NP307 Bioenergy Program

Research Unit: U.S. Dairy Forage Research Center, Madison, WI

Primary contact for bioenergy: Paul J. Weimer

Current research projects and objectives:
CRIS 3655-41000-004-00D "Value-Added Products from Forages and Bioenergy Crops", 1.86 SY

Objectives:
1) Develop harvesting, fractionation and storage processes for forages and bioenergy crops that are economical, and retain product quality.
2) Identify specific varieties of biomass energy crops grown at specific locations under defined environmental conditions, that display maximum fermentability.
3) Develop switchgrass germplasm with broad adaptation across the northern USA and improved fermentability for conversion to value-added products.
4) Develop and improve fermentations for direct bioconversion of cellulosic biomass to value-added products (viz., ethanol, chemical feedstocks and novel bioadhesive components).

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Project Scientists: Michael Casler, Matthew Digman, Peter Vadas, Paul Weimer

Key accomplishments:

Bioenergy Crop Breeding. Developed, from multiple-year selections, upland varieties of switchgrass having enhanced winter-hardiness, for use at northern latitudes (HZ3 and 4) [Michael Casler]

Bioenergy Cropping Systems: Demonstrated that rotations of alfalfa and corn (1 yr alfalfa establishment/2 yr alfalfa cutting/1 yr corn) provide greater net energy yield and lower-cost energy production than does continuous cultivation of switchgrass. [Peter Vadas]

Biomass Harvesting. Developed harvesting strategies for corn stover, switchgrass and reed canary grass, and methods for low-moisture storage of these materials to reduce dry matter losses and retain product quality over prolonged storage periods (~1 yr) [specific cooperative agreement with Kevin Shinners, University of Wisconsin-Madison].

Biomass Quality Evaluation. Developed in vitro gas production measurement system for evaluating fermentability of biomass materials, and used assay to screen thousands of

biomass samples provided by 13 different research collaborators (6 within ARS) [Paul Weimer]
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Biomass Storage and Pretreatment. Demonstrated effective pretreatment of alfalfa, switchgrass and reed canarygrass with several pretreatment agents (sulfuric acid, calcium hydroxide, and ozone) at conditions compatible with low-cost on-farm pretreatments in sealed vessels (anoxic environment, low reactant concentrations, ambient temperature, 30 day exposure time). [Matthew Digman]

Biomass Conversion. Demonstrated that fermentation residues (residual substrate plus bacterial glycocalyx plus microbial cells) from consolidated bioprocessing of cellulosic biomass by ethanol-producing anaerobic bacteria (*Clostridium thermocellum* or *Ruminococcus albus)* can serve as an effective adhesive for bonding wood panels, particularly in combination with phenol-formaldehyde resins to reduce usage of PF, a petroleum-derived toxic chemical. Characterized chemical composition of glycocalyx and identified genes responsible for biosynthesis of glycocalyx precursors. [Paul Weimer]

Other scientific expertise/capabilities: The bioenergy research effort at the US Dairy Forage Research Center is unique in that it covers the entire spectrum of bioenergy production, from plant breeding to production, harvesting, storage, pretreatment and conversion. Because the problem of bioenergy production from cellulosic materials parallels in many respects the problem of improving digestibility of cellulosic materials by ruminant animals, the Center's bioenergy efforts are complemented by other CRIS projects, especially basic research on cell wall structure and biosynthesis, particularly with regard to lignin structure and lignin-polysaccharide crosslinking (John Ralph, Ron Hatfield, John Grabber). Additional expertise is provided by other DFRC scientists in the area of pasture management (Geoff Brink), forage testing and evaluation (David Mertens, Mary Beth Hall), legume breeding (Heathcliff Riday) and legume molecular biology (Michael Sullivan). We also maintain strong linkages with DFRC cluster scientists at St. Paul, MN, aimed primarily at enhancing the suitability of alfalfa as a bioenergy feedstock.