EARLY EFFECTS OF GENETIC IMPROVEMENT ON CHERRYBARK OAKS (*QUERCUS PAGODA* RAF.) IN SOUTHERN ARKANSAS

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Abstract: Our current study attempts to quantify the growth and survival difference between second generation half-sib (improved) and woods-run cherry bark oak (*Quercus pagoda* Raf.) seedlings in operational settings. One-year-old seedlings of both cherrybark oak varieties were planted at two sites in southern Arkansas at 2.43 meters x 3.04 meters spacing using a randomized block design. There were no statistical differences among site or seedling type for ground line diameter. However, there was a signification interaction effect between site and seedling type. Specifically, seedling type differences were present at the Monticello site with improved seedlings having 20% greater average height and 14% greater survival when compared to the unimproved seedlings.

INTRODUCTION

Cherrybark (*Quercus pagoda* Raf.) is currently the only oak species that the Arkansas Forestry Commission (AFC) offers as an improved planting stock through their selective breeding efforts with Western Gulf Tree Improvement Program (WGTIP). Improved cherrybark oak seedlings are predicted by the AFC and WGTIP to have increased survival and rates of growth. The commercial success of hardwood tree improvement programs depends in large part on the ability to produce high quality seedlings with early gains in height and diameter that outweigh the added cost of production.

Early growth in oaks is important due to their susceptibility to being outcompeted by other species. This has led to substantial research in manual and chemical control of competing vegetation (Dubois 2000, Miller 1993, Ezell et al. 2007). Ideally, successful artificial regeneration of oaks should come from planting vigorous and competitive seedlings (Duryea 1985). The ability of oak seedlings to put on early and rapid growth is critical in reducing the time competing vegetation poses a risk to the success of regeneration (Dey et al. 2008). Tree improvement offers one avenue in which to produce seedlings with the qualities that can allow for greater growth and survival in artificially regenerated stands with costs savings from fewer herbicide treatments.

MATERIALS AND METHODS

Two sites in Arkansas, one near Hope (33° 43' 9.76", -93° 31' 49.92") and another near Monticello (33° 37' 12.31", -91° 44' 0.38") were planted with 1-0 seedlings of improved and woods-run cherrybark oaks grown at the AFC's Baucum Nursery in North Little Rock. Prior to planting, the Monticello site was a pine-dominated forest salvage logged following wind damage and then cleared of slash. Soils on the Monticello site are silt loams with a 50-year site index

(SI_{50}) of 85 feet for cherrybark oak. The Hope site, a former old field, is on a silty clay loam soil with a SI_{50} = 90 feet for cherrybark oak.

Each site has two blocks planted with replications for a total of 480 randomly sampled improved and unimproved cherrybark oak seedlings split between the two sites and blocks. Seedlings were planted at 2.438 meters x 3.048 meters spacing. Both received 59.14 milliliters per acre of Oust® XP at the time of planting. Survival, height, and ground line diameter (GLD) were measured for a random subset of each replication at the time of planting and at the end of the first growing season (October 2012). Survival and re-sprouting was measured again at the start of the second growing season (May 2013).

A general linear model using fixed effects was conducted on the data according to a general randomized block design. Survival was analyzed using a general linear mixed model with a specified binomial distribution and a logit link function. Additionally, a logistical regression model was used to determine relationships between sprouting and GLD. In all analysis, an alpha of 0.05 was used as a significance threshold. Means separation was conducted using Least Significance Difference procedures.

RESULTS AND DISCUSSION

GLD for the first year results differed across the two sites but not between treatments (Table 1). At the end of the first growing season, neither planting stock had obtained a mean GLD of 8-10 mm; which has been found to be more competitive at planting time (Johnson 1984, 1992, Stroempl 1985, Johnson et al. 1986, von Althen 1990, Kennedy 1993, Pope 1993, Smith 1993, Dey and Parker 1997). The end of the first growing season GLD measurements were significantly different between sites.

Table 1. General linear model ANOVA for first year height and ground line diameter measurements.

Source of variation	df	Sum of squares	Mean square	F	P
Ht (R=.12)					
Model	5	12318.85	2463.77	8.75	<.0001
Site	1	6461.78	6461.78	22.95	<.0001
Block(site)	1	2086.64	2086.64	7.41	0.0068
Seedling type	1	1026.54	1026.54	3.65	0.0571
Site*Seedling type	1	2654.34	2654.34	9.43	0.0023
Block*Seedling type (site)	1	89.54	89.54	0.32	0.5732
Error	336	94606.41	281.57		
Corrected Total	341	106925.25			
GLD (R=.15)					
Model	5	3.14	0.63	12.21	<0.0001
Site	1	2.25	2.25	43.66	<0.0001
Block(site)	1	0.7	0.7	13.55	0.0003

Source of variation	df	Sum of squares	Mean square	F	P
Seedling Type	1	0.17	0.17	3.4	0.0662
Site*Seedling Type	1	0.01	0.01	.22	0.6406
Block*Seedling Type (site)	1	0.02	0.02	.32	0.5743
Error	336	17.29	0.05		
Corrected Total	341	20.43			

After the first year of growth, improved and unimproved seedlings were not significantly different in regards to height and survival (Table 1). The improved cherrybark oaks had significantly greater survival at the Monticello site compared to the unimproved at the Monticello site and both seedling types at Hope. Total survival is relatively low in comparison to previous findings with bareroot cherrybark oak seedlings (Kormanik et. al. 1976). Low overall survival is likely related to the significant drought experienced by southern Arkansas in the summer of 2013. The unimproved seedlings at the Monticello site had a significantly lower height when compared to the improved planting stock and both seedling types at Hope.

The mean seedling height for both improved and unimproved seedlings at the end of the first growing season is only now exceeding the range, 40 – 50 cm, recommended in literature for seedling shoot length at time of planting (table 2) (Foster and Farmer 1970, Johnson 1981, von Althen 1990, Kennedy 1993).

Table 2. Mean height, ground line diameter, and survival for two levels of genetic improvement of cherrybark oak seedlings in October, 2012.

Variety	Site	Sample Size	Height (cm)[1]	GLD (cm)[2]	Survival (%)[3]
Improved	Monticello	56	54[a]	0.6[a]	68.75[a]
	Hope	110	57[a]	0.7[b]	60.56[b]
Unimproved	Monticello	60	43[b]	0.5[a]	55.23[b]
	Hope	116	58[a]	0.7[b]	63.33[b]

1 Values in this column followed by the same letter are not significantly different at the 0.05 level for site by seedling type interaction.
2 Values in this column followed by the same letter do not have significantly different means at the 0.05 level.
3 Values in this column followed by the same letter are not significantly different at the 0.05 level for site by seedling type interaction.

Oaks are known to put a great deal of energy into root growth in early stages of development (Gardiner and Hodges 1998). This energy allocation helps explain the prolific sprouting seen at the beginning of the second year of growth. Sprouting that occurred during the start of the second growing season increased the rate of seedling deemed to be surviving for both seedling types (Table 3). Our further investigation of re-sprouts found no statistical evidence for a relationship between planting GLD and sprouting (*p*=.3669) that occurred after the end of the first growing season. The effects of this sprouting will likely have an impact on height and ground line diameter measurements to occur at the end of the second year growing season.

Table 3. Mean survival for two levels of genetic improvements of cherrybark oak following leaf-out in May 2013.

Variety	Site	Survival (%)[1]
Improved	Monticello (N=56)	72.50[a]
	Hope (N=110)	67.84[a]
Unimproved	Monticello (N=60)	61.25[b]
	Hope (N=116)	69.01[a]

1 Values in this column followed by the same letter do not have significantly different means at the 0.05 level.

CONCLUSIONS

The significant drought that occurred in the first summer following planting is likely the cause of relatively low survival for both seedling types and may have confounded differences, or lack of thereof, between the improved and unimproved planting stocks in regards to height and diameter measurements. Still, these results do represent the conditions seedlings would face when planted in years with less than ideal conditions.

Sprouting at the start of the second growing season was similar for both planting stocks. It will undoubtedly cause an impact on height and diameter estimates that are planned for the end of the second growing season. At the present, the differences in terms of early gains in height, survival and GLD from improved cherrybark oak planting stock are inconclusive.

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