EVALUATING THE POTENTIAL OF BLACK WILLOW AS A VIABLE BIOMASS SPECIES FOR THE LMAV

R.J. Rousseau[1], **T.D. Leininger**, B.L. Herrin, and E.S. Gardiner

[1]Mississippi State University, Mississippi State, MS

Black willow (*Salix nigra* Marsh.) is commonly found on poorly drained sites that are unsuitable for most other hardwoods species in the lower Mississippi Alluvial Valley (LMAV). These sites are considered marginal for agriculture and forestry production, due to limited accessibility and frequent flooding. The ability of black willow to not only survive but grow well on these sites makes it a good candidate as a biomass species. In addition, other major advantages that black willow possesses are the ease of vegetative propagation using cuttings and the ability to regenerate a stand following harvest via coppice.

While there has been very little research activity into growing black willow in the southeastern United States, there has been considerable work on shrub willows since the 1980's at the State University of New York College of Environmental Science and Forestry (SUNY-ESF). As a result, over 20 organizations have formed a Salix Consortium to develop a willow biomass program for the northeastern United States. Unfortunately, the success of this program has not been adopted in other parts of the United States (Volk et. al 2004, Wright et.al 2000). This may be due in part to the inability of hybrid shrub willows to survive and grow in different environment types. In 2009, Mississippi State University and the U.S. Forest Service Center for Bottomland Hardwoods Research entered into a joint venture agreement to determine the feasibility of black willow as a biomass species. A primary objective of this venture is to determine growth rates and genetic variability within the southern population of black willow when grown on heavy clay soils.

MATERIALS AND METHODS

In the winter of 2008-09, we collected five geographic sources of black willow that included the Atchafalaya River, the Brazos River, the Trinity River, and two geographic areas along the Mississippi River. Four stands were located at each of the five geographic sources and from each stand a total of five to six one or two-year-old seedlings (i.e. whips) were collected and brought back to Mississippi State University for processing into nine-inch cuttings. Cuttings were stored until the spring of 2009 then planted on a 0.91 x 0.31 m spacing into a cutting orchard established in Stoneville, MS. Clonal material raised in the cutting orchard was used to establish a second cutting orchard in 2010, two clonal screening trials in 2010, and two clonal screening trials in 2011.

The clonal screening trials were located at Stoneville, MS and Prairie, MS in 2010, and Hollandale, MS and Prairie, MS in 2011. Each of the four screening trials per year were established with 38-cm unrooted cuttings that had a bottom diameter no larger than 2.5 cm and no smaller than 1.9 cm. Spacing at all four locations was 2.74 by 1.83 m. At each location, a nested design was employed using four blocks, with stands and clones nested within the respected geographic area. Each clone was represented by a two-tree row plot, thus eight ramets per clone were included in each screening trial.

In 2013, we established clone tests located at Stoneville, MS and Holly Springs, MS. The selected material included in these tests was the top 25 clones based on age-three volume performance in the 2010 Screening Trials. A clone test differs from a screening trial in that each clone is represented by a greater number of ramets per clone. Each clone test was arranged as a randomized complete block design consisting of 12 blocks and 25 to 30 clones, which was planted in two-tree row plots.

In 2013, we increased the test population with the inclusion of four geographic sources along the Mississippi River at Baton Rouge, LA, Fort Adams, MS, Vicksburg, MS, and Osceola, AR and another geographic source on the Red River near Shreveport, LA. Sampling protocols defined during the initial phase remained the same for this collection. A new cutting orchard using only material from the second collection was established in May 2013 on the Mississippi Agricultural and Forestry Station near Holly Springs, MS. This orchard will provide cuttings for future screening trials planned for establishment in 2014 and 2015.

RESULTS AND DISCUSSION

Initial collections and establishment of the cutting orchard went exceptionally well with excellent survival and growth. The 0.91 by 0.31 m spacing used in the cutting orchard proved to work very nicely and produced a high number of quality cuttings. Black willow form was quite different in the cutting orchard from the form observed in the 2009 Cutting Length Study, established by Mississippi State University, where the cuttings were planted at a 3.05 by 1.82 m. There the cuttings produced multiple shoots that expressed considerable sinuosity. However, the extremely high density of 35,864 stems/ha employed in the cutting orchard resulted in either a single or double stem having excellent straightness. The extraordinary rooting characteristics of black willow, even when taken from young native stands, resulted in a cutting orchard with very few missing individuals and high uniformity in the cutting orchard.

2010-2011 Black Willow Screening Trials

Since our biomass production rotation is currently aimed at three to five years, only information concerning the 2010 Black Willow Screening Trials will be presented at this time. Our goal is to select superior clones as early as possible because of the short rotation length however it is important to thoroughly evaluate seed source and clonal performance across sites and not to jump to conclusions that are inappropriate.

Survival of the 2010 Stoneville, MS test site averaged 90.4 %, 90.3 %, and 89.4 %, respectively at year one, two, and three. At the 2010 Prairie, MS test site survival averaged 99.7 %, 99.2 %, and 99.0 %, respectively at ages one, two, and three years. Although survival at both test sites was good, the lower age-one survival at the Stoneville site may be attributed to the combination of drought conditions and the heavy clay soils. Although the drought conditions at the Prairie and Stoneville sites were very similar, the lower clay content of the soils at the Prairie site allowed the black willow to extract the moisture needed to survive.

Plants differed in height between the two sites at age one with willow established at Stoneville averaging 18.3 cm shorter than those at the Prairie site. However, by age two this trend was reversed with plants established at the Stoneville site being 74.2 cm taller than the Prairie site. By age three this difference was much larger with the willow at Stoneville site averaging 259 cm taller than the willow at the Prairie site. The extreme difference in soil pH and texture as well as more normal precipitation are factors that likely affected height growth at the two sites. Soil pH at the Prairie site averaged 4.6 while pH at the Stoneville site was much more basic averaging about 7.2. Since black willow is adapted to more neutral to basic soil pH, we would expect it to perform better at Stoneville site. Indeed it did when more normal precipitation returned during ages two and three. While source differences for height were significant at all ages at both sites, we did not observe a strong clinal trend especially as age increased. In fact, we observed only minor differences among sources at each site. At the Stoneville site, the height difference at age three between the tallest source (Brazos River) and the shortest source (Trinity River) was 109 cm. At the Prairie site the tallest source (Atchafalaya River) and the shortest source (Brazos source) showed a height difference of 42.7 cm. As an illustration of the substantial site by source interaction, the Trinity River source grew the tallest at the Prairie site, but was the shortest at the Stoneville site.

The greatest variation in growth was noted among clones within sources. This can be seen in the age-three volume index (D^2H) scores at the Stoneville test site. At this site volume index ranged from 187.92 m^3 for a clone originating from the Tunica source to 22.77 m^3 for a clone originating from the Trinity River source. The top five percent of the test population showed clonal volume index scores that ranged from 187.92 to 145.01 m^3. These five clones originated from three sources, Tunica, MS, the Brazos River, and the Atchafalaya River. In terms of selection efficiency, early–age selection using age-one height to predict age-three volume was rather disappointing but not unexpected. Based on these results we selected the top 25 performing clones and established our first highly replicated clone test in 2013 on two sites in Mississippi.

CONCLUSION

The initial steps in our Black Willow Tree Improvement Program have been taken with a limited population sampling scheme and multiple screening trials established on sites in Mississippi. Early results indicate good gains can be made through the first stage selection. Increased intensity of clonal testing and selection should provide estimates of genetic gain leading to the production of genetically superior black willow clones that can be deployed for growing biomass on marginal agricultural sites.

LITERATURE CITED

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