SURVIVAL AND GROWTH PERFORMANCE OF TWO OAK SPECIES AND THREE PLANTING STOCKS ON LANDS DISTURBED BY HURRICANE KATRINA

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Abstract—Regeneration of oaks is a priority for most landowners in the south given their inherent wildlife benefits, economic return, ascetics, and providing habitat for endangered species. In the case of natural disasters such as Hurricane Katrina artificial regeneration of these stands may be the only viable option to reestablish an overall oak component in a future stands overstory. This study evaluated growth of two oak species, water oak *(Quercus nigra*) and swamp chestnut oak (*Quercus michauxii*), and three planting stocks: 1-0 bareroot, conventional containerized, and EKOgrown™ seedlings were compared for two growing seasons. Conventional containerized planting stock exhibited greater groundline diameter (GLD) growth for both species at the end of the first growing season compared to bareroot and EKO™ planting stock. Bareroot seedlings had similar GLD growth to EKO™ seedlings for both years. Conventional containerized seedlings height differed in water oak but did not differ in swamp chestnut oak at the end of year two compared to bareroot seedlings. EKO™ seedlings exhibited severe dieback at the end of both growing seasons and the least amount of height growth.

INTRODUCTION

The southern states of North America have some of the most productive bottomland soil in the United States. These fertile deposits from rivers coupled with a warmer climate and longer growing season make these sites the primary area for bottomland hardwoods in the region. Hardwoods such as oaks (*Quercus* spp.) are valuable resources to the southern forest for timber production, flood storage, and nutrient charge (Hall and Lambou 1989, Ezell and others 2007, Moree and others 2010). Bottomland hardwoods provide many benefits to both non-industrial private landowners (NIPL) and industry landowners including aesthetics, excellent wildlife habitat, recreational activities, endangered species refuges, and opportunities to generate money from harvesting. Bottomland hardwood forests in Mississippi were damaged by Hurricane Katrina in 2005 when it made landfall along the Gulf Coast. A major problem resulting from the damage is lack of oak regeneration, which can be problematic without advance planning. Thus, the preferred practice of natural regeneration, which requires a well-structured plan and timing to be successful, may not be an option (Coder 1994, Belli 1999, Dey and others 2008). Typically, oaks will be a much smaller percentage of the new overall stand component when compared to the parent stand (Beck and Hooper 1986, Loftis 1988). Some studies suggest that this can be a result of oaks being much slower to grow when compared to light-seeded competitors (Smith 1993, Thompson and Nix 1995). In the South, oaks are not strong competitors with rapid and aggressively growing herbaceous vegetation. Herbaceous competition is the main cause for seedling mortality during the establishment period of 1-2 years (Smith and others 1997). With these circumstances, artificial regeneration of desirable hardwoods is a viable option and may be the only one available in areas disturbed by a major storm.

Regeneration efforts on bottomland sites are mainly focused to enhance wildlife habitat, produce timber, and increase/protect water quality which is a main concern with managers in the South (Witter 1991). Artificial regeneration has become an important forest management option when a stand lacks natural regeneration to restore the oak component of a stand. However, this practice has potential to be problematic on mesic sites (Lorimer 1993, Johnson and others 2002). Seasonal flooding on poorly drained sites causes more problems for oak re-establishment on a floodplain site and favors undesirable species that are more tolerant of wet conditions.

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Planting a high quality and vigorous seedling is an essential element of any artificial regeneration prescription (Dey and Parker 1997). These seedlings will have taller stems, more fibrous roots, ideal shoot to root ratio, and larger diameters. These characteristics lead to better survival and growth rates. According to Dey and Parker (1997), larger seedlings perform better against competing vegetation. Couple a high quality seedling with proper chemical and mechanical methods and survival and growth has shown to increase (Ezell and others 2007).

Proper planting is also an essential component. Improper planting such as J-rooting, excessive root pruning or shallow planting can increase the chances of mortality and seedling stress. Using a high quality seedling is negated if improper planting and handling techniques are used. Many research studies have correlated mortality of seedlings with improper planting. These research studies mainly focused on one planting stock, but little has been done to compare survival and growth of various oak planting stocks. This study will help fill the void of information to help landowners make a more well-informed and more cost-effective decision.

OBJECTIVES

The objectives were (1) compare the two year height growth and groundline diameter growth of water oak (*Q. nigra*) and swamp chestnut oak (*Q. michauxii*); and (2) compare the two year height growth and groundline diameter growth of three planting stocks (high-quality 1-0, bareroot, conventional containerized, and large containerized seedlings).

MATERIALS AND METHODS

Study Sites

Research was conducted on two privately owned sites located in southeast Mississippi. One site is located 16 km northwest of Hattiesburg and the other is 8 km southeast of Lucedale. The soil series represented in this study were Freest-Susquehanna-Prentiss and Lenoir silt loam, respectively. According to the Natural Sources Conservation Service (2012), the Hattiesburg area receives an average of 57 inches of annual rainfall. The Lucedale area receives an average of 61inches of annual rainfall.

The Malone site (3123’47.93N”, -8928’33.24”W) in Lamar County, has a Freest-Suspuehanna-Prentis soil series. Prior to Katrina, timber on this site was a mixed stand of loblolly pine (*Pinus taeda*), sweetgum (*Liquidambar styraciflua*) and water oak. After Katrina, a salvage operation was performed. The site has been kept open by periodic mowing. The few remaining woody stems were injected with a 20 percent aqueous solution of Arsenal® AC (*Imazapyr*) to prepare for planting. A restrictive layer approximately 10 in. below ground was reported by the planting crews that may be a restrictive layer for the first years of growth.

The second site, the Welford site (3049’27.27”N, -8827’13.86”W) in George County, has a Lenoir silt loam soil series. Prior to Katrina the site also had a mixed stand of loblolly pine and hardwoods. A small drain in the center of the site contained several stems of pond cypress (*Taxodium ascendens*). According to the landowner, this site does flood during, wet winters and springs due to its close proximity to the Escatawapa River. After Katrina, a salvage operation was performed and remaining debris was piled. The site was then root-raked and has been mowed and cultivated every year for a wildlife food plot. Remaining stems were injected with a 20 percent aqueous solution of Aresenal® AC to prepare for planting.

Seedlings

Two oak species, water oak and swamp chestnut oak, and three planting stocks: high quality 1-0 bareroot, 240cm^3 conventional containerized, and EKOgrown™ seedlings grown in a Rootmaker® container were used for evaluation. Bareroot seedlings were purchased from the Rayonier nursery in Elberta, Alabama. Conventional containerized seedlings were purchased from Mossy Oak Native Nurseries™ in West Point, Mississippi. EKO™ seedlings were produced and purchased from RES Native Tree Nursery in Montegut, Louisiana.

Planting

A total of 3,600 seedlings were planted for this study. Each site had 1,800 seedlings planted representing 300 seedlings per species and planting stock combination. Mississippi State personnel planted bareroot seedlings and conventional containerized seedlings with planting shovels on the first weekend of February 2013. A commercial planting crew planted the EKO™ seedlings with planting shovels in late October 2012. Seedlings were planted next to a pre-marked pin flag to insure proper spacing for uniformity. Each planting job was monitored by a graduate research assistant to ensure planting quality.

Study Design

The Malone study area was established with 1,800 seedlings planted on a 3.05m by 3.05m spacing. The Welford study area was established with 1,800 seedlings planted on a 2.74m by 2.74m spacing. Spacing was altered for the Welford site due to limited land area. A compass and two 300 ft. surveyor’s tapes were used to ensure row straightness and uniform tree spacing. Each study area was divided into three blocked replicates. Six plots containing 100 planting locations were randomly assigned to groups of adjacent rows within each replicate to represent each of the six species and planting stock combinations. Pin flags of different colors were used to distinguish species and planting stock combinations and mark planting locations. A piece of 1.2m rebar was placed at the beginning and ending of each planting row with an aluminum tag attached denoting the replicate, row number, species, and planting stock. Corners of each study area were marked with 3.0m pieces of polyvinyl chloride (PVC) pipe placed over a 1.2m piece of rebar to ensure no disturbance to the study area.

Herbicide Application

Bareroot and conventional containerized seedlings were treated with a post-plant, pre-bud break application of Oust® XP (140g/sprayed ha) in March of 2013 and 2014. An 11.4L Solo® diaphragm-pump backpack sprayer equipped with a TeeJet 8003 Visiflo® nozzle, specially designed to minimize wind drift, was used to apply the herbicide as a 1.5m band over the top of seedlings.

Seedling Evaluation

Initial groundline diameter (GLD) and height measurements were recorded February 2, 2013. Height of bareroot, conventional containerized and EKO™ seedlings were measured to the nearest centimeter using a meter stick. GLD measurements were measured to the nearest tenth of a millimeter using Mititoyo® digital calipers. First year GLD and height measurements were recorded on November 2, 2013 for both sites. Final measurements were recorded on November 8 and 9, 2014. Only living portions of the dominant stem were measured in height and GLD measurements in the case that a seedling exhibited dieback completely and re-sprouted.

RESULTS AND DISCUSSION

Malone Site

Height Growth—Water oak conventional containerized planting stock had the highest overall total growth (table 1). This may be attributed to the ability of these seedlings being able to mitigate planting shock with the inherent fibrous root system typical to this planting stock. Bareroot seedlings typically need a year to reestablish a root system before allocating resources to height growth. This is evident when comparing year one growth with year two growth. Some water oaks also exhibited high levels of deer browse. These seedlings appeared to be physiologically active when transplanted, which may explain the herbivory and could certainly lead to increased transplant shock, stress, dieback, and mortality. Once bareroot seedlings reestablished roots in the second growing season they added a greater amount of growth. EKO™ seedlings were planted in October which is typically one of the driest months for Mississippi. This factor, when compounded with a shoot to root ratio imbalance and lack of seedling dormancy when planted appeared to result in extreme dieback. The prescribed "plant and walk away" approach for these seedlings which precludes any additional treatment such as herbaceous weed control, may have also contributed to poor performance of these seedlings.

Swamp chestnut oak bareroot seedlings had greater average height growth compared to conventional containerized or EKO™ seedlings. Conventional containerized seedlings had significantly greater height growth in the first growing season than bareroot. Once bareroot seedlings had their roots established, height growth was almost doubled compared to conventional containerized seedling height growth in year two. After two growing seasons, there was no significant difference between bareroot and conventional containerized seedlings regarding average total height growth. EKO™ swamp chestnut oak seedlings appeared to suffer from the same problems as water oak EKO™ seedlings.

GLD Growth—Water oak bareroot and conventional containerized seedlings exhibited positive growth during both growing seasons (table 2). Conventional containerized seedlings had the greatest amount of GLD growth for both growing seasons, with this growth being significantly greater than the other two planting stocks. There was a significant difference between bareroot and EKO™ seedlings at the end of the second growing season. However, bareroot seedlings did not exhibit a significant difference for GLD total growth at the end of year two compared to EKO™ seedlings. EKO™ seedlings exhibited a negative change in GLD the end of the second growing season. The same factors that affected height growth and survival may have contributed to the lesser performance in bareroot and EKO™ seedlings.

Swamp chestnut oak had similar GLD growth to that observed in water oak. At the end of each growing season bareroot and conventional containerized seedlings exhibited positive growth. Conventional containerized seedlings had the greatest GLD growth for each growing season and the greatest amount of overall growth. This growth was significantly different from the other two planting stocks. Bareroot seedlings outperformed EKO™ seedlings during the first growing season. However, bareroot and EKO™ growth did not differ significantly at the end of the second growing season. For overall growth, the amount the bareroot seedlings grew during the first growing season was enough to make its total GLD growth significantly different from EKO™ seedlings. Based on direct observation, the commercial planting crew hired to plant these larger seedlings did not utilize proper

Table 1—Average total height growth for species/planting stock combination for both sites

Height Growth				
Species/Planting Stock	Malone Site		Welford Site	
	--------------------------------*cm*--------------------------------			
WAO/BR	11.31	B	-0.53	B
WAO/CON	23.39	A	17.85	A
WAO/EKO™	-29.22	C	-12.85	C
SCO/BR	14.18	A	3.12	A
SCO/CON	11.72	A	3.39	A
SCO/EKO™	-29.22	B	-32.10	B

WAO= water oak
SCO= swamp chestnut oak
BR= bareroot
CON= conventional containerized
EKO™= Large containerized

Table 2—Average total groundline diameter growth for species/planting stock combination for both sites

GLD Growth				
Species/Planting Stock	Malone Site		Welford Site	
	--------------------------------*mm*--------------------------------			
WAO/BR	1.72	B	2.14	B
WAO/CON	5.33	A	5.76	A
WAO/EKO™	0.22	B	2.37	B
SCO/BR	1.97	B	1.88	B
SCO/CON	3.33	A	2.44	A
SCO/EKO™	-0.59	C	1.42	B

WAO= water oak
SCO= swamp chestnut oak
BR= bareroot
CON= conventional containerized
EKO™= Large containerized

seedling care and planting practices. Thus, EKO™ seedlings were possibly adversely affected.

Welford Site

Height Growth—Water oak conventional containerized planting stock had the greatest average total height growth (table 1). It is surmised that conventional containerized seedlings were better able to mitigate planting shock due to the fibrous root system inherent to containerized seedlings. Bareroot seedlings need a year to reestablish a root system after planting before resources are allocated to height growth. This is evident when comparing year one and year two growth. During the second growing season, bareroot seedlings exhibited positive height growth. Deer browse may have also contributed to poor height growth in bareroot seedlings. These factors resulted in bareroot seedlings being placed under increased stress which resulted in bareroot seedlings exhibiting dieback during the first growing season. EKO™ seedlings were planted in October, which is typically one of the driest months in Mississippi. Problems resulting from this early planting time were likely compounded with a shoot to root ratio imbalance ending with increased dieback. The "plant and walk away" approach, advertised for use with EKO™ stock, may have contributed to poor performance.

Swamp chestnut oak conventional containerized seedlings exhibited greater overall height growth compared to bareroot seedlings or EKO™ seedlings. Conventional containerized seedling growth was not significantly different from bareroot seedlings total height growth. Both conventional containerized and bareroot seedlings had similar height growth for both growing seasons. EKO™ swamp chestnut oak seedlings suffered from the same problems as water oak EKO™ seedlings. They were planted outside of the normal planting season, root to shoot ration imbalance and not being dormant when planted may have led to the onset of extreme dieback.

GLD Growth—Water oak seedlings had the same growth pattern for both growing seasons. The conventional containerized seedlings had a significantly greater average GLD growth than the other two planting stocks (table 2). Bareroot and EKO™ seedlings had positive growth at the end of the first growing season but had negative change at the end of the second growing season. There was not a significant difference for GLD growth among these planting stocks at the end of each growing season or for average total growth. The pattern of growth was most similar to that of observed at the Malone site.

Swamp chestnut oak seedlings performed differently than water oak. At the end of the first growing season there was not a significant difference among the three planting stocks. However, at the end of the second growing season conventional containerized seedlings GLD growth was significantly different from the other two planting stocks. Swamp chestnut oak bareroot and EKO™ seedlings had negative GLD growth at the end of the second growing season. Conventional containerized seedlings had the greatest total GLD growth and differed significantly from the other two planting stocks.

CONCLUSIONS

Despite EKO™ seedlings being twice as large in both height and GLD compared to bareroot and conventional containerized seedlings they did not exhibit a clear advantage in height growth or GLD growth. Results of this study show that with proper site preparation, seedling care, quality planting job, and first year herbaceous weed control a land manager can properly reforest lands with a high quality 1-0, bareroot seedling at a much lower cost compared to using containerized planting stock. This study is applicable to land managers trying to regenerate these two oak species on marginal agricultural lands and areas where typical site preparation has been applied on similar soils and expected growing conditions.

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