FROST HEAVING OF CONTAINER HARDWOOD SEEDLINGS PLANTED IN AN ABANDONED AGRICULTURAL FIELD IN SHARKEY COUNTY, MISSISSIPPI[1]

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Abstract—The use of container hardwood seedlings is an alternative to bareroot planting stock. In January 1996, 1,485 container seedlings of Nuttall oak (*Quercus nuttallii* Palmer), willow oak (*Q. phellos* L.), overcup oak (*Q. lyrata* Walter), and water oak (*Q. nigra* L.) were planted in Sharkey clay on an abandoned agricultural field situated in the Lower Mississippi River Alluvial Valley. Beginning with the passage of a cold front on January 31, daily minimum temperatures dipped as low as 6 °F. For 5 days, daily high temperatures did not climb above 32 °F. This cold period caused 33.7 percent of all seedlings to frost heave and an overall survival of 0.5 percent. Our observations suggest that container seedlings should not be planted on shrink-swell clay soils until after the threat of hard freezing has passed. Seedling root morphology combined with soil conditions at the time of planting may have contributed to the frost heaving.

INTRODUCTION

Bareroot seedlings have traditionally been used in hardwood reforestation. Bareroot seedlings are often preferred over direct seeding for reforestation because of better growth and higher survival rates on flood-prone sites (Allen 1990). However, bareroot seedlings usually have long, branched root systems that are easily damaged by desiccation and handling. Planting in the Lower Mississippi River Alluvial Valley (LMRAV) requires extra effort on the part of planters to ensure maximum survival of seedlings. Incomplete closure of planting holes may result in soil cracks during summer drought, which may expose and damage the roots of seedlings (Williams and others 1992).

Bottomland hardwood reforestation of abandoned agricultural fields in the LMRAV has not always been successful. Planted seedlings must overcome flooded and saturated soils early in the growing season and drought stress during the summer months. Repeated failures have left many landowners in the LMRAV looking for ways to increase seedling survival and growth rates on these harsh sites. Recently, researchers have turned to container seedlings as an alternative to bareroot planting stock. Container seedlings have been shown to have a greater total root length and better overall water relations than bareroot seedlings (Crunkilton and others 1992). These findings have suggested that container planting stock may offer a seedling better suited for tolerating flood and drought stress.

STUDY AREA

This study was conducted in a flood-control impoundment on Yazoo National Wildlife Refuge. Yazoo National Wildlife Refuge is located approximately 60 mi north of Vicksburg, MS, in the LMRAV. This site is adjacent to Delta National Forest and lies 5 mi east of Anguilla, MS. The site is on the floodplain of the Little Sunflower River, a tributary of the Yazoo River. Sharkey clay (very fine, montmorillonitic, nonacid, thermic, Vertic Haplaquepts) (SCS-USDA 1975) is the soil found on the research area. Seedlings are subjected to backwater flooding when waters from the Yazoo River rise in response to high water in the Mississippi River.

The impoundment is situated on an abandoned agricultural field that was cleared within the last 20 to 30 years. The site is typical of most land becoming available for reforestation. During the summer of 1995, the USDA Fish and Wildlife Service and the Natural Resource Conservation Service constructed the impoundment. Before construction began, the area was disked to simulate conditions in a recently abandoned field. Extreme care was taken to insure the soil in each block was not disturbed while levee construction took place.

PLANTING

Four species of container planting stock were used. Species included Nuttall oak (*Quercus nuttallii* Palmer), water oak (*Q. nigra* L.), overcup oak(*Q. lyrata* Walter), and willow oak (*Q. phellos* L.). The container planting stock was grown in 10-in.^{3} plastic containers (Ray Leach "Cone-tainers" Nursery, 1500 N. Maple Street, Canby, Oregon 97103). The containers were filled with a commercial peat-perlite-vermiculite potting medium (Scotts Metro-Mix 366, Scotts-Sierra Horticultural Products Company, 14111 Scottslawn Rd., Marysville OH, 43041).

On January 20, 1996, 1,485 seedlings were planted. The seedlings were planted at 7 ft X 7 ft spacing using planting shovels. After planting, the height of each seedling was measured.

WEATHER DATA

Weather data was obtained from the U.S. Army Corps of Engineers weather station situated on the study site. On January 31, 1996, a series of cold fronts moved through the Southeast breaking many temperature records. Snow, sleet, and freezing precipitation accompanied their passage. Weather like this is seldom seen in the deep South. Temperatures remained below freezing for extended periods of time (fig. 1). The soil surface was frozen and soil temperatures at a depth of 12 in. fell as low as 38 °F.

FROST HEAVING

Two weeks after the freeze, on February 16, 1996, seedlings were checked to ascertain their condition. Observations of the seedlings revealed a large number of them had frost heaved to some degree. The seedlings were classified as (A) no damage, (B) partially frost heaved, or © completely frost heaved. Exactly 500 seedlings (33.7 percent) partially frost heaved (table 1). Only nine seedlings completely

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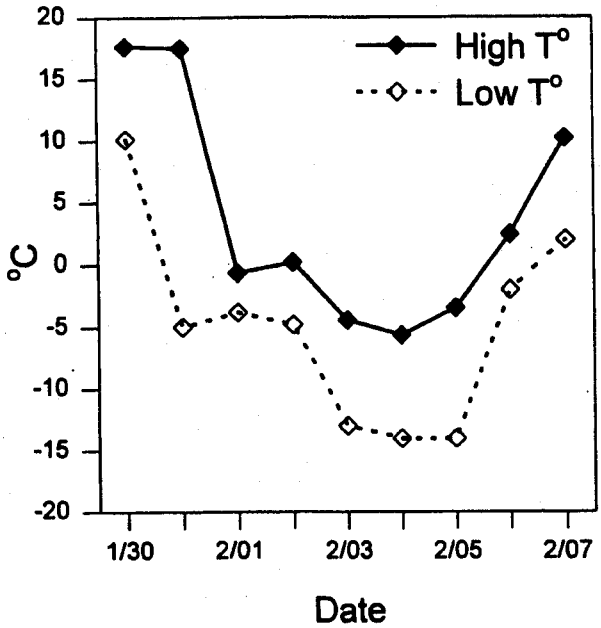

Figure 1—Daily high and low temperatures as recorded from January 30 to February 7, 1996, in an abandoned agricultural field located on Yazoo National Wildlife Refuge, Sharkey County, Mississippi.

Table 1—Results of survey accessing seedling conditions following a frost heaving event which occurred in a flood control impoundment located on Yazoo National Wildlife Refuge, Sharkey County, Mississippi, beginning on January 31, 1996

Seedling condition	Number of seedlings	Percent
No damage	976	65.7
Partially heaved	500	33.7
Completely heaved	9	.06

frost-heaved. All nine of the seedlings that were frost heaved exposed only the roots and left the potting medium unmoved in the soil. Of the heaved seedlings, the species observed to frost heave the most was water oak with 168 seedlings (33.0 percent). Overcup oak was next with 124 seedlings (24.4 percent), followed by willow oak and Nuttall oak with 117 seedlings (23.0 percent) and 100 seedlings (19.6 percent), respectively (table 2). Subsequent examinations revealed only seven seedlings (0.5 percent) had survived to bud out the following spring.

DISCUSSION

On the morning the seedlings were planted, the soil was frozen at the surface. The stiff soil did not close properly and probably allowed frost heaving to occur. This problem was only aggravated further when temperatures began to rise and the soil began to thaw. Moist or saturated clay soils are extremely difficult for planting seedlings. Complete closure

Table 2—Frost heaving susceptibility as a result of a frost heaving event which occurred in a flood control impoundment located on Yazoo National Wildlife Refuge, Sharkey County, Mississippi, beginning on January 31, 1996

Species	Number heaved	Percent
Water oak	168	33.0
Overcup oak	124	24.4
Willow oak	117	23.0
Nuttall oak	100	19.6

of planting holes became almost impossible as the clay began to cling to planting shovels and boots. The moisture that made closing holes difficult increased the frost heaving capacity of the soil. Bare compact clay soils are one of the most difficult sites to establish trees in due to frost heaving in the more northern areas (McQuilken 1946). Disking late in the year further aggravated this situation by loosening up the soil. Disking destroyed the soil structure while removing vegetation that is needed to prevent frost heaving on a clay soil. McQuilken (1946) found 47 percent of unmulched trees frost heaved 1 in. or more. Vegetation slows the cooling of the soil and adds stability to its structure. Alternatives to disking should be considered. Mowing or ripping the site would ease planting for workers while leaving needed vegetative cover to prevent frost heaving. Ripping the soil would leave most of the vegetation intact while still breaking up any plowpan that could be present. Burning may even be an option. The fire would remove the vegetation found on the site but would leave the soil structure intact.

Finally, the combination of precipitation and freezing temperatures played an important role in the frost-heaving of seedlings. Research indicates the moisture condition most likely to produce frost-heaving is one where the soil voids are filled with water (Graber 1971). This condition was present on the study site and provided ample moisture for the formation of ice and ice crystals. Other researchers in the same impoundments noted some frost-heaving on bareroot seedlings and even direct-seeded acorns. In the case of the acorns, they had been pushed completely out of their holes by the shrink-swell action freezing had on the soil. The low survival of container seedlings on this site was caused by a combination of frost heaving and freezing temperatures. The seedlings that were heaved had the majority of their roots exposed to desiccating winds. Those seedlings that were not frost heaved were still in a saturated soil that was frozen to a significant depth, if not to a depth greater than that of the containers. This freezing action is what probably contributed the most to the low survival of seedlings.

In conclusion, large planting stock and adequate soil conditions are essential to successful planting. Data suggests soil conditions are important when planting seedlings in the LMRAV. Care should be taken when the soil has been disked. In some cases it may be advantageous to use some other form of site preparation. Planting stock of an adequate size should be used for reforestation on

abandoned agricultural fields. Frost heaving will occur even with larger planting stock. However, survival from frost heaving is greater with larger planting stock (McQuilken 1946).

REFERENCES

Allen, J.A. 1990. Establishment of bottomland oak plantations on the Yazoo National Wildlife Refuge Complex. Southern Journal of Applied Forestry. 14(4): 206-210.

Crunkilton, P.D.; Pallardy, S.G.; Garrett, H.E. 1992. Water relations and gas exchange of northern red oak seedlings planted in a central Missouri clearcut and shelterwood. Forest Ecology and Management. 53: 117-129.

Graber, R.E. 1971. Frost heaving - seedling losses can be reduced. Tree Planters Notes. 22(4): 24-28.

McQuilken, W.E. 1946. Use of mulch, fertilizer, and large stock in planting clay sites. Journal of Forestry. 44(1): 28-29.

Soil Conservation Service, U.S. Department of Agriculture. 1975. Soil survey of Yazoo County, Mississippi. [Place of publication unknown]: U.S. Department of Agriculture, Forest Service, Mississippi Agriculture and Forestry Experiment Station. [Number of pages unknown].

Williams, H.M.; Kleiss, B.A.; Humphrey, M.N.; Klimas, C.V. 1992. First-year field performance of oak species with varying flood tolerance planted on hydric and non-hydric soils. In: Brissette, John C., ed. Proceedings of the seventh biennial southern silvicultural research conference; 1992 November 17-19; Mobile, AL. Gen. Tech. Rep. SO-93. New Orleans: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 409-414.