Container Depth as it Influences Plains Cottonwood and Bur Oak Seedling Survival and Growth

Joseph Scianna¹ and Jim Jacobs²

Figure 1. Bur oak seedling grown in a 36-inch deep pot, Bridger, MT. 2012.

ABSTRACT

Plains cottonwood [Populus deltoides W. Bartram ex Marshall ssp. monilifera (Aiton) Eckenwalder] and bur oak (Quercus macrocarpa Michx.) have potential for several woody conservation planting applications because of their size, longevity, and value for windbreaks and wildlife habitat. Information on establishment and growth of these species in Montana and Wyoming is limited. The goal of this study was to compare establishment and growth of plains cottonwood and bur oak seedlings in experimental conservation plantings after they were cultured in 10-inch, 24-inch, and 36-inch deep pots. We hypothesized seedlings cultured in deeper pots will have greater establishment and growth than seedlings cultured in conventional 10-inch pots because longer roots can access deep soil moisture. We tested the hypothesis at the Bridger Plant Materials Center (MTPMC) using randomized complete block design studies, one for cottonwood and one for oak, with three replications each and 10 seedlings per pot depth level, for a total of 90 seedlings per species. The effect of pot depth treatment on survival was analyzed using multi-sample survival tests, and the effect on growth rates was analyzed using analysis of variance. Pot depth did not affect survival or height growth of either species. These results support culturing both plains cottonwood and bur oak in conventional 10-inch deep pots and following established conservation practice specifications for seedling establishment and protection.

¹ Joseph Scianna, PMC Manager, USDA-NRCS, Bridger, MT. ² Jim Jacobs, Plant Materials Specialist (retired), USDA-NRCS, Bozeman, MT
INTRODUCTION

Plains cottonwood and bur oak have important conservation applications on agricultural land, rangeland, and riparian forests where they provide wind protection, shade for livestock and wildlife, ameliorate soil erosion, and provide vertical strata, food, roosting, nesting, and cover for wildlife. Plains cottonwood is a fast growing, tall stature deciduous tree, whereas bur oak is a slow growing, long lived, short stature deciduous tree. Both species are used in windbreaks and shelterbelts, woody draw restoration, and wildlife plantings. Establishment along riparian corridors and in riparian forest buffers has been poor and variable depending on stock and container type. Survival and growth data for dryland establishment of these tree species for windbreak and shelterbelt systems is limited.

Preliminary research at Los Lunas, New Mexico Plant Materials Center supported a hypothesis that seedlings propagated in deep containers have longer root systems, higher survival and grow more rapidly in conservation plantings than seedlings propagated in shallow conventional pots (10 inches deep). In theory, deeper roots should improve access to sub-surface soil moisture over the course of the growing season.

The overall goal of this study was to improve the establishment of plains cottonwood and bur oak for conservation plantings on riparian and dryland sites by addressing planting stock and container size variables. This study compares seedling survival and growth rate after out-planting seedlings propagated in container depths of 10-inch, 24-inch, and 36-inch. Our hypotheses are that survival and growth rate will improve as pot depth increases. We base this on the assumption that seedlings with longer roots will have more water available from deep soil resources than seedlings with shorter roots.

MATERIALS AND METHODS

The experimental site was at the USDA-NRCS Bridger Plant Materials Center in Bridger, MT (45º17’12.7”, 108º53’9.7”) in a Heldt silt loam soil. The mean average precipitation is 11.5 inches per year. The study was maintained as a dryland site to provide guidance for conservation windbreak and shelterbelt plantings, and for riparian sites with a deepwater table.

The experimental layout had each pot depth treatment arranged as a randomized complete block design with three replications. There were ten seedlings per depth treatment for a total of 30 seedlings total of each species. Each of tree species were planted as separate experiments with no intention of comparing performance between species. Plains cottonwood seeds were wildland collected in Miles City, Montana in 2009, and bur oak seeds were collected in 2009 from the seed orchard at the MTPMC. Seeds were sown in early 2010 in a peat based potting mix, Sunshine #1® (Sun Gro Horticulture, Agawam, MA) in 7-cubic-inch Ray Leach cone-tainers® (Stuewe & Sons, Inc., Tangent, OR) in a greenhouse maintained for 16-hour photoperiods at 75 to 80°F (day) and 65 to 70°F (night) when they germinated. The seedlings were moved outdoors in late summer to a partially shaded area to harden off, and over-wintered in a coldframe maintained at approximately 35°F. In spring 2011, seedlings were transplanted into conventional D40 Deepots®, 2.5-inch by 10-inch deep containers (Stuewe & Sons Inc., Tangent, OR), 2.5-inch by 24-inch deep PVC (polyvinyl chloride) tubing, and 2.5-inch by 36-inch deep PVC tubing in Sunshine #1® potting mix (Figure 1). Seedlings were over-wintered a second year in a cold frame and planted in summer 2012.
Each seedling received five gallons of water at planting time and an additional three gallons approximately two weeks after planting. The entire test area was fenced from wildlife. Seedling survival was recorded in 2012, 2014, and 2015 for both species, and in 2017 for bur oak.
Seedling height was measured before planting and in fall of 2013 and 2014, and the spring of 2015 and 2016 for cottonwood, and in the spring of 2012, 2013, 2016, and 2017 for bur oak.

To test differences in survival of seedlings among pot depth treatments we used multi-sample survival tests (Statistix10, Tallahassee, FL), Gehan-Wilcoxon, Logrank, and Peto-Wilcoxon non-parametric tests comparing survival distributions. In these tests each seedling is the test subject grouped in one of the three pot depth populations. The chi-square is used to determine differences among the populations ($p<0.05$).

Growth rate for each seedling was calculated by subtracting the previous year’s height (cm) from the current year’s height (cm) to determine centimeters of growth per year. We calculated growth rates for cottonwood surviving seedling in 2012, 2013, 2014, and 2015, and bur oak growth rate as well as total height in 2013 and 2016. The mean growth rate of the surviving seedlings with positive height growth of each pot depth population ($N\leq 10$) was calculated for each replication, and the mean growth rates were analyzed by species in a split-plot in time analysis of variance with pot depth treatment as the whole-plot, year as the sub-plot, and the treatment by year interaction was tested. When the f-test resulted in a $p$-value less than 0.05, differences among means were tested using Tukey’s HSD at $p<0.05$.

**RESULTS AND DISCUSSION**

Results show that survival of plains cottonwood and bur oak were not affected by pot depth (i.e. length of their roots) at the time of planting. In 2012, only two plains cottonwood seedlings from the 36-inch pot treatment died. All bur oak seedlings survived the 2012 growing season. By the fall of 2014, five 10-inch pot cottonwood seedlings died, nine 24-inch pot cottonwood seedlings died, and six 36-inch pot cottonwood seedlings died. All the bur oak seedlings were alive in 2014.

By the fall of 2015, the 10-inch pot cottonwood seedling population had 80% survival (24 living seedlings), the 24-inch pot cottonwood seedling population had 70% survival (21 living seedlings), and the 36-inch pot cottonwood seedling population had 73% survival (22 living seedlings). The 10-inch pot bur oak population had 93% survival (28 living seedlings) the 24-inch pot population had 93% survival (28 living seedlings), and the 36-inch pot population had 100% survival (30 living seedlings). The $p$-values from the three survival analyses for cottonwood were 0.8580, 0.7219, and 0.5901 and for bur oak were 0.9946, 0.9802, and 0.2141 for the Gehan-Wilcoxon, Logrank, and Peto-Wilcoxon tests, respectively.

The growth rates for cottonwood ranged from a low of 14.6 centimeters per year (cm/year) for the 24-inch seedlings in 2012 to a high of 140.7 cm/year for the 36-inch seedlings in 2014 (Table 1). The analysis found no differences among treatments in any year ($p>0.5$). Averaged over all years, the growth rate of the 10-inch seedlings was 79.3 cm/year, the 24-inch seedlings was 75.2 cm/year, and the 36-inch seedlings was 85.3 cm/year. These rates were not significantly different ($p>0.4$). Averaged over all treatments, the growth rates in 2012 (21.0 cm/year) and 2013 (51.4 cm/year) were less than ($p<0.0001$) the growth rates in 2014 (123.3 cm/year) and 2015 (124.1 cm/year). The results show root length as determined by pot depth did not affect the height growth rate of the seedlings during a four-year establishment period.
Table 1. The average seedling height growth rates of plains cottonwood for pot depth treatments 10-, 24-, and 36-inches for the years 2012, 2013, 2014, and 2015, Bridger, MT.

<table>
<thead>
<tr>
<th>Pot Depth (inches)</th>
<th>Seedling Height Growth Rate (cm/year)</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td></td>
<td>30.7</td>
<td>49.3</td>
<td>113.4</td>
<td>123.6</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>14.6</td>
<td>50.2</td>
<td>115.8</td>
<td>119.7</td>
</tr>
<tr>
<td>36</td>
<td></td>
<td>17.5</td>
<td>54.3</td>
<td>140.7</td>
<td>128.8</td>
</tr>
</tbody>
</table>

Field notes from sampling bur oak suggest some plants suffered from stress and browsing, and some plants had a negative growth rate. The average growth rates for seedlings with positive growth from each pot depth treatment are shown in Table 2. The analysis found no pot depth treatment effect on the growth rate or total height of the bur oak seedlings.

Table 2. The average seedling height growth rates in 2013, 2016 and total seedling growth for bur oak seedlings grown in 10-inch, 24-inch and 36-inch containers before planting, Bridger MT.

<table>
<thead>
<tr>
<th>Pot Depth (inches)</th>
<th>Seedling Height Growth Rate (cm/year)</th>
<th>2013 (p&gt;0.4)</th>
<th>2016 (p&gt;0.4)</th>
<th>Total (p&gt;0.1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td></td>
<td>17.5</td>
<td>11.8</td>
<td>30.7</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>14.5</td>
<td>8.7</td>
<td>19.3</td>
</tr>
<tr>
<td>36</td>
<td></td>
<td>10.9</td>
<td>8.0</td>
<td>17.2</td>
</tr>
</tbody>
</table>

CONCLUSION

The results support using plains cottonwood or bur oak seedlings grown in 10-inch deep pots for dry-land conservation plantings, giving them supplemental water at planting, protecting them from browse, and controlling weeds according to conservation practice specifications.

We conclude that growing plains cottonwood or bur oak seedlings in pots deeper than the standard 10 inches does not give the seedling higher survival rates or greater height growth than seedlings grown in deeper pots (24- and 36-inch). These results are applicable where seedlings are planted as windbreaks or shelterbelts and given five gallons of supplemental water at planting, three gallons two weeks later, and weeds controlled, as was done in this experiment. Without this extra available soil moisture, seedlings with longer roots may have an advantage over seedlings with 10-inch roots.

We also conclude that seedling height growth rate of plains cottonwood will increase as much as two-fold, or more, two years after planting. We surmise seedlings allocate significantly more energy to root growth during the first two years after planting, regardless of their initial root length, than three or four years after planting.

We also believe protecting bur oak and plains cottonwood from herbivory and plant competition after planting is more important for seedling survival and growth than the pot size in which they are cultured.

Helping People Help the Land

USDA IS AN EQUAL OPPORTUNITY PROVIDER, EMPLOYER and LENDER