Genetic Improvement of Shrub Willow as a Bioenergy Crop

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New York State Energy Facts - 2005

• Of New York’s primary energy consumption by Btu:
  - 77% petroleum, natural gas, coal
  - 10% nuclear power
  - 5% hydro
  - 3% bioenergy (wood residues and municipal waste)
  - 5% imported electricity
  . . . costing $2,984 and releasing 12.5 tons of CO₂ per person

• Only 10% of that was supplied by in-state sources

• 90% of petroleum used in NY is from foreign sources
Annual Ethanol Production in the U.S.

Data source: Renewable Fuels Association (http://www.ethanolrfa.org/)
Annual Ethanol Production in the U.S.
“20 in 10” = 20% of petroleum replaced by 2017

Data source: Renewable Fuels Association (http://www.ethanolrfa.org/)
Perennial Energy Crops Will be Grown on 55 M acres by 2030 - to replace 30% of U.S. petroleum consumption

Regional Perennial Energy Crops

Willow Shrubs

Switchgrass
Source: U.S. DOE

Hybrid Poplar
The center of the basket willow industry (ca. 1892) is now a center for growth of shrub willow energy crops.

Harvest of willow stems for basketry
Photo: Liverpool Willow Museum

Harvesting wood chips using a New Holland forage harvester and specialized head.
Genetic Improvement of Shrub Willow as a Bioenergy Crop

Intro to short-rotation willow culture

Breeding and selection for high yield
- *Establish a diverse willow collection*
- *Controlled pollination & hybridization*
- *Selection and field testing for yield*
- *Tech transfer and commercialization*
Willow Biomass Production Cycle

Site preparation

Planting

First-year growth
Willow Biomass Production Cycle

- Site preparation
- Planting
- First-year growth
- Winter Coppice
- Regrowth after coppice
- Three years old after coppice
- One year old after coppice
Willow Biomass Production Cycle

- Winter harvest
- At least 7 harvests
- Three years old after coppice
- One year old after coppice
- Regrowth after coppice
Heat/Power from Willow Wood Chips

- Burn in wood-fired heat/power plants
- Co-fire with coal in existing power plants
- Gasify to generate heat and power

Wood-fired boiler at Lyonsdale Biomass, Lyons Falls, NY
Willow Energy Crops Provide CO₂ Benefits

100% Carbon Closure
(Assumes 0.25 t/ha-yr increase in soil carbon)

Net CO₂ Emissions: 0%

Feedstock Production (62%)
Transportation (12%)
Power Plant Construction (26%)

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Breeding is Likely to Improve Productivity of Willows

A 20% increase in yield reduces cost by 13%

- High genetic diversity
- Little domestication
- Short generation time
- Clonal propagation
- Many species can hybridize
Generalized Willow Breeding Strategy

Breeding Population
- Many clones of 10-15 species

Molecular Techniques
- ongoing
- Nursery screening
- Select parents for breeding

Family Screening Trial
- Many crosses; Single-plant plots
- 2-3 years
- Select, propagate

Selection Trial
- Replicated, multi-plant plots
- 2-4 years
- Select

Yield Trials
More than 600 Accessions Collected: 1994 - 2006

- *S. eriocephala*
- *S. nigra*
- *S. purpurea*
- other *Salix* spp.

Also . . .
Since 1998, more than 600 crosses attempted

- 26 families of *S. purpurea*
- 101 families of *S. eriocephala*
- 91 other families, mainly *S. sachalinensis*, *S. miyabeana*
1999 Family Screening Trial - Syracuse

Two years post-coppice measurements
2002 Genetic Selection Trial
First year post-coppice measurements
Four-plant plots; eight reps; Tully, NY
2002 Genetic Selection Trial
Biomass harvest - Two years post-coppice

• 15 varieties with greater yield than ‘SV1’
• top variety had 40% greater yield than ‘SV1’

- 2006: 1 year post-coppice, Belleville, NY
- 78 plants per plot
- 4 replicate blocks
- 18-30 varieties
- double-row spacing
- hand planted/harvested

★ Tully (2005)
Yield Trials Planted on 12 Sites

- Edmonton, AB (2006)
- Saskatoon, SK (2007)
- Montréal, QC (2007)
- Escanaba, MI (2007)
- Middlebury, VT (2007)
- Waseca, MN (2006)

Also in 2007:
- Loughgall, N. Ireland (2007)

http://sis.agr.gc.ca/cansis/nsdb/climate/hardiness/
Establishing a Commercial Willow Nursery in New York

Double A Vineyards dba Double A Willow (Fredonia, NY) will produce and sell whips for commercial scale-up

Nursery beds doubled each of last three years to >300,000 plants in 2007

(www.doubleawillow.com)
**Summary**

- Shrub willow is a viable perennial bioenergy crop with established systems for planting, harvesting, transport, and use of willow biomass.

- New varieties produced through traditional breeding generate higher yields than existing varieties.

- Trials have been planted on 12 sites to estimate regional yield potentials.

- New willow bioenergy crop varieties are being deployed commercially in the U.S.
Collaborators and Funding

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Dr. Kim Cameron  
Research Scientist

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