Estimating yield of shrub willow in the Northeast U.S. using a dynamic simulation model.

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Problem

Shrub willow (*Salix* spp.), has several characteristics making it ideal for perennial energy cropping systems: high yield potential, vigorous coppicing ability and a broad genetic base. In the Northeast U.S., there is a large production potential for shrub willow because of extensive areas of abandoned or marginal agricultural land. Our goal is to assess site-specific yield potential for shrub willow production in the Northeast US using dynamic simulation modeling.

Approach

We developed a modified version of the Precision Nitrogen Management (PNM) soil-crop process model (Melkonian et al., 2007) for this project. This model is a linkage between a soil N/water process model (LEACHN; Hutson, 2003) and a willow N uptake and growth model (Eckersten et al., 2006; Tharakan et al., 2008). This model simulates both crop growth, including stem biomass yield, as well as key crop and soil processes that can be used to determine site-specific yield potential. Key processes include:

• Daily potential N uptake as a function of LAI development (Eckersten et al., 2006) then adjusted for root zone available N;

• Annual potential stem biomass = RUE*fractional intercepted radiation and adjusted for seasonal PAW and N (Eckersten et al., 2006; Tharakan et al., 2008);

•Modified tipping bucket (soil)/simple water uptake (crop) (Riha, 2003);

•First order rate processes for N transformations;

Results

The PNM model was calibrated and parameterized based on relevant literature and comparison of simulations with measured shrub willow yield and N uptake data from experiments conducted at the SUNY-ESF Genetics Field Station in Tully, NY. The model was then tested by comparing simulated and measured 3 year rotation stem biomass yields (oven-dried tons ha^{-1}) for several locations in New York State and Vermont as the first step in using it to assess site-specific yield potential. We present the initial results of the testing below.

Table 1. Location, soil textural class, N management, measured and simulated stem biomass yields (3 yr rotation), and rotational growing season precipitation of test sites.

Location	Soil Textural Class	N management	Three Year Rotation Yields (odt ha-1) Measured	Simulated	Rotation / growing season precip (mm)
Wolcott	Sandy loam	20 t ha^{-1} chicken manure	27.5	30.6	1920
Burlington, VT	Silt loam	110 kg N ha^{-1} (1st yr)	25.5	19.3	2350
Tully_1	Silt loam	110 kg N ha^{-1} (1st yr)	26.8	30.4	2734
Tully_2	Silt loam	135 kg N ha^{-1} (1st yr)	22.2	20.2	2339
Sheridan	Clay loam	110 kg N ha^{-1} (1st yr)	18.8	18.3	2078
Canastota_1	Clay loam	Previous hay sod	27.5	22.7	2413
Canastota_2_Rot_1	Clay loam	110 kg N ha^{-1} (1st yr)	29.8	26.2	2413
Canastota_2_Rot_2	Clay loam	110 kg N ha^{-1} (1st yr)	35.6	33.8	2885

Figure. 1. Simulated vs Measured yield

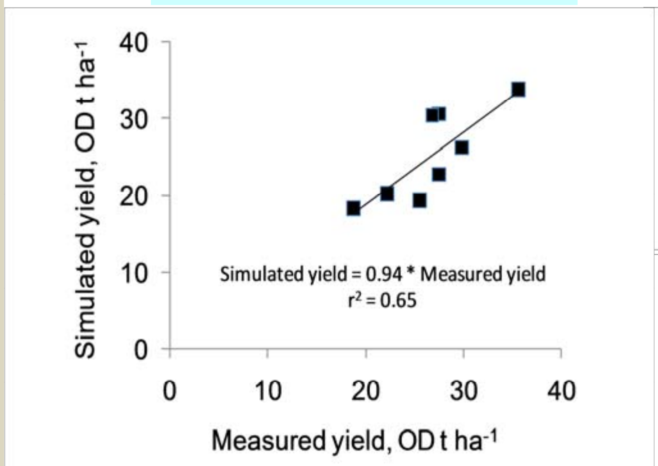
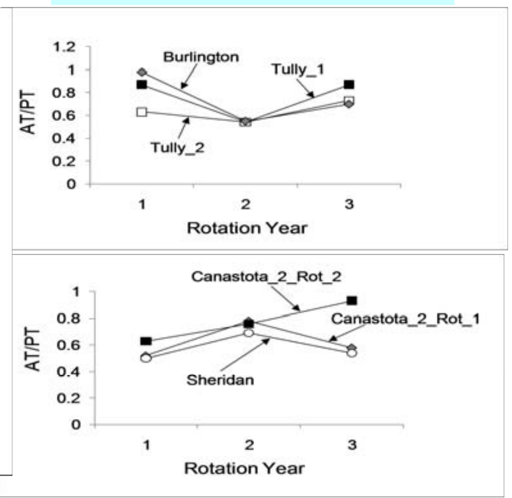


Figure 2. Actual Ts/ Potential Ts



Summary

• Reasonably good fit between model and measured 3-year biomass yield over a range of soil types, measured yields and total rotational growing season precipitation (Table 1; Fig. 1).

• Model results (Fig. 2) suggest that plant available water during the growing season is the primary site factor limiting productivity at current recommended N applications for shrub willow.

• Second rotation yield data will provide a more robust test of the model because of the influence of factors on the first rotation yield related to plantation establishment. These data will be available in 2010.

• Site characterization data, particularly soil water retention characteristics, rooting depth and the presence of a shallow water table (Wolcott location), are critical for accurate model estimates of site-specific yield.

• The model did not perform well at predicting year-to-year biomass yield for first rotation willow. We believe this is related to factors during plantation establishment (e.g. root system development, weed competition) not presently accounted for in the model. Second rotation data should help clarify discrepancies between model and measured year-to-year biomass yields.

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