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Oak Regeneration by Direct Seeding

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DIRECT SOWING OF OAK ACORNS has not always met with success. This paper summarizes recent research regarding direct sowing of oaks in research plots and commercial trials. Present findings indicate that seedlings can be established from properly stored acorns sown any month of the year by hand or machine. They should be sown at a two-inch depth, although they can be sown up to six inches deep.

Oaks are an important major component of southern bottomland hardwood forests. Not only does industry depend on a steady supply of high quality oak logs, but the vitality of many different species of wildlife is dependent at least in part on oak mast.

In most sections of the South, the current supply of high quality oak sawtimber is adequate, but meeting future needs may require that we artificially establish oaks, since stands resulting from natural regeneration often have few oak seedlings. Oaks will have to be established artificially in recently abandoned agricultural fields intended to provide timber and prime forest habitat for wildlife.

Planting of one- to three-year-old seedlings with followup weed control is a proven way to establish oaks. It has been successfully done at Stoneville, Mississippi, and elsewhere. But the technique is expensive and time consuming. Planting of large, bare-rooted seedlings up to three years of age without weed control is being studied, as is planting of containerized oak seedlings. Neither method is being used commercially.

Another option for establishing oaks is direct seeding of acorns. This approach is less expensive than planting because it eliminates the costs involved with growing seedlings in a nursery. It is also less time consuming than planting seedlings.

There have been several efforts in the past 25 years to direct-seed oaks in the eastern United States. Only a few have been successful. However, investigators have generally agreed on the following:

1. Acorns must be covered with soil.
2. Fall and spring seeding give about equal results.
3. Animals, particularly squirrels and chipmunks, are the greatest deterrent to direct seeding, as they dig up and destroy a high percentage of the acorns. No suitable repellent is available.

This paper summarizes results of oak seeding research at Stoneville, Mississippi, from the 1960's to present, and from commercial seedings in the 1980's that cover about 500 acres. Research plots have been studied on several different sites, including eight in the Mississippi Delta, two in minor stream bottoms of the coastal plain, and five in the silty uplands. Commercial trials have been in the Mississippi Delta and the silty uplands.

Animal Damage

Earliest seeding tests at Stoneville, Mississippi, were conducted under a full forest canopy; most were considered unsuccessful due to rodent losses. It was later found that site-prepared forest openings of two acres or more and agricultural fields had much less rodent damage, and seeding was much more successful. Therefore, results and recommendations presented in this paper are applicable only to two-acre or larger forest openings and to old fields relatively free of competing vegetation.

Species

Research trials included the following oak species: Nuttall (*Quercus nuttallii Palmer*) Shumard (*Q. shumardii Buckl.*), cherrybark (*Q. falcata var. pagodifolia Ell.*), and water (*Q. nigra L.*). However, commercial seedings also involved swamp chestnut (*Q. michauxii Nutt.*), chinkapin (*Q. muehlenbergii Engelm.*), overcup (*Q. lyrata Walt.*), willow (*Q. phellos L.*), and bur (*Q. macrocarpa Michx.*) oaks. To date, Nuttall oak appears to be the most adaptable species and has consistently given the best results.

Acorns of the white oak group (swamp chestnut, chinkapin, overcup, and bur oaks) have had poorer field germination than red oak acorns in two successive spring sowings in a commercial seeding venture. Number of acorns sown per foot of row was unknown, but a machine seeder was used for both groups of acorns in both years. In 1983, eight sites were seeded, 4 each with red oaks and white oaks, and 14 sites were seeded in 1984, 8 to red oaks and 6 to white oaks. Based on six 50-foot row samples per site, average distance between seedlings after one growing season of the 1983 sowing was 10 feet for the white oak group and 4 feet for the red oak group; the 1984 sowing averaged 24 and 7 feet between seedlings for the white and red oak groups, respectively. If 4 seedlings per 50 feet can be considered at least adequate, then 71 and 23 percent of the white oak seedings and 96 and 69 percent of the red oak seedings for the 2 years would be adequately stocked.

Site Selection

The same guidelines used for site evaluation prior to planting of seedlings should be suitable for use with direct seeding. In most cases, the guides developed by Baker and Broadfoot (1979) will suffice. A key consideration is the timing and duration of flooding on a site. Shumard and cherrybark oak acorns should be sown on well-drained soils that flood for periods of only a week or less during the growing season. As a general rule, neither species should be sown on clay soils subject to growing season flooding. Conversely, Nuttall oak acorns grow well in clay soils and can withstand constant flooding from January through mid-May. Water oak acorns are somewhat less water tolerant.

Seed Collection and Storage

Seed maturity varies by species and by

year, but generally acorns mature and drop from about the first of October to the first of January. The first acorns to fall are usually defective. With experience, they can be detected by their light weight and pale-colored pericarp. Acorn collection must not be delayed, as most acorns will be devoured within a few days by animals such as deer, turkeys, racoons, and squirrels. A few acorns from each parent tree should be cut in the field to determine that they are not rotten, infested with insects, or under-developed.

Acorns should be placed in cold storage immediately; never leave them in a warm, dry environment such as a heated building. They should be stored in 4-mil thick polyethylene bags at about 35°F. Nuttall acorns can also be stored in water at 35°F, but they are the only acorns to which this storage procedure applies. If cooler facilities are not available, acorns can be stored loose or in polyethylene bags buried about 1 foot deep in the ground. After a few days of cold storage, acorns should be put in water and the floaters discarded. Sometimes, with very small acorns, even good seeds will float. Thus, a small sample of floaters should be cut to verify their condition. If facilities are available, an additional check of viability is to place 5 to 10 acorns, with their pericarps removed, in a germinator at about 80°F. Germination should begin in about 6 to 8 days. Every 1 to 2 months a few acorns should be removed from storage and cut or test germinated. It is also worthwhile to run float tests periodically.

Red oak acorns must not drop below a 30 percent moisture content (based on ovendry weight) during storage. Moisture contents of the stored population can be estimated by checking moisture content of a few sample seeds every 3 or 4 months. If sample seeds average below 35 percent moisture content, the stored population should be submerged in water at room temperature for about 24 to 48 hours. Generally, 40 to 45 percent moisture content is a good storage range for red oak acorns.

According to Bonner (1973), properly stored red oak acorns will remain viable for up to 3 years, although percent germination may decrease. Under any long-term storage method, some acorns will germinate, but they can still be successfully direct sown—even if the radicle is broken in the sowing process (Bonner 1982). There are no reported techniques for successfully storing white oak acorns beyond a few months.

Time of Seeding

Recent research indicates that, with an occasional exception, acorns can be successfully sown any time of the year. This finding is particularly important in regenerating sites covered with water or otherwise unworkable during the dormant season. Simply seed after the water recedes, which for some bottomland areas could be June or July.

In a 1983 old-field test of Nuttall oak, seedling percent (the ratio of the number of live seedlings to the number of sown acorns) in mid-October was 67, 78, 78, and 59 for May, June, July, and August sowings, respectively. August differed from June and July, but not May, at the 0.05 level of significance. While initial germination began approximately 45 to 60 days after the May sowing, depending on sowing depths, germination of later sowing dates started within 30 days of sowing regardless of depth (**FIGURE 1**). Acorns that had been sown on the same old-field site in March had a seedling percent of only 9, probably because of flooding that occurred after germination began, but before the May planting.

Cherrybark oak and Shumard oak were sown in the silty uplands, following logging and deadening or lopping of remaining stems. Sowing was in 1983, beginning in February and then monthly from April through August. By October the range in cherrybark oak seedling percent was from 12 (for seeds sown in April) to 36 (for seeds sown in July). For Shumard oak, the range was from 16 (for seeds sown in August) to 54 (for seeds sown in May). Over all months, seedling percent averaged 23 for cherrybark and 37 for Shumard.

A commercial seeding done in April 1984 was followed by 2 months of dry weather and little germination. Sprouting of acorns increased in July—after a good rain. Based on total seedlings counted in October, 13 percent of the acorns had germinated by July 2, 28 percent by July

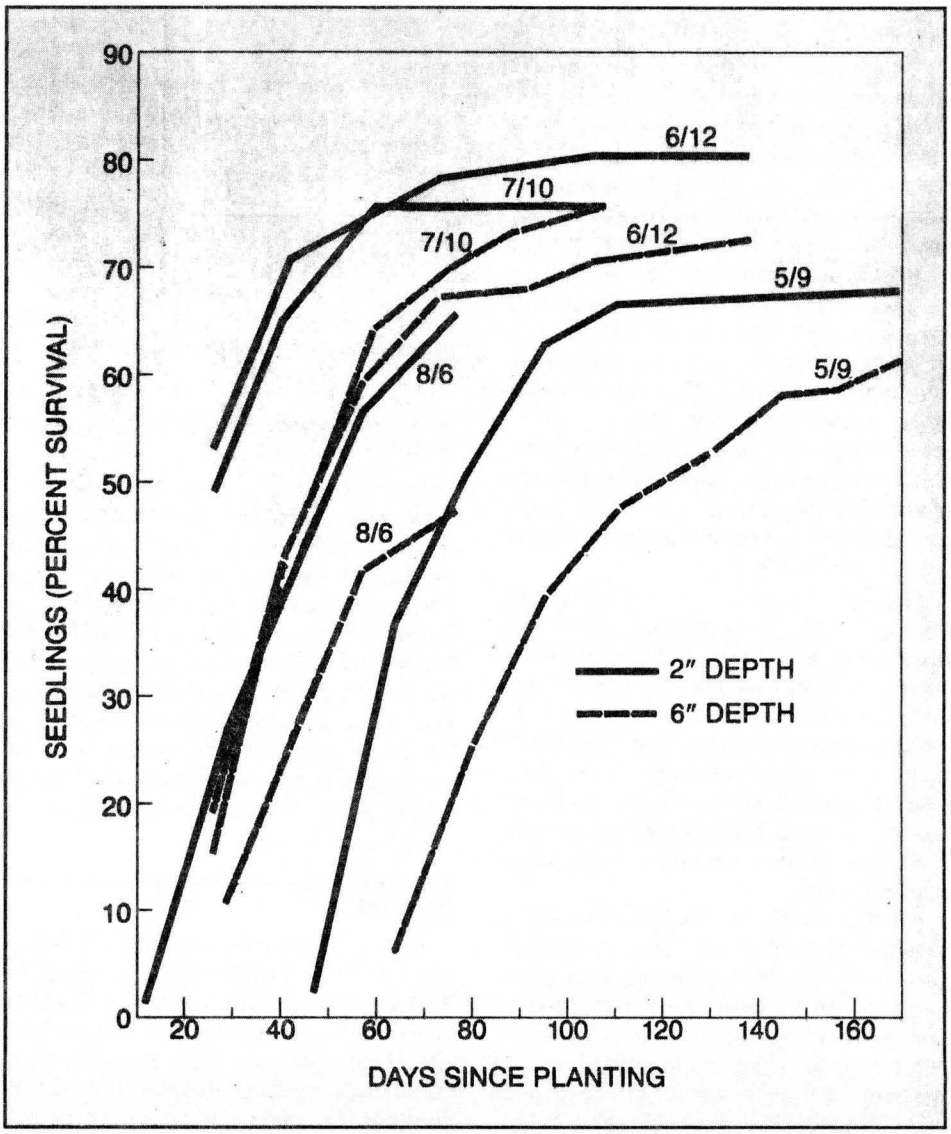

FIGURE 1. Seedlings produced from acorns sown at two different depths on four different dates in 1984 (5/9, 6/12, 7/10, 8/6) by number of days since sowing. Data through October 18, 1984. Sowing dates noted on plotted curves.

16, 36 percent by July 31, and 70 percent by August 12. Thus, acorns may remain dormant in the soil most of the summer but still germinate late in the growing season. There was a mixture of red oak acorns involved: Shumard, cherrybark, water, willow, and Nuttall. Counts were made on forty-eight, 50-foot row samples.

Depth of Seeding

Acorns of any size, from the smallest water oak to the largest Nuttall, can be successfully sown at any depth, down to six inches. However, depth and size may influence percent germination and early seedling size.

On old-field Sharkey clay soil, a test of Nuttall and water oak acorns involving three planting depths—2, 4, and 6 inches—showed a greater seedling percent at 2 inches (54) than at 4 or 6 inches (41 and 40). Testing was at the 0.05 level using Duncan's Multiple Range Test. The seedling percent of Nuttall oak (55) was greater than water oak (35). There was no interaction of depth by species. First-year seedling heights were inversely related to planting depths, but differences were less than 0.1 foot.

In another 1984 trial, Nuttall oak acorns were sown at 2 and 6 inches in January on clay soil where a nearly pure stand of overcup oak had been growing for 50 years. The overcup oak were either cleared by KG blade, injected the summer before sowing, or left untreated. After one growing season, 2-inch survival was greater than 6-inch—52 vs. 32 percent—and survival on the cleared plots (58 percent) was greater than the injected plots (45 percent), which was greater than the untreated plots (22 percent).

A 2- and 6-inch sowing depth trial, where sowing was done in mid-July, 1984, on old-field clay soils with Nuttall oak acorns, was combined with three temperature conditions: acorns removed from a cooler and sown immediately, acorns allowed to warm and dry in the sun for either 1 hour prior to sowing, or acorns allowed to remain in the sun for 3 hours prior to sowing. Temperature conditions and depth did not influence seedling percent after the first or second growing season. Apparently there was delayed germination in some instances because survival values were higher the second year than the first year, with survival at 2 inches increasing from 22 to 37 percent and at 6 inches from 30 to 35 percent.

There are two reasons for sowing deeper than 2 inches. One is to discourage pilfering by rodents, and the other is to have acorns in a less hostile environment than that near the soil surface. Deep sowing may reduce

the loss to rodents, but not enough to justify the extra sowing effort. The environmental factor seems most important in clay soils, where the soil surface may change from fully saturated to extremely dry within a few days.

Method of Sowing

Both hand and machine seeding have been successful. Hand seeding can be done with a tool such as one developed at Stoneville, Mississippi, or the acorns may be sown in holes made with a bar or even a stick. The hand tool gives the advantage that depth of seeding can be consistent; also, the person does not have to bend over to put acorns in the holes.

Machine seeding is well suited for open fields. There are at least three different machines in use. One was developed at Stoneville by modifying a soybean planter. It will handle acorns ranging in size from water oak (small) to Nuttall oak (large), and it automatically drops a seed every 30 inches. Machine seeding is an option only when soil moisture conditions are suitable, which may not occur until the growing season.

Spacing

Our experience has shown that: (1) 35 percent germination is a reasonable expectation for acorns, (2) 1 out of 10 or 11 sown acorns produced a free-to-grow tree in 10 years on cleared, forested sites of the ash-elm-sugarberry type, and (3) 1 out of 4 sown produced a free-to-grow tree in 10 years on old fields. Thus, sowing about 1,500 acorns per acre would provide for a first-year stocking of 500 seedlings, with 150 to 375 free-to-grow trees in 10 years (depending on site conditions) and good prospects for a future sawlog oak stand. Between-row and within-row spacing to allow for approximately 30 square feet per acorn would depend on site conditions and whether the area is to be hand or machine sown. Thus, spacings could range from about 3 by 10 feet—to allow for future between-row weed control if desired—to 2 by 15 feet or even wider.

Eleven years after machine sowing Nuttall oak acorns at a spacing of 2 by 10 feet, Johnson (1983) obtained about 550 codominant trees averaging 2 inches d.b.h. (diameter breast height). The spacing appears a little close, but it allows for thinning of unneeded trees for firewood. The stand can only have about 200 codominants per acre when trees average 6 inches d.b.h.

In a 16-year-old test of hand-sown Nuttall, there were still over 400 free-to-grow oaks per acre from about 3,500 acorns sown (four per spot with spots spaced at 5 by 10 feet) (Johnson 1981). Free-to-grow trees had successfully competed with natural sprouts and seedlings of green ash (*Fraxinus pennsylvanica Marsh.*), water hickory (*Carya aquatica (Michx. f.) Nutt.*), and sugarberry (*Celtis laevigata Willd.*).

Uniform spacings are not feasible in cut-over areas, but one technique already used is to have the planting crew line up abreast and sow seeds across the opening, bypassing stumps, tops, and other impediments. The method appears to give a good distribution of seedlings.

Particularly in cut-over areas, but also in old fields, natural regeneration will compete with the direct-seeded oaks. But, based on research efforts to date, oaks will be competitive in the elm-ash-sugarberry forest type. Conversely, on sites where yellow-poplar (*Liriodendron tulipifera L.*) grows well, direct-seeded oaks are soon overtopped, and unless released, few oaks will survive (Johnson 1984).

Weed Control

Studies show that intensive control of weeds by disking improves early height and diameter growth of planted oak seedlings. Mowing between planted or seeded rows of oaks reduces overtopping competition from other tree species and provides additional sidelight to developing oaks, but the treatment probably does not stimulate their rate of growth (Kennedy 1981). Even without weed control, direct-seeded oaks will continue to develop provided they have direct overhead sunlight.

When the largest oaks average between 15 and 25 feet tall in a regeneration stand, they may be released by deadening or cutting competitors. Indications are that earlier release is not effective because the oaks may again be overtopped by faster growing species.

Survival and Growth

Survival one year after germination is generally very good. Even overtopped trees may survive eight or more years. Some oaks only two feet tall have survived overtopping for fifteen years.

Growth rates vary by species and site, but as a general rule, trees of all oak species grow slowly the first 5 years. About 1 to 2 feet of annual height growth is average for the best trees. From age 5 to 15, trees may add 2 to 3 feet of height annually. Thus trees that have been free-to-grow should be 30 to 40 feet tall after 15 years.

Growth in d.b.h. was also slow for all oaks during early years in these direct seeding studies. In 15 years, the best trees averaged 3 to 4 inches d.b.h. Based on development of natural oaks, free-to-grow direct-seeded trees should grow much more rapidly in diameter during the next 25 years (Putnam et al. 1960).

Future of Oak Seeding

At Stoneville, Mississippi, we are continuing to test direct seeding in several locations. Commercial trials are proceeding on at least two National Wildlife Refuges and one National Forest, and a project of several thousand acres has been instituted on a State wildlife refuge in Louisiana. There are also several small privately-owned, old agricultural fields being seeded to oaks.

Direct seeding of oaks shows promise as a relatively inexpensive and flexible method to regenerate a very important species group. Compared to planting, preliminary figures indicate that direct seeding may be much faster and one-third to one-half the cost. It can also be done any time of the year, provided the soil is not covered with more than 2 inches of standing water or is too dry to make a hole for the acorns to be sown in.

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