

GENETIC IMPROVEMENT OF SHRUB WILLOW (*SALIX*) CROPS FOR BIOENERGY AND ENVIRONMENTAL APPLICATIONS

Lawrence B. Smart¹, Juan Lin, Richard F. Kopp, Ingrid S. Phillips, Kimberly D. Cameron, Timothy A. Volk, Edwin H. White, Lawrence P. Abrahamson

The domestication and development of fast-growing perennial plants as dedicated energy crops can provide a long-term, sustainable replacement for fossil fuels. Shrub willows, grown as short-rotation woody crops, have outstanding potential to serve as a dedicated and custom-tailored feedstock for the production of bioenergy, biofuels, and bioproducts. Despite numerous positive environmental benefits and potential to stimulate rural development, shrub willow crops have not yet been widely adopted in the United States due to their cost of production. Our objective is to demonstrate that improved shrub willow varieties can reliably produce high yields across a range of sites and can support a viable commercial enterprise in the Northeast and Midwest United States.

The goals of this project are to reduce the cost of willow biomass by developing varieties with consistently greater yields and to identify varieties with optimal wood chemistry for low-input pretreatment, fractionation, and conversion in the biorefinery. Toward this end, we have established and are maintaining the largest willow breeding program in North America. This includes assembling a nursery of diverse clones collected from natural sites across the Northeast and Midwest United States. Collaborators in China, Japan, Canada, Ukraine, and Sweden have also contributed bred and native accessions to our collection. We are using amplified fragment length polymorphism (AFLP) markers and microsatellites to fingerprint the clones in our collection and to characterize the diversity of populations of *S. purpurea* and *S. eriocephala* in New York State.

One focus of our breeding program is *S. eriocephala*, which is native to the eastern United States. Initial microsatellite analysis suggests that natural populations are highly diverse. Measurements of replicated genetics trials have yielded estimates of heritability that are low to moderate for traits important for biomass production. Family means of F1 progeny are mostly greater than midpoint parental means. Greenhouse- and field-based studies of second generation progeny indicate that there is no significant impact of inbreeding depression. Taken together, these results suggest that regular, incremental improvements in the yield of *S. eriocephala* can be realized through controlled breeding and selection.

Short-term gains have been achieved through species hybridization, which is possible among many shrub willow species. Hybrids of *S. miyabeana* with *S. sachalinensis*, *S. purpurea*, and *S. viminalis* have yielded progeny with growth that is ~150% of that of a standard clone of *S. dasyclados* (SV1) in replicated selection trials. Intraspecific hybrids of *S. purpurea* are also showing dramatic improvements over parental means. Since a 20% increase in the yield of willow biomass crops decreases the delivered cost of biomass by 13%, our near term successes will enhance the economic viability of the system. Additional gains in yield, coupled with improved harvesting efficiency achieved through multidisciplinary research over the long term will assure widespread adoption of willow crops in the United States.

Keywords

biomass, breeding, molecular markers, *Salix eriocephala*, *Salix purpurea*, willow

¹ Department of Environmental and Forest Biology and Department of Forest and Natural Resources Management, SUNY College of Environmental Science and Forestry, Syracuse, NY 13210, USA. E-mail: lbsmart@esf.edu