

SURVIVAL AND INITIAL GROWTH ATTRIBUTES OF IMPROVED AND UNIMPROVED CHERRYBARK OAK IN SOUTH ARKANSAS

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Abstract--Thousands of acres are planted every year with genetically improved seedlings; but while pine continues to be extensively explored, the same is not true for hardwoods due to costs and rotation length. An improved cherrybark oak (*Quercus pagoda* Raf.) seed orchard exists in North Little Rock, AR, providing an opportunity to evaluate hardwood improvement. However, the cost and limited testing of these seedlings have been large limiting factors in their deployment. In February 2012, improved and woods-run seedlings were hand-planted at two sites in southern Arkansas including a site near Hope, AR, and one near Monticello, AR. The sites were treated with 2 ounces per acre of Oust XP[®] 2 weeks after tree planting with manual control of sumac (*Rhus* spp.) and sweetgum (*Liquidambar styraciflua* L.) shortly thereafter. A random sample of seedlings at the nursery confirmed that seedling undercutting effectively controlled root length which was statistically the same for both groups at 21.8 inches. However, root collar diameter of an improved seedling was on average 27 percent larger than an unimproved seedling. These trends were similar to those among planted seedlings in which improved seedlings were 9 percent and 8 percent greater in regards to ground line diameter and height, respectively. However, improved seedlings exhibited greater initial mortality, by 6.2 percent, in the first few months of their growing season. While initial mortality is often considered random, disparity between the two groups points to other causes, such as the larger root sizes, which may pose planting problems. In conclusion, these results indicate that genetic improvement has increased 1-0 seedling size, but survivability must be carefully monitored.

INTRODUCTION

Cherrybark oak (*Quercus pagoda* Raf.) is a red oak that is one of the most highly valued hardwood species in southern forests. Similar to other hardwood species, very few genetic improvement studies have been performed on it. Adams and others (2006) determined that trees grown from seeds collected in the central area of the cherrybark oak range, predominately on the loess hills along the Mississippi River, had superior volume production. Substantial variation among families within a geographical region was also observed by Greene and others (1990) and Adams and others (2006) leading to the recommendation that provenance and individual family considerations should be made in tandem during selection for future generations. This is similar to recommendations for water oak (*Q. nigra* L.) in a provenance study (Adams 1989) that overlapped geographically with the studies conducted on cherrybark oak.

Cherrybark oak does have high individual tree height heritability (i.e., the proportion of variability that can be explained by genetic variability) in these studies and is comparable with findings in Nuttall oak (*Quercus texana* Buckl.) which have a family heritability of 0.72 to 0.96 for height and 0.22 to 0.95 for diameter (Gwaze and others 2003). These genetic assessments of oaks indicate that genetic gain

in volume production can be achieved through proper selections. While some commercial work has been undertaken, field tests of the resulting progeny are unique.

Successful hardwood stand establishment generally requires both high quality seedlings and costly silviculture treatments, including herbaceous weed control through herbicide. The high costs of hardwood seedlings and higher planting costs make initial growth and survival critical to justify the costs of stand establishment. Additional costs from using improved genetic seedlings makes deployment even more economically challenging. For instance, the Arkansas Forestry Commission (AFC) sells 2nd generation improved cherrybark oak seedlings for \$400 per 1000 seedlings (<http://forestry.arkansas.gov>). While these seedlings are twice as expensive as the unimproved cherrybark oak, they are projected to achieve a 13 to 18 percent volume gain. At an 8- by 10-foot spacing, improved seedlings add an additional \$109 per acre at establishment. At a 6 percent rate of return over a 50 year rotation, the added timber value must result in \$2,007 per acre over the unimproved seedlings. Thus, added expenses must be carefully examined based solely on genetic volume gains from a progeny test. Regardless of the genetic nature of the seedlings, the cost of establishment is

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high and competition control is needed to ensure adequate seedling survival. To ensure that survival and growth goals are met, further investments in herbaceous weed control are recommended (Dubois and others 2000, Ezell and Catchot 1998, Ezell and Hodges 2002, Ezell and Yeiser 2007, Schuler and others 2004). Competition control before planting and 1 year after planting have consistently shown increased survival to the degree that the added cost may be warranted. However, every application of herbicide (including labor) increases the cost by \$30 to \$50 an acre for a pre-emergent herbicide application and over \$200 for direct spraying of herbicide after the first year of growth. If the added tree vigor, often quoted as an attribute of genetically improved seedlings, allows for adequate survival without extra herbicide treatments, then the costs savings would justify the added costs of buying the improved oak seedlings.

MATERIAL AND METHODS

Initial dimensions of seedlings were assessed directly from the nursery grounds. Seedlings ($n = 400$) were sampled from Arkansas Forestry Commission cool storage at the Baucum Nursery in North Little Rock, AR. Four random bags were pulled from storage, and 100 seedlings from each were measured for root length, defined as root collar to the end of the tap root, and root collar diameter. Data were analyzed with a general linear model to assess differences between the two seedling types.

A random selection of 840 seedlings, 420 improved and 420 unimproved, were planted at two locations in south Arkansas. The first location was an old-field site near Hope, AR at the University of Arkansas Southwest Research and Extension Center, and the second was a recently cleared pine forest on the University of Arkansas-Monticello School Teaching and Research Forest near Monticello, AR. Both sites had site indices over 80 feet at 50 years for oaks.

Each site was divided into two blocks, and seedlings were planted at an 8- by 10-foot spacing. A border row of oaks was planted around the outside of the study. After planting, a random sample of 480 seedlings (220 per seedling type) was assessed for initial height and ground line diameter (gld). After leaf-out in late April, all seedlings were assessed for survival.

A general linear model was used to assess differences in height and gld among sites and seedling types. All factors were considered random for the analysis. Interaction terms among the variables were pooled into the error term since there was no biological interaction immediately following planting and before growth initiated. Survival differences were assessed using a general linear mixed model (PROC GLIMMIX; SAS[®]) with a specification of a binomial distribution logit link function. Potential interaction effects were included in this model since there was a potential biological interaction. Variable means were calculated using a least square means estimation for each significant random source effect.

RESULTS AND DISCUSSION

Rot collar diameter was significantly affected by seedling type ($p = 0.02$) when seedlings taken directly from cold storage were sampled. Improved seedlings were 27 percent greater in root collar diameter (fig. 1). Conversely, root length was statistically the same ($p = 0.98$) for both seedling types (21.8 inches) indicating effective and homogenous undercutting prior to seedling harvest.

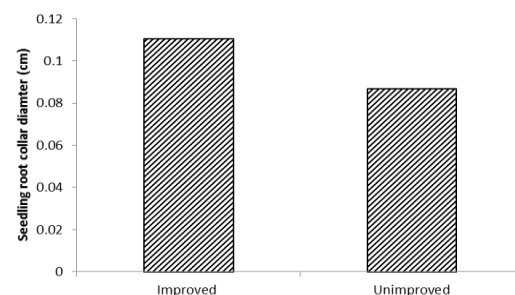


Figure 1—Average root collar diameters for random samples of improved and unimproved seedlings taken directly from the Baucum Nursery, North Little Rock, AR.

Planting height and gld were both significant and only affected by seedling type ($p < 0.001$ for both). The unimproved seedlings were 8 percent shorter in height than the improved seedlings (fig. 2a). While the difference is not as exaggerated as the root collar findings from the nursery or the height differences, the gld of unimproved seedlings was 9 percent less than

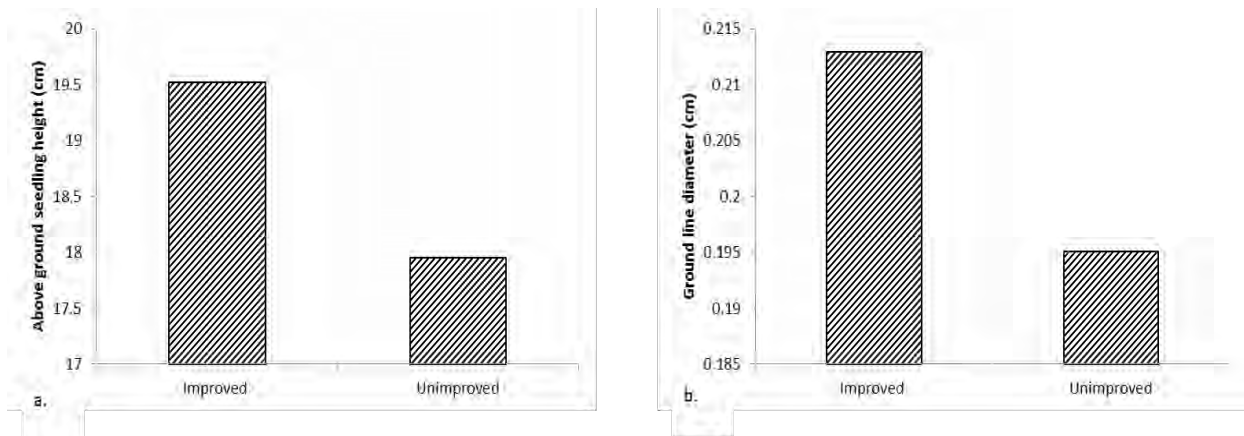


Figure 2—Significantly different ($\alpha = 0.05$) seedling type averages of (a) above ground height and (b) ground line diameter across two sites in southern Arkansas immediately after planting.

the improved seedlings (fig. 2b). Gld and root collar diameter would be expected to be very similar from random samples. The smaller differences and overall smaller widths measured at ground line diameters probably demonstrate that many of the seedlings were planted with root collars slightly below ground level.

Overall, seedlings that come from the improved seedling stock are inherently larger than their unimproved counterparts in both above-ground height and gld. This could have a great impact on future needs, and costs, of herbicide application or manual weeding of herbaceous competition. Greater initial height of the improved seedlings may allow them to overtop competing vegetation more quickly and avoid negative impacts to growth and development (Kolb and Steiner 1990, Lorimer and others 1994). Potentially, this could lead to a reduction in the number of herbicide applications needed during establishment and offsetting some of the higher costs of the improved seedlings.

These initial planted seedling measurements support results from the independent samples taken at the AFC storage area, where improved seedling root collar diameter was significantly larger by an average of 0.06 cm. However, this larger improved seedling does not seem to lead towards better survival immediately following leaf-out. In the survival analysis, seedling type also significantly affected ($p = 0.01$) the probability of survival. The improved seedlings were 6 percent less likely to survive to 3 months after planting with 85.8 percent surviving opposed to 91.5 percent for the unimproved seedlings. This is surprising as the improved

seedlings were quantitatively larger and their roots were visually more robust in lateral root size and length and larger in overall root biomass. Generally, more developed roots of 1-0 seedlings are associated with better survival (Thompson and Schultz 1995). In this study, the extreme horizontal root mass caused difficulties in planting. Planters were highly supervised and were aided by broad oak-style dibble bars. Still, many of the roots were so massive that proper orientation and protection of roots was marginal. Undercutting of the seedlings was conducted at the nursery regulating total length of the seedlings which has been shown in some cases to improve survivorship (Zaczek and others 1997). Still, no control of the width or mass of the roots is conducted which may pose problems with planting in normal field conditions.

In conclusion, the cherrybark oak genetic improvement efforts have produced larger seedlings than their woods-run counterparts. This potentially will alleviate costs of competition control because seedlings will have a chance to emerge from the understory more quickly with the initial head-start. At the same time survivorship was lower which is, in part, attributed to planting difficulties of large seedlings. Still, later data from this study, not yet published, is pointing toward a closure of the survivorship gap or better survival of the improved seedlings. Thus, these very initial results must be weighed with caution since the study is a long-term one.

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