Plant Science Research Unit Summary
NP 213 Workshop, September 18-20, 2007

RU name: Plant Science Research Unit
Location: St. Paul, MN
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Current research projects and objectives

a. ***Germplasm Development and Improvement***
Develop alfalfa biomass germplasm having higher yield, non-lodging large stems, and improved leaf retention for use in bioenergy crop rotation.

b. ***Genetic Modification of Cell Walls***
Develop alfalfa populations with modified cellulose, pectin, xylan, and lignin concentrations. Develop interfering RNA (RNAi) for knockdown of gene expression for genes involved in cell wall composition.

c. ***Translate Genomics from Model Plants to Crops***
Evaluate the effectiveness of using the *Medicago* gene chip for whole genome studies in alfalfa.

d. ***Genomic Analysis of Stem Cell Walls***
Evaluate whole genome transcript expression in elongation and post-elongation stem internodes of alfalfa and the model legume *Medicago truncatula* and identify candidate genes for modifying cell walls.

e. ***Cell Wall Biochemistry***
Identify and characterize the key enzymes (and their associated genes) involved in the production of activated monomers for cellulose and hemicellulose. Modulate enzyme activity through gene over-expression and gene knock down through RNAi.

f. ***Cell Wall Cross-Linking Effect on Degradation of Cell Walls***
Determine whether cross-linking of lignin and arabinoxylans by ferulate in corn stover and forage grasses slows microbial digestion of cell wall.

g. ***Crop Management Strategies for Bioenergy***
Determine how net energy yield and ethanol production potential varies with soil type, cropping system, and distance from the processing facility.

h. ***Nitrogen Contribution to Bioenergy Crop Production***
Determine nitrogen fixation rates of alfalfa and evaluate the contribution of symbiotically fixed nitrogen to maize production in sustainable biofuel crop production management.

i. ***Forage Composition and Its Effect on Ethanol Production***
Determine how cell wall lignin and polysaccharides affect ethanol and syngas production potential.

j. ***Genetic Markers for Bioenergy Quality in Maize Stover***
Identify QTL and molecular markers related to stover cell wall bioenergy availability.

Lead SYs and contact information

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Key Accomplishments

a. ***Germplasm***
Initial cycle of selection has been completed for a biomass alfalfa having stem and leaf traits ideal for bioenergy cropping management. Divergent selection for alfalfa with contrasting amounts of pectin, lignin, xylan, and cellulose has been completed.
b. ***Genomics***
The *Medicago* gene chip has been shown to be an effective tool to measure whole genome transcript expression in alfalfa. Initial array studies of elongation and post-elongation internodes of alfalfa have shown some 300 transcripts are overexpressed in elongating internodes as compared to post-elongating internodes.
c. ***Cell Wall Biochemistry***
The gene encoding USP a key enzyme in matrix polysaccharide biosynthesis has been identified and characterized. Expression patterns were analyzed in the model plant Arabidopsis. Expression knockdown lines for USP in alfalfa are being produced through RNAi.
d. ***Cell Wall Chemistry***
-- Genetic selection for reduced ferulic acid cross-linking in grasses results in improved microbial degradation of cell walls. A putative maize transposon mutant has been identified which contains reduced ferulate.
-- Microbial degradation of forage cell walls is inversely related to lignin.
-- Alfalfa cell walls modified for both cellulose and lignin composition improve ethanol production potential.
-- NIR spectroscopy prediction equations for rapid inexpensive evaluation of cell wall have been developed for sugar and lignin in alfalfa.
e. ***Management***
-- Biomass alfalfa germplasm when grown in a two-cut management system doubled ethanol yield potential and does not reduce leaf protein yield potential.
-- Alfalfa grown in rotation can effectively reduce the need for nitrogen fertilizer and results in greater economic yield for farmers.

Key Scientific Expertise at Location that can Impact Bioenergy Research

The forage scientists in the PSRU have active collaborations with University of Minnesota faculty on *Medicago* genomics related to bioenergy, cropping systems and bioenergy production, cell wall biochemistry, and QTL analysis in maize, soybean, and *Medicago*.