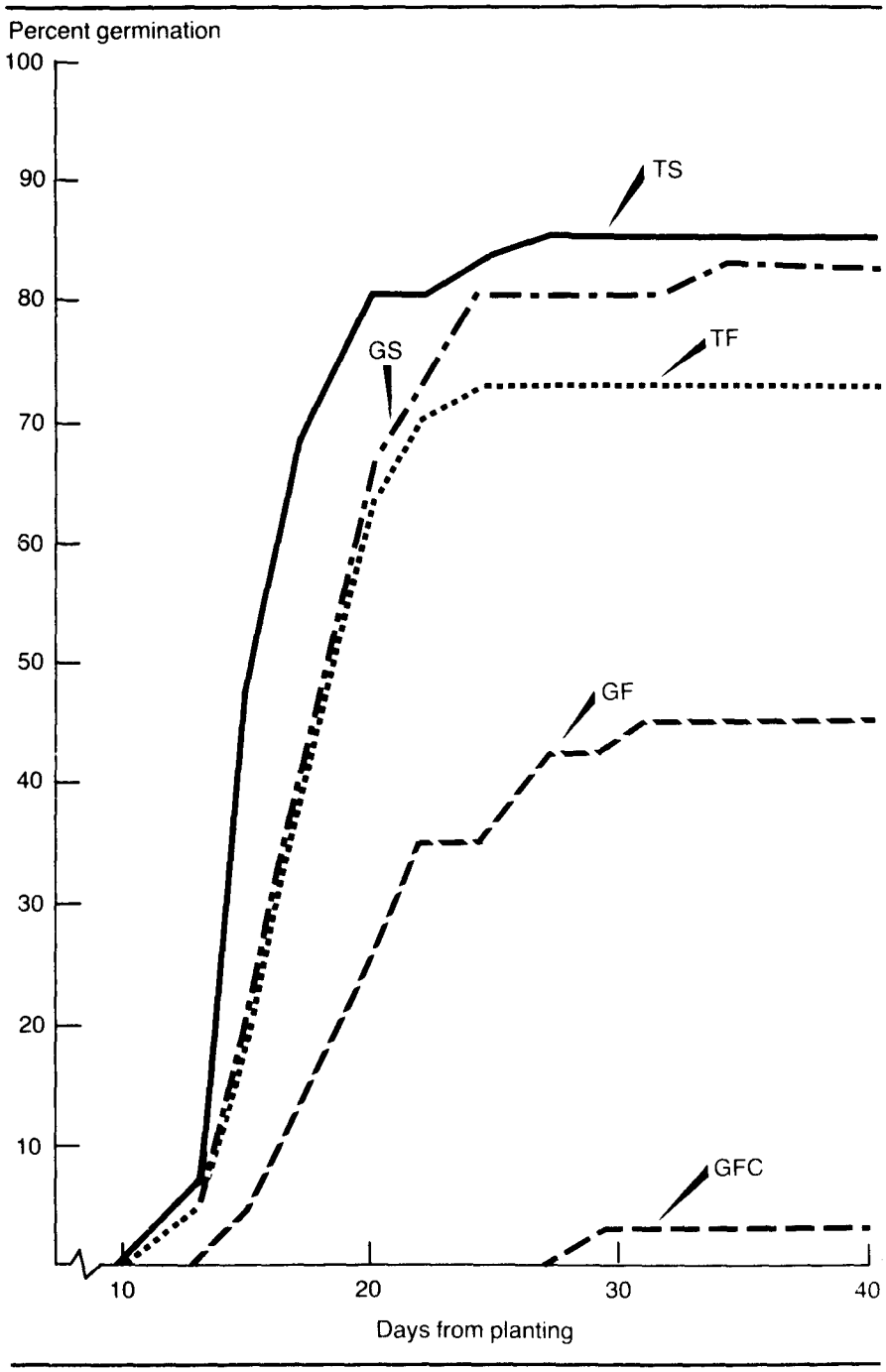

Figure *1-Percent germination of northern red oak acorns over time after various collection procedures and water flotation. TS = tree-collected sinkers, GS = ground-collected sinkers, TF = tree-collected floaters, GF = ground-collected floaters, and GFC = ground-collected floaters with cups. Acorns were collected in Oneida County, WI, in 1982.*

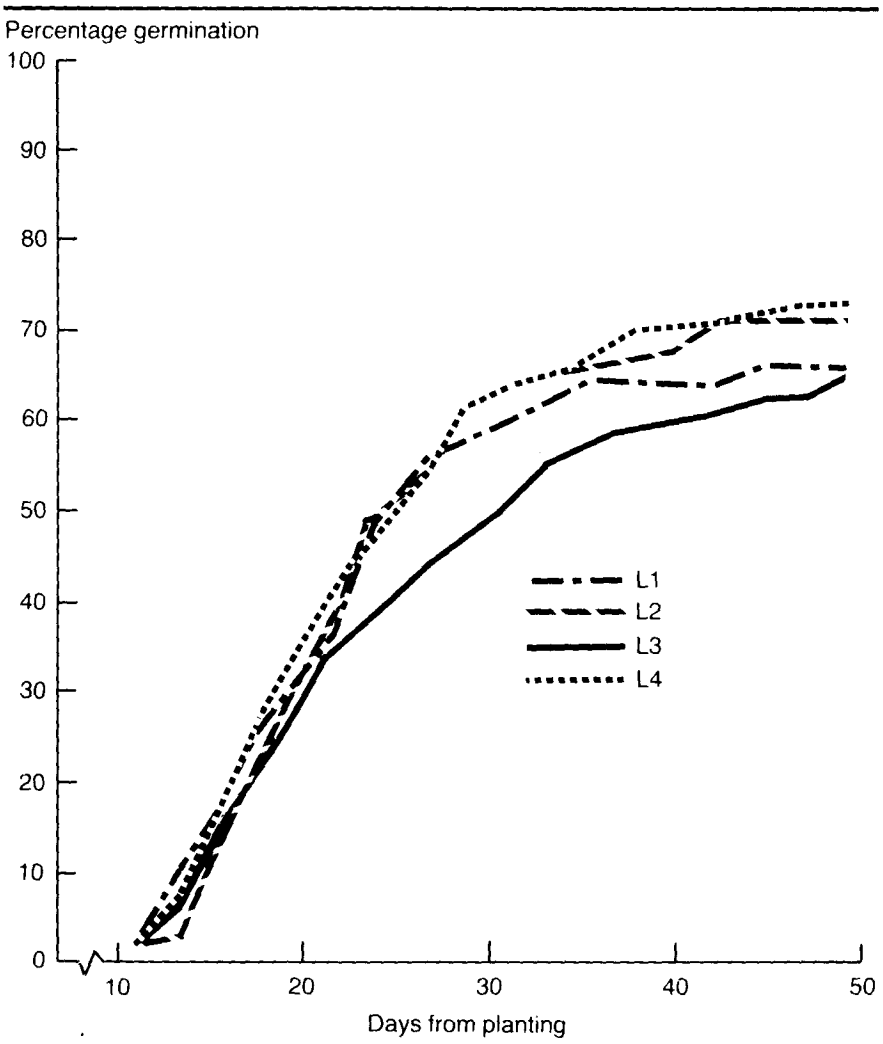

Figure 2—*Percent germination of acorns collected from branches at four heights in a northern red oak tree. L1 = 16-meter-high branches (top); L2 = 12-meter-high branches; L3 = 8-meter-high branches; and L4 = 4-meter-high branches (bottom). Acorns were collected in Oneida County, WI, in 1983.*

even the tree-collected floaters. The fact that tree-collected floaters germinated better than ground-collected floaters is important, because it means that foresters have an additional source of viable acorns, particularly in poor seed crop years. To our knowledge the distinction between tree and ground floaters has not been made previously.

Ground-collected floaters without cups had a much lower germination percent (< 50 percent) and germinated much slower than either the sinkers or the tree-collected floaters (table 2). Ground-collected floaters with cups germinated poorly, and are not likely to germinate in either a natural or artificial environment.

Acorns in 1983 had lower germination percents (fig. 2) and lower peak values (table 1) than acorns from the first study tree in 1982. Despite the fact that all acorns in experiment II were tree-collected sinkers, their germination percent ranged from only 65 to 73 percent in 7 weeks which was somewhat lower than in 1982. However, location within the tree made no significant difference in either germination percent or peak value (fig. 2; table 2). It should be noted that this was a vigorous, young tree growing in a mixed hardwood stand. Older trees growing under different stand conditions may not produce such a uniform crop of acorns.

The reason for the lower germination percents and peak values in the second experiment may be the fact that the acorns were collected from a different tree, during a different year. Including more trees in the study may have helped answer this question. However, this is an example of the kind of variation that foresters who collect acorns routinely face due to the uncer-

tainty of acorn crops from tree to tree and from year to year (8). The acorns in experiment II may have been collected slightly before their maturation date, because many were just beginning to turn brown and had not yet separated from their cups (2).

Conclusions

Our findings should be helpful to foresters and nurserymen who wish to propagate oak, particularly in poor seed years. Acorn collection and handling procedures can affect both the percentage and rate of germination of northern red oak seed. Tree collection of acorns can be made from all portions of the red oak crown, and acorns should be collected after they lose their green color just before separating from the cup. Tree collection is recommended for best germination.

Acorns that sink during water flotation are the most viable regardless of whether they are collected before or after falling from the tree. Thus, we recommend water flotation for all acorn collections. Surprisingly, tree-collected floaters without cups also germinate well, but ground-collected floaters without cups do not. Ground-collected floaters with their cups intact have little or no germination capability.

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