GROWING AND HARVESTING WILLOW FOR BIOMASS ENERGY: FIELD RESEARCH INTO METHODS, BENEFITS AND COSTS FOR FARMERS

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Larry Abrahamson has worked in upstate New York for many years developing commercial willow production. His research is with the SUNY College of Environmental Science and Forestry. He sees willow as a promising crop for several reasons:

- *High Biomass Potential*: Willow yields more biomass per acre than any hardwood.
- *Potential for Genetic Improvement*: A short (yearly) breeding cycle facilitates breeding work. Very little has been done with genetic improvements in the past, so there may be significant gains available for the future.
- *Easily Established*: Willow can be raised from unrooted cuttings. Growers can harvest willow six or seven times (with 3-4 years between harvests) before replanting.
- *Coppiced*: Willows resprout vigorously after cutting.
- *Sustainable Agriculture*: Willows require significantly fewer pesticides than other common crops. They rapidly establish extensive root systems that remain in place through several harvest cycles (20-25 years before clearing the land again) and mitigate erosion. Microarthropod diversity in the soil reaches close to undisturbed conditions four years after planting.

The willow-raising cycle begins with unrooted cuttings planted two feet apart in double rows separated by five feet. This first year is the only time when weed control is a problem. At the end of the year, he cuts back the willow so that multiple stems return the second year. After three to four years of growing time Larry harvests in the winter and fertilizes with nitrogen following the harvest. He collects 5 dry tons per acre.

Larry's research into willow began with electric utilities that were concerned about finding alternative energy sources. One of his oldest clone trial sites grows outside of Burlington. The energy economics for willow work out much better than many other sources. 1 Joule energy input yields 11-16 Joules as useable energy output. For comparison, the best conversion achieved for corn-based ethanol has been 1 Joule to 1.67 Joules. Natural gas is a negative equation with 1

Joule yielding 0.4 Joules. Furthermore, unlike natural gas, willow is carbon neutral; the carbon released as carbon dioxide during willow combustion came from carbon within our environment, not from carbon sequestered in fossil fuels.

Potential markets for willow bioenergy include:

- Co-firing with Coal (the first market Larry investigated)
- Gasification (converting the biomass to a gas then combusting the gas)
- Combined heat and power systems
- Biorefinery for ethanol production along with bioplastics. Larry is attempting to establish a pilot biorefinery at an IP pulp mill.

Potential marketable bioproducts include:

- Bio-based chemicals
- Biofuels and Biodiesel
- Biodegradable thermoplastic polyesters
- Composite materials
- Thermoset polymers
- Adhesives
- Sulfur-free lignin

In addition to selling bioenergy and bioproducts, Larry estimates a host of other community-based benefits from willow production:

- *Sustainable Agriculture* See earlier list.
- *Bird Diversity*: Willows provide an excellent shrub community habitat between field and forest.
- *Riparian Buffer Strips*: Willow works particularly well because it starts its growing season, and therefore its nutrient demands, in early spring.
- *Living Snow Fences*
- *Bioremediation/ Brownfield Redevelopment*: Microorganisms in willow roots break down hydrocarbons.
- *Rural Development*: Larry calculates that 10,000 willow acres support 75 jobs.

One uncertainty with bioenergy from willow crop is the financial return. Farmers need to collect $28/ green ton to make their investment ($600-$700 per acre) worthwhile. This payment would be equivalent to $3.00/ BTU. By contrast coal is $1.50-$2.00/ BTU (and has gone as low as $1.00/BTU). Larry suggests several ways to increase willow returns:

- *Increase Yield*. Raising yields by 18% would make possible a 13% decrease in delivered cost.
- *Genetic Improvement through Breeding*.
- *Better Harvesting Efficiency* – New Holland and Coppice Resources Ltd. have developed a new system through simple modifications to corn harvesting equipment that may already resolve this problem.
- *Biorefineries*. A refinery could take sugars from willow for energy production and still leave product to use for paper.
- *Incentives:* Allow tax credits along with willow harvesting on CRP lands. These incentives would tip the scales quickly in balance for willow.

More information on Larry's project is available online at: http://www.esf.edu/willow