SEVENTEEN-YEAR GROWTH OF CHERRYBARK OAK AND LOBLOLLY PINE ON A PREVIOUSLY FARMED BOTTOMLAND SITE

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Abstract-This study documents the effects of cultural treatments on 17-year growth of cherrybark oak (*Quercus pagoda* Raf.) and loblolly pine (*Pinus taeda* L.) planted on a previously farmed bottomland site in southwestern Tennessee. Yellow-poplar (*Liriodendron tulipifera* L.) was part of the original study, but was excluded due to very high mortality in early years. The experiment was a randomized, complete-block design located on a former soybean field prone to occasional flooding. Cultural treatments were third-year fertilization (nitrogen and phosphorus) as well as disking and mowing for weed control. Natural regeneration as a means of afforestation also was investigated. Survival after 17 years averaged 64 percent for cherrybark oak and 63 percent for loblolly pine. Mean total height was 34.0 feet for cherrybark oak and 55.0 feet for loblolly pine. The mean diameters at breast height (DBH) of cherrybark oak and loblolly pine were 4.1 and 10.2 inches, respectively. Survival, height, and DBH of both species were not significantly affected by fertilization, mowing, or disking, nor were there any significant interactions among the treatments. Natural regeneration resulted in dense stands (4,340 trees per acre) dominated by small-diameter sweetgum (*Liquidambar styraciflua* L.).

INTRODUCTION

A number of studies have investigated afforestation of abandoned agricultural wetlands in the Mississippi Valley, but few studies have provided long-term results of afforestation practices on these sites. A plantation in southwest Tennessee provided the opportunity to observe seventeen-year effects of cultural treatments on a highly desirable bottomland hardwood species and an adaptive pine likely to perform well on such sites.

Cost share programs such as the Conservation Reserve Program and the Wetland Reserve Program have encouraged afforestation of farmed wetlands. The cultural practices used on these sites to improve early growth and to insure dominance of tree seedlings have varied. Mowing or disking for weed control is not as common today as in the past, but it is still important to understand the residual effects of these establishment practices on bottomland plantations. The primary objective of this study was to determine the suitability of cherrybark oak and loblolly pine for planting on a previously farmed bottomland site, and to evaluate the effects of cultural treatments on their establishment and growth. The planted plots in this study also were compared to a naturally regenerated area on the same site.

METHODS

The study took place on the Ames Plantation in Fayette County, Tennessee, 50 miles east of Memphis (35” 07’ N and 89” 19’ W). The site was a former soybean field on a floodplain of the North Fork of the Wolf River. According to the USDA Natural Resources Conservation Service county soil map, soils are of the Waverly (Coarse-silty, mixed, acid, thermic Typic Fluvaquents) and Falaya series (Coarse-silty, mixed, active, acid, thermic Aeric Fluvaquents) (Flowers 1964). The Falaya series consists of somewhat poorly drained silty and sandy alluvium, and the Waverly series is a poorly drained silty alluvial soil. The study site had been in cultivation for more than 20 years prior to the establishment of hardwoods in 1981. Mean annual precipitation is 53 inches (Flowers 1964).

In spring of 1981, 1-O seedlings were hand-planted among the previous year’s soybean stubble at a 10- x lo-foot spacing. The study initially included 1,200 each of cherrybark oak, loblolly pine, and yellow-poplar seedlings. However, the yellow-poplar suffered very high mortality and was excluded from the study after the first 2 years.

The experiment was a randomized, complete-block design with a strip-plot treatment arrangement and four replications. Main plot treatments were arranged in a 2 x 3

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factorial composed of fertilized and unfertilized plots of the 3 species. The fertilization treatment was 150 pounds per acre nitrogen (ammonium nitrate) and 35 pounds per acre phosphorus (triple super phosphate) applied at the beginning of the third growing season. Three treatments were tested on the sub-plot level: disking, mowing, and no weed control. One-way disking and mowing were repeated as needed (three to five times annually) until the end of the fifth growing season to control competing vegetation. The plantings were never thinned. A 1.2-acre section of the same soybean field was left to regenerate naturally.

In January 1998, 17 years after planting, total height of each surviving tree was measured with a Haga altimeter. Diameter at breast height (DBH) was measured with a caliper. In the naturally regenerated area, 10 circular, 0.01-acre plots were randomly placed. Height, DBH, and species were recorded for each stem on these plots greater than 4.5 feet in height. Equations developed by Matney and others (1985) and Baldwin and Feduccia (1987) were used to estimate total bole volumes of individual trees outside bark. Stand volume estimates ($feet^3$ per acre) were calculated based on estimated tree volumes, survival rates, and planting density. Survival and growth data were analyzed by Analysis of Variance (ANOVA) using Proc Mixed in SAS (SAS Institute Inc 1997). Survival data were transformed with the arcsine-square root transformation to meet the normality and homoscedasticity requirements of ANOVA. Post-ANOVA mean separations were made with single degree of freedom contrasts (alpha = 0.05).

RESULTS AND DISCUSSION

Survival for cherrybark oak averaged 89 percent after 1 year, 77 percent after 2 years, and 64 percent after 17 years. Loblolly pine survival averaged 80 percent, 74 percent, and 63 percent after 1, 2, and 17 years, respectively. Fertilization and weed control treatments did not significantly affect survival at any age for either species (table 1).

Seventeen-year height, DBH, basal area, and stand volume for both species were not significantly affected by fertilization or weed control treatment, nor were there any significant treatment interactions. Although there were numerical differences among some of the treatment means, the variability of cherrybark oak height and diameter among blocks (replications) prevented any statistically significant differences. Loblolly pine had consistent height and diameter among both blocks and treatments, but survival rates varied widely among blocks.

Cherrybark oak had a mean height of 34.0 feet and a mean DBH of 4.1 inches after 17 years (tables 2 and 3). Because cherrybark oak it best suited to well drained soils (Krinard 1990), the poor drainage on parts of the study site may have hindered growth and root development. It is likely that soils in this study were more variable than indicated by the county soil map (Flowers 1964). A neighboring bottomland study in which soils were evaluated showed wide variations in soil properties including drainage over distances of less than 100 feet (Devine and others 2000). Even minor variations in soils can have major impacts on the success of planted hardwoods (Kormanik and others 1999). Due to the slow growth rate of the cherrybark oak, the 17-year-old plantation still had not formed a canopy sufficient to shade out competition. Several areas were heavily infested with Japanese honeysuckle *(Lonicera japonica Thunberg)* and other herbaceous and woody weed species. There was a visible reduction in woody competition on plots which had been disked or mowed, but this did not translate into a significant increase in growth for the plantation trees.

Table I-Survival after 1, 2, and 17 years for planted cherrybark oak and loblolly pine under six different treatment combinations"

Species/ Fertilization/ Weed Control	Age 1	Age 2	Age 17
		Percent	
Cherrybark oak			
Unfertilized/ None	88	73	62
Unfertilized/ None	88	78	72
Unfertilized/ Mowed	88	70	66
Fertilized/ None	91	81	66
Fertilized/ Disked	94	80	60
Fertilized/ Mowed	89	79	57
Lobolly Pine			
Unfertilized/ None	73	68	45
Unfertilized/ None	86	74	72
Unfertilized/ Mowed	80	80	66
Fertilized/ None	79	73	54
Fertilized/ Disked	81	77	66
Fertilized/ Mowed	83	76	76

[a] There were no significant differences among treatment combinations for either species at alpha=0.05.

Cherrybark oak averaged 32.8 $feet^2$ per acre basal acre after 17 years of growth (table 4). The potential merchantability of this stand will depend on whether growth rates increase in the near future. On some of the plots, enough woody competition had already become established to make the planted trees a relatively minor component of the stand. Clatterbuck and Hodges (1988) noted that cherrybark oak reached its maximum growth rate later than sweetgum and eventually exceeded it in height. It is possible that this could occur in the present study because sweetgum is the predominant co-occurring species.

Table P-Height after 17 years for planted cherrybark oak and loblolly pine under six treatment combinations[a]

Fertilization/ Weed control	Cherrybark Oak	Loblolly Pine
	----- Feet -----	
Unfertilized/None	30.4	53.7
Unfertilized/Disked	37.1	56.1
Unfertilized/Mowed	33.3	56.5
Fertilized/None	32.8	52.3
Fertilized/Disked	34.6	56.0
Fertilized/Mowed	35.8	54.3

[a] There were no significant differences among treatment combinations for either species at alpha=0.05.

By year 17, loblolly pine had reached a mean DBH of 10.2 inches and a mean total height of 55.0 feet. Diameter and height growth was quite consistent among all treatments, and the plots had long since formed a closed canopy. At age 17 there was virtually no weed competition present in the pine plantings. Basal area averaged 160.9 ft^2 per acre for all treatments. Variations in basal area and stand volume of loblolly pine in tables 4 and 5 are a reflection of variation in survival among treatments and not of variation in growth. However, because survival rates varied widely among replications, there were no statistically significant differences in basal area or stand volume due to treatments. Hopper and others (1993) found that weed control, but not fertilization, increased growth and survival at age 4 of loblolly pine, sweetgum, and green ash (*Fraxinus pennsylvanica* Marsh.) planted on a West Tennessee bottomland site. Hunt and Cleveland (1978) also found that disking, but not fertilization at planting, increased height growth of loblolly pine through age 5. If differences in growth of loblolly pine due to weed control or fertilization were present early in the current study, they have since disappeared.

Table 3—DBH after 17 years for planted cherrybark oak and loblolly pine under six treatment combinations[a]

Fertilization/ Weed control	Cherrybark oak	Loblolly Pine
	...... Inches	
Unfertilized/None	3.5	10.0
Unfertilized/Disked	4.7	10.1
Unfertilized/Mowed	4.3	10.3
Fertilized/None	3.7	10.3
Fertilized/Disked	4.4	10.3
Fertilized/Mowed	4.2	09.9

[a] There were no significant differences among treatment combinations for either species at alpha=0.05.

Table 4—Stand basal area after 17 years for planted cherrybark oak and loblolly pine under six treatment combinations[a]

Fertilization/ Weed control	Cherrybark Oak	Loblolly Pine
	.... Feet² per acre	
Unfertilized/None	25.0	110.2
Unfertilized/Disked	42.8	179.7
Unfertilized/Mowed	41.7	171.2
Fertilized/None	23.1	142.3
Fertilized/Disked	32.5	170.7
Fertilized/Mowed	31.4	183.2

[a] There were no significant differences among treatment combinations for either species at alpha=0.05.

On disked plots of both species, 6- to 12-inch deep depressions were present between the tree rows. These depressions were accompanied by small ridges in line with the rows. Both features were likely caused by compaction and heaving of soil that resulted from disking. During wet periods, water ponded in the majority of these depressions, most notably those in poorly-drained areas. These depressions were still present 12 years after the plots had last been disked.

Natural regeneration resulted in dense stands (4,340 trees/acre) of sweetgum (74 percent of stems), boxelder (*Acer negundo* L.) (12 percent), red maple (*Acer rubrum* L.) (11 percent), and other hardwoods. Over 99 percent of the stems in this stand were less than 5 inches in DBH, and 46 percent of the stems were less than 1 inch in DBH. Species composition of this stand was heavily influenced by the adjacent, mature forest stands. The naturally-regenerated stand clearly had low potential for merchantability at age 17.

Table 5-Stand volume (total bole) after 17 years for planted cherrybark oak and loblolly pine under six treatment combinations[a]

Fertilization/ Weed control	Cherrybark Oak	Loblolly Pine
	.... -Feet³ per acre-	
Unfertilized/None	469	2,953
Unfertilized/Disked	895	4,965
Unfertilized/Mowed	744	4.788
Fertilized/None	553	3,455
Fertilized/Disked	629	4,726
Fertilized/Mowed	630	5.008

[a] There were no significant differences among treatment combinations for either species at alpha=0.05.

CONCLUSIONS

Loblolly pine planted on a bottomland soybean field with no site preparation established a well-stocked stand by age 17. Cherrybark oak plots showed inconsistent growth, perhaps due to variations in soils. A single application of N and P fertilizers at year 3 did not increase growth of cherrybark oak or loblolly pine, nor did mowing or disking for weed control. Since disking resulted in depressions between tree rows still present 12 years after the site was last disked, its usefulness as a method of weed control on flood-prone or poorly-drained sites is questionable. The depressions increase the amount of time that water ponds on the soil which can be detrimental to the growth and survival of planted tree species not adapted to periods of extended flooding. Composition of natural regeneration on the former soybean field depended on neighboring stands and did not produce merchantable trees after 17 years.

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