2002

First-year survival and growth of bareroot and container water oak and willow oak seedlings grown at different levels of mineral nutrition

Hans Michael Williams
Arthur Temple College of Forestry and Agriculture Division of Stephen F. Austin State University, hwilliams@sfasu.edu

Matthew Stroupe

FIRST-YEAR SURVIVAL AND GROWTH OF BAREROOT AND CONTAINER WATER OAK AND WILLOW OAK SEEDLINGS GROWN AT DIFFERENT LEVELS OF MINERAL NUTRITION

Hans Williams and Matthew Stroupe[1]

Abstract-Bareroot and container water oak *(Quercus* nigra) and willow oak *(Quercus* phellos) seedlings were treated with 3 different levels of nitrogen (N) mineral fertilizer applied during the growing season in the nursery. Comparisons were made between species, N treatments, and stock-types for seedling morphology, first-year survival and height growth, and seedling water relations. Water oak seedlings were shorter, heavier, and more first-order lateral roots than the willow oak seedlings. The N fertilizer treatments did not have a statistically significant effect on seedling morphology. Bareroot seedlings were taller, had greater root-collar diameters, and were heavier than the container seedlings. The seedlings were hand-planted on an old pasture site located near Nacogdoches, TX. First-year survival was about 80 percent regardless of species, N treatment, or stock-type. Bareroot seedlings had less first-year height growth than container seedlings. Container seedlings fertilized at the highest N rate had greater stomatal conductance and transpiration rates early in the growing season than the container seedlings fertilized at the lowest rate.

INTRODUCTION

The reforestation of frequently flooded agricultural land with bottomland hardwood species has become an important activity in the Southeastern U.S. Federal programs like the Wetland Reserve Program (WRP) have promoted the reforestation efforts by providing financial support to landowners(Shepard 1995). A significant portion of the reforestation has occurred in the Lower Mississippi Alluvial Valley (LMAV). Compliance with the Clean Water Act and plantings initiated by organizations such as the The Nature Conservancy and Ducks Unlimited also contribute to the bottomland hardwood reforestation activity. Survival and early growth is often poor for these plantings because of frequent, long-term, flooding and herbaceous and woody plant competition. As a result, research continues to study ways to improve bottomland hardwood reforestation success (Allen 1990).

At locations where flooding is minimal, research results indicate that establishment with bareroot seedlings can be successful. Allen (1990) observed adequate bottom/and hardwood oak stocking for five planted seedling stands (266 trees/ac.) and five direct seeded stands (293 trees/ ac.) about 6 years after establishment. Miwa (1995) observed first-year seedling survival greater than 70 percent for four bottomland hardwood species planted on hydric and non-hydric soils which no longer experience significant flooding. Five years after planting, seedling survival was still greater than 60 percent (Ozalp and others 1998). Stanturf and Kennedy (1996) observed survival exceeding 60 percent after 5 years for cherrybark oak *(Quercus* pagoda) seedlings planted in a floodplain clearcut.

The use of container-grown hardwood seedlings instead of bareroot seedlings may be a potential option for the reforestation of flood-prone sites. White and others(1970) presented the possible advantages of using container hardwood planting stock. Advantages that may be especially important to a wetland reforestation planner are the ability to extend the planting season and the higher survival usually observed on adverse sites. For example, container seedlings could be planted after the floodwaters recede in early summer. Bareroot seedlings, typically lifted from the nursery during the winter, must spend an extended period of time in cold storage prior to planting. Since hardwood seedlings are sometimes packed in bundles or bags that cannot be completely sealed, there is a risk of seedling desiccation during unplanned, long-term cold storage.

In this study, bareroot and container water oak and willow oak seedlings were treated at 3 different levels of nitrogen. The objectives of the research included studying the early survival and growth between bareroot and container seedlings. Also, the effects of altering N rates in the nursery were observed for seedling morphology and field survival and growth.

MET'HODS

The container seedlings were grown under a shadehouse located at Stephen F. Austin State University, Nacogdoches, TX. The shadehouse was covered with a fabric that allowed 50 percent of the incident light to reach the seedlings. Water oak and willow oak seed were purchased from a regional vendor. The seed were sown in March, 1996, in 164 cm^3 plastic cone container filled with a

[1]Associate Professor, Arthur Temple College of Forestry, Stephen F. Austin State University, Nacogdoches, TX; Forester; Barksdale Air Force Base, U.S. Department of Defense, Shreveport, LA., respectively.

Citation for proceedings: Outcalt, Kenneth W., ed. 2002. Proceedings of the eleventh biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-48. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 622 p.

peat-perlite-vermiculite medium. Seedlings were grown at a density of 264 seedlings /m². The seedlings were irrigated as needed to prevent plant water stress.

The bareroot seedlings were grown at the Texas Forest Service Indian Mound Nursery, Alto, TX. The water oak and willow seed were collected from an orchard located near the nursery. The seed were sown in nursery beds in the Fall, 1995. During the 1996 growing season, the seedlings were irrigated with about 2 cm of water per week. The seedlings were top-pruned to a height of about 51 cm in July and August, 1996. Seedbed density at the end of the growing season was 86 seedlings/m* for water oak and 118 seedlings/m* for willow oak.

The fertilizer treatment involved increasing the nitrogen rate 2-times (2X) and 3-times (3X) the operational rate (IX). For the container seedings, a 15-30-15 ($N-P_2O_5-K_2O$) water soluble fertilizer was used. The 1X treatment, the operational rate, was equivalent to applying 34 kg N ha/yr. The fertilizer was applied over 10 applications during the 1996 growing season. The bareroot seedlings were fertilized with liquid ammonium nitrate (32-O-O). The 1X rate was equivalent to applying 18 kg N ha/yr. The fertilizer was applied over 5 applications during the 1996 growing season.

Prior to planting, ten seedlings were randomly sampled from each replication, stock-type, species and fertilizer treatment combination for biomass measurements. Each seedling was measured for height, root-collar diameter (RCD), number of first-order lateral roots (FOLR) greater than 1 mm in diameter, shoot oven-dry weight, and root oven-dry weight. The seedlings were hand-planted, using planting shovels, in January, 1997. The planting site is at the Alazan Bayou Wildlife Management Area located about 11 km south of Nacogdoches, TX. The site was former pasture with soils from the Woden series(Typic Paleudalfs)and contains inclusions of soil from the Mantachie series (Aeric Fluvaquent) series.

Measurements after planting include first-year height growth and survival. Also, during the growing season following planting, leaf water potential, stomatal conductance, and transpiration was measured for container water oak and willow oak seedlings treated at the 1X and 3X N rates in late-June and late-August Leaf water potential was measured with a plant pressure chamber. Stomatal conductance and transpiration was measured using a steady-state porometer. The measurements were conducted at mid-day (about 1:00 to 2:00 pm). The leaf water relation measurements were conducted on four seedlings from each replication, species, and N-rate treatment combination.

The study was designed as a randomized complete block split plot with 3 replications. The whole plots were the stock-types, the subplots were the species, and the sub-subplots were the N fertilizer rates. Differences between main effects and their interactions for the dependent variables measured are discussed as statistically significant at the 5 percent probability level.

Table I-Mean morphological characteristics prior to planting of bareroot and container water oak and willow oak seedlings treated with three levels of nitrogen fertilizer

Treatment	Stem Height (cm)	Root-Collar Diameter (mm)	First-Order Lateral Roots (no.)	Shoot Weight (g)	Root Weight (g)
Stock-type					
Bareroot	65*[a]	8.9.	10*	13.5'	14.3'
Container	38	5.5	5	1.8	3.0
Species					
WaterOak	50'	7.3	9'	8.7'	10.0
Willow Oak	53	7.1	7	6.6	7.0
Nitrogen Rate[b]					
I X	49	7.1	8	7.6	9.0
2x	53	7.1	8	7.5	8.0
3x	52	7.4	8	7.8	9.0

[a] Means within a treatment followed by an asterisk are statistically different at the 5 percent probability level.
[b] The 1 X N rate was 18 kg N ha/yr and 34 kg N ha/yr for bareroot seedlings and container seedlings, respectively.

RESULTS

Bareroot seedlings were taller, had larger RCD, were heavier and had greater number of FOLR than the container seedlings (table 1). Water oak seedlings were shorter than the willow oak seedlings, but had a greater number of FOLR. a. Means within a treatment followed by an asterisk are statistically different at the 5 percent probability level b. The 1 X N rate was 18 kg N ha/yr and 34 kg N hatyrfor bareroot seedlings andcontainer seedlings, respectively Water oak seedlings were heavier than the willow oak seedlings. The N fertilizer treatment did not have a statistically significant effect on seedling morphology measured prior to planting. The statistically significant interactions between species and stock-types for seedling morphology were relatively small. Bareroot water oak seedlings were shorter than bareroot willow oak seedlings. Container water oak seedlings were taller than container willow oak seedlings. Bareroot seedlings fertilized at the higher N rates were shorter than the bareroot seedlings fertilized at the lowest N rate. Container seedlings were taller when fertilized at the higher N rates. Bareroot water oak seedlings had larger RCD than the bareroot willow oak seedlings, but the container seedlings of both species, had a similar RCD. Bareroot water oak seedlings had heavier stems than the bareroot willow oak seedlings. The container water oak seedlings had lighter stems than the container willow oak seedlings. Bareroot water oak seedlings had heavier roots than the bareroot willow oak seedlings. The container seedlings of both species had similar root weights. Bareroot willow oak seedlings had a

Table P-Mean first-year survival, height growth and percent stem dieback for bareroot and container water oak and willow oak seedings treated in the nursery with 3 levels of nitrogen fertilizer

Treatment	Survival (Percent)	Stem Growth (cm)	Dieback (Percent)
Stock-type			
Bareroot	81	8*[a]	6.8
Container	83	27	1.1
Species			
WaterOak	81	15*	4.2
Willow Oak	82	20	3.7
Nitrogen Rate[b]			
IX	85	17	3.6
2x	8-t	19	4.1
3x	79	17	4.2

[a] Means within a treatment followed by an asterisk arestatistically different at the 5 percent probability level.
[b] The 1 X N rate was 18 kg N ha/yr and 34 kg N ha/yr for bareroot seedlings and container seedlings,respectively.

lower number of FOLR than the bareroot water oak seedlings. Container seedlings of both species have similar numbers of FOLR. Water oak seedlings fertilized at the higher N rates had greater numbers of FOLR than water oaks fertilized at the lowest N rate. Willow oak seedlings fertilized at the lowest N rate had higher numbers of FOLR than the willow oak seedlings fertilized with the higher N rates.

First-year survival after planting was about 80 percent or greater regardless of stock-type, species or N-rate treatments (table 2). Container seedlings had greater first-year shoot growth than the bareroot seedlings. Willow oak seedlings had greater shoot growth than the water oak seedlings. The N fertilizer treatment did not affect first-year survival and shoot growth. Bareroot willow oak seedlings had greater amounts of shoot growth than the bareroot water oak seedlings. The container seedlings of both species had similar amounts of shoot growth. Bareroot seedlings fertilized at the higher N rates had greater shoot growth than the bareroot seedlings fertilized at the lowest N rate. First-year height growth was less for container seedlings fertilized at the highest N rates.

The difference in mid-day stomatal conductance, transpiration, and leaf water potential between container water oak and willow oak seedlings was not statistically significant when measured in late-June and late-August following planting (table 3). The container seedlings fertilized at the highest N rate had statistically greater rates of stomatal conductance and transpiration when measured in late-June. Differences between N-rate treatments were not statistically significant when measured in late-August.

Table 3-Mean mid-day stomatal conductance (g,), transpiration (E), and leaf water potential (Y),for container water oak and willow oak seedlings treated in the nursery with 2 levels of nitrogen fertilizer. Seedlings measured during growing season after planting

Treatment	g_w (mmoles $m^{-2} s^{-1}$)	E (mmoles $m^{-2} s^{-1}$)	Y (MPa)
June 23-27.1997			
Species			
Water Oak	343.0	7.84	-1.6
Willow Oak	264.2	6.2	-1.7
Nitroaen Rate			
1 x	258.9*[a]	5.97*	-1.6
3 x	343.7	8.07	-1.7
August 25-28. 1997			
Species			
WaterOak	434.5	12.20	-1.8
WillowOak	431.4	12.41	-2.2
Nitrogen Rate[b]			
1 X	402.6	11.73	-2.1
3 x	463.3	12.89	-2.0

[a] For each sample period, means within a treatmentfollowed by an asterisk are statistically different atthe 5 percent probability level.
[b] The 1 X N rate was 18 kg N ha/yr and 34 kgN ha/yr bareroot seedlings and container seedlings, respectively.

CONCLUSIONS

The careful seedling handling and planting and the adequate growing conditions may partially explain the good first-year survival for all treatment combinations. While the seedlings were planted in a location with significant herbaceous and woody plant competition, the 1997 growing season was characterized by above average rainfall. In August alone, over 30 cm of rain occurred in Nacogdoches, TX. Bareroot hardwood seedlings require careful handling, especially to protect the root systems. However, when the right species are matched to the site and proper handling and planting procedures are followed, good early establishment of bareroot seedlings should be expected (Kennedy 1993). The greater first-year height growth observed for the container seedlings may be a response to the reduced handling and planting stress when compared to bareroot seedlings (White and others 1970). Williams and Craft (1998) observed similar first-year results for bareroot and container Nuttall oak (*Quercus texana*) seedlings planted on a hydric soil in the LMAV.

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.

Kennedy, Jr. H. E. 1993. Artificial regeneration of bottomland oaks, In: Loftis, D.; McGee, C. E., eds. Oak regeneration: Serious problems, practical recommendations. Symposium Proceedings; 1992 September 8-10; Knoxville, TN Gen. Tech. Rep. SE-84. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 241-249.

Miwa, M. 1995. Reestablishment of bottomland oak species in lower Mississippi Valley alluvial soils. Tech. Rep. WRP-RE-14, Vicksburg, MS, U.S. Army Engineers Waterways Experiment Station.

Olzap, M.; Schoenholtz, S. H.; Hodges, J. D.; Miwa, M. 1998. Influence of soil series and planting methods on fifth-year survival and growth of bottomland oak reestablishment in a farmed wetland. In: Proceedings of the 9th Biennial Southern Silvicultural Research Conference; 1997 February 25-27; Clemson, SC. Gen. Tech. Rep. SRS-20, Asheville, NC: U.S. Department of Agriculture. Forest Service, Southern Research Station: 277-280.

Shepard, J. P. 1995. Reforesting marginal agricultural land. Forest Farmer 54: 7-19.

Stanturf, J. A.; Kennedy, H.E., Jr. 1996. Survival and growth of planted and direct seeded cherrybark oak in South Carolina. Southern Journal of Applied Forestry 20(4): 194-196.

White, D. P.; Schneider, G.; Lemmien, W. 1970. Hardwood plantation establishment using container grown stock. Tree Planters' Notes 21(2): 20-25.

Williams, H. M.; Craft, M. N. 1998. First-year survival and growth of bareroot, container, and direct-seeded Nuttall oak planted on flood-prone agricultural fields. In: Proceedings of the ninth biennial southern silvicultural research conference; 1997 February 25-27; Clemson, SC. Gen. Tech. Rep. SRS-20. Asheville, NC: U. S. Department of Agriculture, Forest Service, Southern Research Station: 300-303.