

Genetic Potential of Loblolly Pine for Hydrolytic Conversion to Ethanol

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The development of alternative fuels can help to alleviate environmental issues such as air pollution and can reduce the dependency on fossil fuels. Ethanol is one such alternative fuel, and it can be made from a variety of feedstocks including woody plant matter (i.e., lignocellulosic biomass). To date, corn has been the main feedstock supplying production facilities, but it is not an ideal resource for fuel production because of its status as an important food crop. Woody plant matter is a viable alternative as it is widely available and is not a staple food.

As the most productive tree species in the southern US, loblolly pine (*Pinus taeda* L.) has great potential as a feedstock species for ethanol production, but production of ethanol from loblolly pine wood is challenging. Many different chemical and physical wood properties are genetically controlled traits, and variation in properties affecting ethanol production may exist. Currently, 23 clonal varieties of loblolly pine, selected for a diverse range of chemical/wood properties, are being converted into ethanol via enzymatic hydrolysis. Preliminary results are encouraging. The best clone out of ten already tested with a dilute acid pretreatment yielded almost 13% more sugar per gram than the average. These sugars once released can be fermented to create ethanol. This variation in sugar yields among pine varieties suggests there are significant genetic differences that can be used to improve conversion to ethanol.

Keywords: loblolly pine, biomass, biofuels, tree genetics, cellulosic ethanol, enzymatic hydrolysis

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Subject Area: 3. End Use Applications

Varietal Susceptibility of Shrub Willows Bred in Sweden and United Kingdom to Potato Leafhopper and Other Pests in the Northeastern United States

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Breeding programs in Sweden and United Kingdom (UK) have produced fast growing varieties of shrub willow largely utilizing *Salix viminalis* and *S. schwerinii* that are commercially available to growers across Europe. Thirteen varieties from Europe were planted in replicated 32-plant plots in Tully, NY in June, 2007. Seven more varieties from Sweden were imported and planted in nursery beds in Geneva, NY in 2009. The 2007 Tully yield trial also included 16 varieties bred or collected in North America. Periodically during the 2007 through 2010 growing seasons, surveys were performed to assess damage from potato leafhopper (*Empoasca fabae* Harris) and other pests. Based on establishment year measurements of aboveground biomass and first-year post-coppice height and stem diameter measurements, growth of many of the European varieties in the 2007 trial was severely stunted due to their susceptibility to potato leafhopper. Many Swedish varieties in nursery beds also displayed susceptibility to potato leafhopper. The feeding activity of this sucking insect leads to “hopperburn”, observable as curling and yellowing of the young leaves and diminished shoot growth, which ultimately causes decreased yield. Four of the 13 European varieties in the 2007 yield trial were notably less susceptible to potato leafhopper, as reflected in the lack of hopperburn symptoms and in their stem growth comparable to the reference variety, *S. sachalinensis* ‘SX61’. The best UK variety, *S. viminalis* x *S. cordata* ‘LA970253’ had mean stem area 44% greater than ‘SX61’. Three of the seven new Swedish varieties, ‘Gudrun’, ‘Nora’ and ‘Doris’, all *S. burjatica* hybrids, displayed noticeable susceptibility to two-spotted spider mite (*Tetranychus urticae* Koch), but little damage from potato leafhopper in nursery beds. Additional field trial assessments of these varieties will be required to determine their yield potential in regions of North America with differing pest pressures.

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Keywords: breeding, *Empoasca fabae*, insects, *Salix viminalis*

Preferred topic area:

1. Production Systems and Operations

Diversity of Pathogenic Fungi Affecting Shrub Willows (*Salix* spp.) Grown in Short Rotation Biomass Plantations in New York State

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Native and naturalized willows (*Salix* spp.) in forests and landscapes of the northeast United States are hosts for numerous phytopathogenic fungi. However to date, there is limited information on the occurrence of foliar- or stem-infecting fungi on shrub willows (subgenus *Vetrix*) grown in short rotation coppice (SRC) plantations. A preliminary survey, therefore, was conducted to identify fungal taxa causing disease on commercially important willow varieties and hybrids at SRC plantations in Belleville, Constableville, Fredonia, and Tully, New York. In 2008-2009, samples were collected from diseased tissue(s) on 2-3 year-old stems at each of the sites, and taken to the laboratory for microscopic examination and isolation and identification of the causal organism(s). Fifteen (n=15) fungal taxa were found causing disease on the aboveground parts of shrub willows. Leaf rust, caused by *Melampsora* spp., was the most common disease affecting *S. eriocephala*, *S. purpurea*, *S. miyabeana*, and the hybrids *S. purpurea* x *S. integra*, and *S. viminalis* x *S. miyabeana*. The scab fungus (causal organism: *Venturia saliciperda*) also was found infecting the leaves and petioles of several willows – *S. eriocephala*, *S. miyabeana*, and *S. purpurea* – and frequently caused significant damage to the apical portions of branches and twigs. Cercospora leaf spot (*Cercospora salicina*) and willow leaf blister (*Taphrina* spp.) were identified on *S. viminalis* x *S. miyabeana*; however, the incidence of these diseases was limited. Diseases recorded on the main stem or branches included: Botryosphaeria canker (*Botryosphaeria dothidea* and related anamorphs), black canker (*Glomerella miyabeana*), Cytospora twig blight (*Cytospora* spp.), and Leucostoma canker (*Leucostoma niveum*). The black canker fungus (*G. miyabeana*) and *Cytospora* spp. initiated twig blights on *S. purpurea* and *S. viminalis* x *S. miyabeana*, respectively. The aim of future work will be to further identify pathogenic fungi on willows destined for commercial deployment and evaluate their yield reducing potential.

Keywords: willow, disease, *Melampsora*, *Salix*, pathogens

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Subject area: Production Systems and Operations

Comparison about different species in SWRC in Spain.

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In this paper we study and compare the different energy crops in SRWC in Spain in the last ten years. We locate main intensive plantations of poplar, eucalyptus and paulownia in Spain.

We present the results obtained in the laboratory for biomass characterization of these species. We studied six species of poplar, two species of eucalyptus and four species of paulownia. The variables studied were: density, moisture and heating value.

We compared also other variables: water requirements, adaptation to dry climates, systems and harvesting costs, adaptation to waterlogged soils and silviculture.

Keywords: *Paulownia, Populus, Eucalyptus*, Spain

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Subject Area: P1.Production Systems and Operations.

Evaluation of *Salix* spp. genotypes from European, Swedish and American breeding programmes

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In early 2007 a small number of cuttings, of a range of *Salix* spp. genotypes were exchanged between the Agri-Food and Biosciences Institute in Northern Ireland, UK and the State University of New York, Syracuse, USA. Care was taken to ensure compliance with relevant plant health regulations and the protection of breeding material. A trial was planted at the Northern Ireland Horticulture and Plant Breeding Station, Loughgall, comprising thirty-nine genotypes which came from America (16), and Europe / Sweden (23). The trial was planted in spring 2007 in four fully randomised blocks. Each genotype plot comprised a single / double / single row with each row containing nine plants. The plantation was cut back at the end of its establishment in December 2007. In December 2009 the number of shoots per stool was recorded and each stool was harvested and weighed individually. With the exception of European genotypes Nimrod and Endurance and the US genotype S25, survival was over 90%. Survival of Endurance was less than 60%, which was a reflection of poor establishment, possibly due to poor planting material. At this first two-year harvest, in general, the genotypes from the US did not perform as well as the other genotypes. There was a significant variation between the number of stems produced per stool. Stools of Allegany, SQ83, 77082 and ORM all had more than seven stems, while SX64 had less than three. The number of stems may be a critical selection criterion, as a large number of very small thin stems often does not give an adequate yield, whilst large thick stems will present problems for the harvester. The genotype giving the highest yield per stool was LA970253, which is a numbered genotype from the European programme and the highest yield per plot was Tora, which is a commercial Swedish genotype. However this did not differ significantly from LA970253 or LA980451, both of which are new numbered genotypes from the European breeding programme or Otisco, which was the only US genotype that compared favourable with the European or Swedish genotypes.

A parallel trial incorporating a similar set of genotypes was planted at Tully, NY, USA, although for regulatory reason the trial was not fully randomised. Of the 13 genotypes received in the US only four were not damaged excessively by potato leaf hopper (*Empoasca fabae*), a common pest in North America which causes stunting of shoot growth and leaf curling. Those four were: Nimrod; Terra Nova, LA970253, and LA980451. The entire trial was cut back again in winter 08-09 to make cuttings after the quarantine was lifted and these four genotypes have been planted in a 10 variety yield trial at Cornell University in Geneva, NY.

Keywords: *Salix*, genotype evaluation

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Subject Area: Production Systems and Operations

The economics of SRC willow and hybrid poplar afforestation biomass production for bioenergy in Ontario, inclusive and exclusive of carbon values

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Bioenergy forest plantations are generally considered a carbon-neutral source of clean energy for industrial, domestic and heating purposes. However, while the possible role of biomass-based fuels as an alternative energy source is well recognized, better quantifying the economics of the bioenergy plantations and understanding key biophysical and economic drivers of their regional variation remains an important issue for government and private sector investors in Canada. Our work in collaboration with practitioners from different parts of Canada examines biomass production from short rotation coppice woody crops and high-yield afforestation established specifically for the purposes of bioenergy production in Canadian conditions. Our assessments include regional variation of growth rates due to climatic suitability and heterogeneity of local site conditions. We present what we call “current expectations” and “aspirational targets” that reflect features such as increased growth rates and lower costs, both of which could come from technological change. Included in our results are scenarios that map out carbon price conditions that may be required to make this kind of biomass production more economically attractive.

Keywords: short rotation coppice, high-yield afforestation, hybrid poplar, hybrid willow, economics, carbon sequestration

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Subject Area: 1. Production Systems and Operations

***Paulownia* spp. as SRWC in Spain.**

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In this paper we study the paulownia Short Rotation Woody Crops in Spain. Firstly, we indicate main plantations of paulownia in Spain and their characteristics. In addition, we studied some physical and chemical characteristics of the biomass (wood and bark) for the energetic characterization of the paulownia biomass. We estimate, density, moisture and heating value according to standard UNE 164 001 in Biofuels Laboratory Rodolfo Carretero (Escuela Técnica Superior de Ingenieros de Montes, Madrid). Chemical composition of biomass (%) on dry weight were determined in The Liquid Biofuels Division of CIEMAT in Madrid.

Main conclusions of this study were:

- 1.-The productivity of paulownia's SRWC in Spain was considerably high, ranging from 36 – 38,5 odt·ha⁻¹·year⁻¹.
- 2.-The density of paulownia's wood ranged from 0,240 – 0.319 kg dm⁻³. These values are lower than the average density of poplar or pine
- 3.-The Heating Value is according to other bioenergetics species. Our results provided similar values than the *Salicaceae* and lower values than the conifers.
- 4.-The residues generated after combustion were low.
- 5.-The cellulose content was considerably high (40.2 % in dry weight). This result encourages the application of this specie for the production of bioethanol.

Keywords: *Paulownia*, SRWC, Spain

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Subject Area: P1.Production Systems and Operations.

An approximation of fixed CO₂ in poplar Short Rotation Woody Crops in West Central Spain.

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In this study we estimate biomass production and carbon dioxide fixation in a *Populus x euramericana* I-214 Short Rotation Woody Crop (SRWC). An experimental plantation was located in Cabrerizos (Salamanca) in the northwest of Spain. Poplars spacing was 0,33 m x 0,9 m and the rotation was 10 years (2+2+2+2+2). To estimate biomass, 250 trees were selected and felled down. For each tree, the diameter at 1,30 m (diameter at breast height, dbh), 3 m and 4,5 m and total height were measured. These measurements were used to build an allometric equation ($V(\text{dm}^3) = 0,388 + 0,038 \cdot D^2 \cdot H$) by regression analysis to estimate the volume of the poplar trees. In addition, wood samples were prepared to calculate some wood energetic parameters, i.e. density, moisture, heating value, % of residues. The estimation of the volume from regression analysis and the density led us to calculate the production of biomass in the crop. To estimate CO₂ fixation of the poplar SWRC, we balanced between C contained into wood (i.e. biomass productivity) and CO₂ emission from the activities associated to plantation, culture and harvest (i.e. machinery, herbicide and fertilization).

Main conclusions of this study were:

- 1.-The average productivity of the poplar SRWC was high (more 22 odt·ha⁻¹·year⁻¹) with a maximum of 26,5 odt·ha⁻¹·year⁻¹.
- 2.-This high productivity indicates that the poplar energetic crops are an important source of energy. In addition, as CO₂ fixation is a function of the productivity, poplar SRWC meets the international protocols of greenhouse effect gases emissions
- 3.-The residues generated after combustion were low, therefore the ashes do not affect boiler operation.
- 4.-A limitation factor for the development of SRWC of poplars is its water needs. Other limitation factors are the high cost associated to the dried of biomass for its energetic use.

Keywords: *Populus*, Spain, CO₂, SRWC.

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Subject Area: P1.Production Systems and Operations.

Comparing the Soil CO₂ Flux in Short Rotation Willow Crop (*Salix dasyclados*) Stand as Affected by Tear Out and Continues Production Treatments

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In shrub willow and other short rotation woody crops (SRWC) production systems, the complete understanding of the carbon balance requires quantification of inputs and outputs from various carbon pools. Carbon dioxide (CO₂) emissions via root respiration and decomposition of organic matter constitute a major fraction of carbon losses in SRWC systems. Very little data are available on soil respiration rates in SRWC. This study aimed to quantify soil CO₂ flux between treatments where willow was harvested and allowed to regrow vs willow that was harvested and allowed to resprout, killed with herbicide and the killed stump was ground into the soil. Treatments were applied across willow plots ranging in age from 5 to 19 years old. Measurements of soil CO₂ flux have been carried out using an automated soil respiration machine (LiCor 8100) and soda lime method to address spatial and temporal variability.

Preliminary results from the soda lime method indicated no statistically significant difference in CO₂ flux between and within rows of willow stems, although apparent within-row CO₂ flux was higher than between rows. The correlation between CO₂ flux and soil temperature ranged from 0.45 to 0.82 in all age classes. The CO₂ flux was significantly different among age classes. Before treatment application, the average soil CO₂ flux ranged from 1.03 to 1.66 $\mu\text{mol s}^{-1} \text{m}^{-2}$, which is equivalent to 4.1 to 6.6 Mg ha⁻¹ for a period of 104 days. Initial observations also revealed that the values obtained from soda lime method was not significantly different in some age classes, although values obtained from soda lime tended to be lower than those obtained from automated CO₂ flux machine. Soil CO₂ flux from both continuous production and tear out treatments increased immediately after treatments were applied.

Keywords: heterothropic respiration, soda lime, soil respiration machine,

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Poster Abstracts

Subject Area: 1. Production Systems and Operations

Introducing Alley Cropping on the Canadian Prairies

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The agroforestry practice known as alley cropping has long been valued in agricultural systems throughout the world. Unfortunately, little to no work has been done to explore the potential benefits on the Canadian Plains. To address this gap, the Saskatchewan Research Council has partnered with others to establish the first known alley cropping demonstration in Western Canada. This land use practice may not be feasible for the large scale cereal and legume producers on the prairies. A specialized set of growers such as First Nations, orchardists and biomass feedstock producers, who are often overlooked, will be the ones who benefit. The site was established on a research and demonstration farm in northeast Saskatchewan which provides an ideal place for farmers, students, researchers and the public to see firsthand the demonstration. The information presented will highlight the experiences encountered while planning and establishing the site in the spring and summer of 2010. As well, there will be a discussion of future crops to be planted in the alleys and how they fit the needs of the small scale producer.

Keywords: biomass, establishment, alley cropping, first nations, demonstration

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Subject: 1. Production Systems

Early Results for a Biomass Production System using Black Willow, Eastern Cottonwood and American Sycamore Under Two Levels of Fertility

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The interest in producing woody feedstocks for bioenergy has renewed focus on short rotation woody crop (SRWC) production systems. Much attention is being given to converting marginal agriculture lands in the Lower Mississippi Alluvial Valley into SRWCs. To address the questions concerning production and sustainability of these systems, a study was installed in the spring 2009 to compare three SRWC species on what is considered marginal cropland in eastern Arkansas (i.e., non-irrigated, non-leveled, and often poorly- to somewhat poorly- drained). Black willow, eastern cottonwood, and American sycamore were established on plots with and without fertilization. Survival was excellent (+95%) for all species except cottonwood. Aboveground biomass and fine root biomass production will be presented.

Keywords: fertilization, *Platanus occidentalis*, *Populus deltoides*, *Salix nigra*, SRWC

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Subject Area: 1. Production Systems and Operations

Field Trials Testing Commercial Herbicide Phytotoxicity on Shrub Willow (*Salix* spp.) Bioenergy Crops

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Successful establishment of plantations of shrub willow bioenergy crops requires effective weed management, especially during the first two growing seasons. While a number of pre-emergence and post-emergence herbicides have been regularly used in academic research trials and demonstration fields, there are no commercial products labeled in the United States specifically for use on shrub willow bioenergy crops. This project was designed to identify products that can serve in the management of weeds in commercial shrub willow fields, based on low phytotoxicity and efficacy in the control of typical problem weeds in willow plantings. In the spring 2010, field trials were established on three sites: Geneva and Fredonia, NY and Escanaba, MI using seven commercial willow varieties in six-plant plots replicated four times at each site. Eight individual pre-emergence herbicides were applied at two rates each: a typical labeled rate for each product and double that rate. Two additional treatments were mixtures of two different pre-emergence herbicides. Approximately 30 d after planting, five post-emergence herbicides were applied at two rates each. Mid-season and end-of-season stem growth measurements were collected that together with a second year of trial results can be submitted for supplemental labeling of desirable products for use in commercial shrub willow bioenergy crops.

Keywords: pesticides, pre-emergence, post-emergence, weed management

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