MECHANICAL SITE PREPARATION AND OUST XP® EFFECTS ON STEM BIOMASS IN THREE-YEAR-OLD NUTTALL OAK SEEDLINGS PLANTED ON A FORMER AGRICULTURAL FIELD

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Abstract-- Mechanical site preparation is frequently proposed to alleviate problematic soil conditions when afforesting retired agricultural fields. Without management of soil problems, any seedlings planted in these areas may exhibit poor growth and survival. Seeding height and groundline diameter are often used to evaluate effects of site preparation methods, but stem biomass may provide a more appropriate assessment of treatment effect in some circumstances. Four mechanical site preparation and two post-plant Oust XP® treatments were utilized in an attempt to evaluate resulting stem biomass differences. Mechanical site preparation treatments included a control, subsoiling, bedding, and combination plowing. A 1-year Oust XP® treatment was applied over one half of treatment areas. A 2-year treatment of Oust XP® was applied on the remaining half. A total of 1,440 bare-root Nuttall oak (*Quercus texana* Buckley) seedlings were planted in February 2008 on Malmaison Wildlife Management Area near Grenada, MS. All sites were of comparable soils and received above average precipitation for the majority of the 3-year duration of the study. Treatment effects on stem biomass were analyzed. Seedling stems in bedded and combination plowed areas exhibited greater woody biomass (210.25 g and 198.62 g, respectively) compared to seedlings in control or subsoiled areas (139.88 g and 118.9 g, respectively). Seedlings in areas treated with 2 years of Oust XP® exhibited greater stem biomass (202.71 g) compared to seedlings in areas treated with the 1-year Oust XP® treatment (131.11 g).

INTRODUCTION

Over the course of the past few decades, the practice of planting hardwood plantations in the Lower Mississippi Alluvial Valley (LMAV) has accounted for the afforestation of several hundred thousand acres of retired agricultural areas (King and Keeland 1999, Stanturf and others 2004). With an estimated 30 million acres of retired agricultural fields expected to undergo afforestation by the year 2040 (Wear and Greis 2002), the development of successful methods for establishing plantations on former agricultural areas cannot be understated.

Often, growth and survival of planted seedlings on former agriculture fields has not been satisfactory, resulting in a low percentage of oaks in established stands (McGee and Loftis 1986, Schoenholtz and others 2001, Stanturf and others 2004, Stanturf and others 2001). The preponderance of these failed afforestation attempts on former agriculture fields indicates a need for greater understanding of proper plantation establishment techniques. Several factors can decrease seedling growth and survival including: soil conditions, planting techniques, seedling quality, and competing vegetation. These problems can be alleviated through proper planting of high-quality seedlings, as well as applying proper silvicultural practices to enhance survival and growth. Notably, planting success on these areas can be improved through the use of herbaceous weed control (HWC) and mechanical site preparation.

Competing vegetation is often the primary cause of oak plantation failures. While both herbaceous and woody competition pose threats to the survival and growth of planted seedlings, herbaceous competition typically poses the greatest threat during the first years of establishment (Peltzer and Kochy 2001). Improved growth and survival of hardwood seedlings treated with broad-spectrum pre-emergent herbicides has been well documented (Ezell and Catchot 1997, Ezell and Hodges 2002, Ezell and others 2007, Groninger and others 2004, Woeste and others 2005).

One of the primary reasons to use mechanical site preparation is for alleviation of problematic soil conditions. In addition to decreasing soil strength and consequently lessening the difficulty of root penetration in the soil, nutrient availability is increased due to improved accessibility and consolidation (Fisher and

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Binkley 2000, Kabrick and others 2005, Miller 1993, Morris and Lowery 1988, Russell and others 1997). Variation in water and nutrient availability can lead to variable seedling growth (Lutze and Gifford 1998, Poorter and Nagal 2000, Reich 2002, Ryser and Lambers 1995, Volin and Reich 1996). Differences in the availability of soil nutrients and changes in microsite in areas with different resource availability can result in stem growth differences (Kozlowski and Pallardy 1997, Van Hees and Clerkx 2003). Thus, increases in seedling growth could be a response to HWC and mechanical soil treatment. Shoot growth is of particular interest in determining how young trees respond to HWC and mechanical site preparation.

Researchers often use seedling parameters such as height and diameter in attempts to quantify seedling response to chemical and cultural treatments. Stem biomass is an often-overlooked metric that can provide useful insight into treatment effects on seedling success. Biomass estimation can be extremely useful in ascertaining seedling performance under different treatment regimes. Treatment influences that might remain undetected when utilizing more easily measured parameters may be recognized through biomass determination.

OBJECTIVES

The objectives of this study were: (1) to evaluate the effects of HWC on stem biomass of 3-year-old Nuttall oak (*Quercus texana* Buckley) seedlings; and (2) to evaluate the effects of subsoiling, bedding, and combination plowing on stem biomass of 3-year-old Nuttall oak seedlings.

MATERIALS AND METHODS

Site Description

The study area is located on Malmaison Wildlife Management Area (WMA) approximately 14 miles northeast of Greenwood, MS (90.0531° W, 33.6876° N) in Grenada County. The site was formerly used in row-crop production and was retired from agricultural production in the late 1990s. It was maintained as an opening for wildlife through mowing and disking from agricultural retirement until the initiation of this study. Soils are Falaya and Collins silt loams, and average yearly precipitation is 53.8 inches (NOAA 2011). Soil tests indicated that onsite pH ranges from 6.3 to 7.0. Using the Baker and Broadfoot method for site evaluation, site index (base age 50) for Nuttall oak is 93.

At initiation of this project, dominant onsite herbaceous species were ryegrass (*Lolium* spp.), bermudagrass [*Cynodon dactylon* (L.) Pers], Brazilian vervain (*Verbena brasiliensis* Vell.), and Carolina horsenettle *(Solanum carolinense* L). Forty other herbaceous species occurred in small quantities. Cumulative herbaceous coverage by these species was 100 percent.

Experimental Design

This experiment utilized a randomized complete block design. Three blocks with eight plots per block were established. Each plot received a randomly assigned combination of mechanical site preparation and HWC treatment. The experimental unit was a plot with its unique combination of site preparation and HWC treatments. The response variable was third-year oven-dried weight of stems.

Mechanical Site Preparation and HWC Treatments

Four mechanical site preparation treatments were employed: control (no site preparation), subsoiling, bedding, and combination plowing. Site preparation treatments were applied on 10-foot centers. Subsoil trenches were cut to a depth of 15 inches. Bedding was performed using a furrow plow with the blades set to pull a soil bed approximately 3-feet wide and between 8- and 10-inches deep. Combination plowing involved pulling a soil bed over the top of subsoiled trenches. Mechanical site preparation treatments were applied during the first week of November 2007.

HWC treatments included a 1-year application and a 2-year application of Oust XP®. Both treatments were applied in 5-foot-wide bands using a rate of 2 ounces of product per acre and were applied over the top of seedlings prior to budbreak. The 1-year Oust XP® application was applied during March 2008. The 2-year Oust XP® application was applied during March 2008 and March 2009. A Solo® backpack sprayer was used for herbicide application with total spray volume of 10 gallons per acre (GPA).

Seedling Establishment

Nuttall oak was chosen for use in the biomass study because it is known for fast growth. Expectations were that there would be an abundant amount of woody biomass for use in analyses. Seedlings were lifted mid-January 2008, and purchased under specifications requiring 1-0 seedlings to be of overall vigorous appearance and have relatively intact root systems. Seedling parameters dictated that seedling stems be 18- to 24-inches tall and possess root systems 8- to 10-inches long with a minimum of eight first-order lateral roots (FOLRs). A total of 480 seedlings were planted at root collar depth using a 10-foot spacing during February 2008 by Mississippi State University personnel.

Stem Biomass Measurements

During November-December 2010, individual trees were sampled for stem biomass production. A total of seven Nuttall oak trees were selected for sampling from each treatment combination (site preparation/HWC) in each block. Stems from a total of 168 trees were collected. Stems were clipped at ground level and tagged by block and tree number. Leaves were removed, and each stem was cut into lengths that would fit into paper sacks labeled to identify each seedling. Stems were then weighed and dried at 212 °F for 48 hours in a desiccating oven before reweighing. The stems were then dried for an additional 24 hours to check for further weight loss. Final weights were recorded to 0.1g after sack weight was subtracted.

Data Analysis

All statistical analyses were performed using Statistical Analysis System version 9.2 (SAS Institute, Cary, NC). Proc Univariate was used for univariate analysis of biomass weight response. Analyses indicated some skewness which was corrected by taking the log of biomass weights. Outlier analysis using Studentized residual and Cook's D tests for outliers indicated that five sample trees were outliers. These trees were eliminated from further analyses. General Linear Modeling (GLM) and Analysis of Variance (ANOVA) were used to test for main effects and interactions, and to estimate least square means (LSMEANS). The LSMEANS LINES option was used to identify differences. Differences were considered significant at $\alpha = 0.05$. While transformed biomass data were used for analyses, actual means are presented for ease of interpretation.

RESULTS AND DISCUSSION

Stem Biomass by Site Preparation Treatment

ANOVA detected a significant main effect difference ($p = 0.0029$, $F = 4.87$) among site preparation treatments for stem biomass. Seedling stems in bedded and combination plowed areas exhibited greater woody biomass (210.25 g and 198.62 g, respectively) compared to seedlings in control or subsoiled areas (139.88 g and 118.9 g, respectively) (table 1).

Table 1--Stem biomass of Nuttall oak seedlings at Malmaison WMA, MS, December 2010 by site preparation treatment

Mechanical	Weight
	grams
Bedded	210.25a[a]
Combination plowed	198.62a
Flat planted (no mechanical)	139.88b
Subsoiled	118.91b

[a]Values followed by different letters are significantly different at $\alpha = 0.05$.

Typically, some separation in stem biomass would be expected between seedlings in control and subsoiled treatments. However, it is possible that excellent precipitation levels during the first two growing seasons of this study (19.4 inch surplus over average for the 2 years) negated the inherent enhanced growth potential of the subsoiling treatment. Greater stem biomass in seedlings planted in bedded and combination plowed areas compared to control or subsoiled areas indicates that over the span of this study, the more intensive treatments consistently produced seedlings with greater biomass.

Stem Biomass by HWC Treatment

ANOVA detected a significant main effect difference ($p = 0.0005$, $F = 12.56$) among HWC treatments for stem biomass. Seedlings in areas treated with 2-years of Oust XP® exhibited significantly greater stem biomass (202.71 g) compared to seedlings in areas treated with the 1-year Oust XP® treatment (131.11 g) (table 2). Greater stem biomass in 2-year Oust XP® areas compared to 1-year Oust XP® areas is the result of a greater "free-to-grow" period of time. During this period, seedlings did not suffer the adverse effects of herbaceous competition and resources that would have otherwise been lost to competitive stress were allocated to biomass growth.

Table 2--Stem biomass of Nuttall oak seedlings at Malmaison WMA, MS, December 2010 by pre-emergent Oust XP treatment

Pre-emergent treatment	Weight
	grams
One-year	131.11b[a]
Two-year	202.71a

[a]Values followed by different letters are significantly different at $\alpha = 0.05$.

SUMMARY AND CONCLUSIONS

The intent of this study was to determine if seedling biomass was affected by mechanical site preparation or HWC treatments. Mechanical site preparation had substantial impacts on stem biomass growth of Nuttall oak seedlings. Seedlings in bedded and combination plowed treatment areas exhibited significantly more stem biomass compared to those in control or subsoiled areas, and 2-year Oust XP® treatment areas exhibited greater biomass compared to 1-year Oust XP® treatment areas.

No statistical difference was detected in stem biomass accumulation between bedded and combination plowed areas. With no statistical advantage, higher combination plowing costs would preclude its use under conditions similar to those encountered in this study. Thus, based on this study, bedding would be the mechanical site preparation treatment of choice. However, subsoiling should not be discounted as a possible mechanical treatment. In areas where substantial resistant layers are present in the soil, subsoiling offers benefits in the amelioration of compaction problems. Additionally, subsoiling is less expensive than bedding or combination plowing and might be the treatment of choice in some situations where more intensive treatments are not possible (e.g., expense, erosion concerns, contractor availability, etc.). While seedling biomass was greater in 2-year Oust XP® areas compared to biomass in 1-year Oust XP® areas, the greater expense of the 2-year Oust XP® treatment might be cost prohibitive in many management efforts.

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