Increasing the Growth of Black Willow as a Biomass Crop through Genetic Testing

MISSISSIPPI STATE UNIVERSITY EXTENSION

As the United States moves to increase its production of renewable energy, biomass has become more important, especially in the Southeast. Fast-growth tree species, including poplars and willows, have been included with energy crops, such as switchgrass, miscanthus, and energy cane.

Like any crop, trees, especially hardwood trees such as black willow, grow best when matched with the right soils. It is important to remember that the production of biomass must be sustainable. It should also require few inputs, such as fertilizer or irrigation.

Unlike annual crops and poplars, black willows grow well on soils that remain wet for long periods during the year. While wet sites are not ideal for agricultural crops, they are perfect for growing black willow biomass. In other words, growing black willows does not remove land from food production, but rather uses land that would probably be unprofitable otherwise.

In cooperation with the USDA Forest Service Center for Bottomland Hardwoods Research, Mississippi State University has been exploring whether black willows could be used as a source of biomass. In the past, black willows have not been a sought-after species. As a result, there is not much research on the species in the southern United States. However, the species has several key traits that make it a good biomass candidate.

For example, black willows grow rapidly, root well, propagate and coppice easily, and grow well on wet sites. Research on willows in the northeastern and north-central United States began in the late 1980s. Those studies focused on shrub willows, many of which are suited to much colder environments than ours in Mississippi (Kopp et al., 2001).

Willows represent a viable model for the northeastern and north-central United States because the disease *Septoria* canker has severely limited the use of hybrid poplars. *Septoria* is also present in the Lower Mississippi Alluvial Valley, which includes the alluvial soils found from the junction of the Mississippi and Ohio Rivers to the Gulf of Mexico. It has killed many hybrid poplars. Eastern cottonwoods are resistant to the disease but do not grow well on wet sites. By contrast, black willows thrive on wet sites. Today, no disease is known that would impact the use of black willows.

This publication is designed to give landowners and others interested in growing biomass for bioenergy a first look at the current black willow research being done by the MSU Forestry Department and the USDA Forest Service Center for Bottomland Hardwoods Research.

Testing Planting Stock

In 2009, a test was established on the Mississippi Agricultural and Forestry Experiment Station (MAFES) site near Stoneville to examine certain characteristics of black willows. Specifically, scientists wanted to know how black willow's growth was affected by cutting length, cutting diameter, and depth of planting. They used dormant, unrooted planting stock for the tests. They were looking for the best cutting size for black willow regeneration.

Cutting length was set at 9, 15, and 21 inches. Cutting diameter was set at ⅜, ½, ¾, and 1 inch. The depth of planting was measured by the length of the cutting left out of the ground. The 9-inch cuttings were planted to a depth of 4 and 7 inches; the 15-inch cuttings were planted to a depth of 7, 10, and 13 inches; and the 21-inch cuttings were planted to a depth of 13, 16, and 19 inches.

Cutting diameter, length, and depth of planting did not have a significant effect on survival. In fact, only two cuttings died during year 1, resulting in a 99.6 percent survival for the entire study. This high survival rate

Figure 1. Age-1 black willow in the 2009 cutting length study near Stoneville during the growing season (left) and the dormant season (right).

shows black willow's excellent rooting characteristics. When the trees were measured after 1 year, researchers saw these trends:

- The longer the cutting, the taller the tree at age 1.
- The diameter of the cuttings and depth of planting did not affect height at age 1.

The 15-inch cuttings were 0.3 foot taller than the 9-inch cuttings at age 1. The 21-inch cuttings were 0.7 foot taller than the 15-inch cuttings at age 1 (**Figure 1**). Planting shorter cuttings will reduce age-1 height by about 1 foot. This difference might seem small, but if you plant a large number of trees and harvest them when they are 1 to 3 years old, the difference will add up.

Testing Black Willow Rooting

Researchers examined rooting characteristics, as well. They wanted to track the growth of root systems in relationship to bud break. Dormant, unrooted black willow cuttings break bud soon after planting in the early spring (**Figure 2**). Early bud break could be a problem if those cuttings took a long time to produce roots. However, because black willows root so quickly, the trees have excellent survival rates. This trait is very important because trees grown for biomass production may number thousands per acre. The rooting characteristics shown in **Figure 2** are typical of dormant unrooted cuttings of black willows.

Testing Genetic Material

The ability to begin testing at the clonal level is definitely an advantage. Being able to easily produce genetically identical trees from a limb or stem portions allows researchers the ability to capture the total genetic component. Black willows can be cloned from the main stem, known as a whip, from 1- to 2-year-old trees. The whip then can be cut into pieces, known as cuttings, and used for regeneration.

In the first phase of the program, researchers collected dormant black willow whips from the five different geographic areas shown in **Table 1**. Each geographic area included four stands, with each stand separated by at least 1 mile. Researchers collected five trees from each of the four stands and cut the trees into segments for cuttings. Thus, researchers collected 20 clones from each geographic area, for a total of 100 clones. To provide more uniform material,

Figure 2. Bud break of a dormant unrooted cutting of black willow 10 days after planting (left). Typical rooting characteristics of a dormant unrooted black willow cutting, 3 weeks after planting (right).

Table 1. Geographic areas, river systems, and coordinates of the black willow cutting collection program of MSU and the USDA Forest Service Center for Bottomland Hardwoods Research.

Geographic area	River system	Latitude and longitude
Tunica, MS	Mississippi	34°50′N 90°16′W
Rosedale, MS	Mississippi	32°48′N 91°03′W
Morgan City, LA	Atchafalaya	29°41′N 91°12′W
College Station, TX	Brazos	30°37′N 96°32′W
Liberty, TX	Trinity	30°03′N 94°49′W

these cuttings were placed into a nursery setting called a stool-bed for 1 year. The harvest of these whips from the stool-bed provided the cuttings needed to test each of the 100 clones. The cuttings were then graded for uniformity and planted at two MAFES sites near Stoneville and Prairie in 2010. Another two test sites were planted in 2011, with one near Hollandale and the other again near Prairie.

Based on height and diameter performance of these tests, 25 of the best-growing clones were selected and planted at the MAFES site near the MSU campus. This test differs from the others in that the number of replications is much greater, which provides a more thorough understanding of the selected 25 clones.

This test was also duplicated in 2013 and 2014 to provide information on year-to-year differences as well as environmental differences among the top 25 black willow clones selected from the 2010 and 2011 trials. In 2016, the required data from the 2013 and 2014 tests will be in hand to define the very best of the 25 clones that can be released for bioenergy plantings.

The latest results based on 2018 measurements indicate that three specific clones performed the best. Two of the three clones originated from the Brazos River collection while the third clone was from the Atchafalaya River collection.

The second phase of testing included a total of 141 new clones from four sites along the Mississippi River: Plaquemine, LA to Osceola, AR, as well as one collection from the Red River near Shreveport, LA. The first round of selections has been completed and the final round of testing of the best clones from these 141 clones began in 2017. To date, the best clones from this second collection originated from the Vicksburg, MS portion. The final step will be to include the top performing clones from the first and second phase into a growth and yield trial to determine the best genetically superior black willow biomass clones.

Conclusion

Black willow may become a significant biomass species. It has many promising characteristics: rapid growth and production of vegetation, excellent rooting, ease of coppice, and ability to grow on sites unsuitable for most agricultural crops and forest tree species. Although no genetically superior black willow is currently available, research is well under way to provide superior planting stock within the next few years.

The research efforts by the MSU Forestry Department and the USDA Forest Service Center for Bottomland Hardwoods Research will continue to provide both silvicultural and genetic information on black willow as a dedicated biomass source for biofuel and bioenergy production.

Resources

Kopp, R.F., L.B. Smart, C.A. Maynard, J.G. Isebrands, G.A. Tuskan, & L.P. Abrahamson. 2001. The development of improved willow clones for eastern North America. *The Forestry Chronicle, 77*(2): 287–292.

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