



Plant Feedstock Genomics for Bioenergy U.S. Departments of Agriculture and Energy

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2009 Awards

The U.S. Department of Energy's Office of Science, Office of Biological and Environmental Research, and the U.S. Department of Agriculture Cooperative State Research, Education, and Extension Service National Research Initiative have jointly selected seven projects for awards totaling \$6.3 million for biobased-fuel research*. These awards continue a commitment begun in 2006 to conduct fundamental research in biomass genomics that will establish a scientific foundation to facilitate and accelerate the use of woody plant tissue for bioenergy and biofuels.

The Hunt for Green Every April: Factors Affecting Fitness in Switchgrass

- Gautam Sarath, USDA-ARS, Lincoln

Goal: This project will investigate winter survival in switchgrass populations and individual plants specifically selected for greater yields and with known differences in winter survival. Molecular events occurring in the crowns and rhizomes will be studied over two growing seasons and winters. The goal is to make a significant and lasting contribution to the future improvement of switchgrass as a bioenergy crop, and will also directly benefit researchers working on developing other perennial grasses into biomass energy crops.

Phenomic Analysis of Natural and Induced Variation in *Brachypodium distachyon*

- John P. Vogel, USDA-ARS Western Regional Research Center, Albany

Goal: In this project, high-throughput phenotypic analysis (phenomics) of homozygous T-DNA mutants and natural accessions of the model grass *Brachypodium distachyon* (*Brachypodium*) will be conducted to accelerate the understanding of the basic biology underlying traits that control the utility of grasses as energy crops.

Accelerating the Domestication of *Miscanthus* for Biofuel Production

- Andrew H. Paterson, University of Georgia, Athens

Goal: This project will provide genomic tools and resources for a promising cellulosic biofuel crop, *Miscanthus*, that will (a) foster innovative strategies for its improvement and (b) develop comparative and bioinformatic approaches to enhance fundamental knowledge of *Miscanthus* genome structure, function, and organization.

Improving Alfalfa as a Biofuel Feedstock

- E. Charles Brummer, University of Georgia, Athens

Goal: Biofuel crops must maximize the production of energy, which requires a high yield of biomass with optimum fuel quality. In this project, molecular markers that are associated with optimal biofuel characteristics will be identified in alfalfa and directly integrated into traditional field-oriented alfalfa breeding programs. The long-term goal of this project is to develop biofuel-ready alfalfa cultivars that have improved yield and quality.

A Systems Biology Approach to Elucidate Regulation of Root Development in *Populus*

- Victor Busov, Michigan Technological University

Goal: This project will identify key regulators of root architecture in relation to nitrogen and water use in the bioenergy crop *Populus* using an integrated systems biology approach. This research will generate resources and innovations that can enable robust biomass productivity under marginal conditions for sustainable lignocellulosic biomass production.

Mechanism of Carbon Partitioning Regulation by *cpg13* in the Bioenergy Woody Crop Poplar

- Matias Kirst, University of Florida

Goal: This project will characterize genes that regulate the balance of carbon going to cellulose or lignin, leading to the development of plant materials that are more suitable for biofuel production.

Characterization of Nitrogen Use Efficiency in Sweet Sorghum

- Ismail Dweikat, University of Nebraska, Lincoln

Goal: Enhancing the ability of sweet sorghum to utilize nitrogen will increase its potential as a leading and cost-effective bioenergy crop. This project will identify novel nitrogen use efficiency alleles in wild sorghum germplasm that can be used to improve sweet sorghum.

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2008 Awards

The U.S. Department of Energy's Office of Science, Office of Biological and Environmental Research, and the U.S. Department of Agriculture Cooperative State Research, Education, and Extension Service National Research Initiative have jointly selected 10 projects for awards totaling \$10 million for biobased-fuel research*. These awards continue a commitment begun in 2006 to conduct fundamental research in biomass genomics that will establish a scientific foundation to facilitate and accelerate the use of woody plant tissue for bioenergy and biofuels.

Development of Genomic and Genetic Tools for Foxtail Millet, and Use of These Tools in the Improvement of Biomass Production for Bioenergy Crops

- Jeff Bennetzen, University of Georgia

Goal: Generate a variety of genomic and genetic tools for foxtail millet, including SNPs, BAC libraries, optimized foxtail millet transformation technology, and a high-density QTL and genetic map of foxtail millet for significant biomass traits. These resources will complement the DOE Joint Genome Institute whole genome sequencing of foxtail millet, enhancing its value as a functional genomic model for second-generation bioenergy crops such as switchgrass.

Identifying Genes Controlling Ferulate Cross-Link Formation in Grass Cell Walls

- Marcia Maria de Oliveira Buanafina, Pennsylvania State University

Goal: Investigate the regulation of ferulic acid cross-linking in the cell walls of *Brachypodium distachyon* and generate a saturated EMS mutant population for forward genetic studies in this model bioenergy crop.

Computational Resources for Biofuel Feedstock Species

- C. Robin Buell, Michigan State University

Goal: Provide computational tools and resources for data-mining of genome sequence, genome annotation, and large-scale functional genomic datasets available for biofuel feedstock species. Such species include candidates within the *Poaceae*, *Pinaceae*, and *Salicaceae* families, for which a diversity of genome sequence resources currently exist, ranging from whole genome sequences to modest EST transcriptome datasets.

Translational Genomics for the Improvement of Switchgrass

- Nick Carpita, Purdue University

Goal: Study the cell walls of grass species, performing bioinformatics analyses on cell-wall biosynthetic genes in maize, and annotate switchgrass orthologs. The project will also generate mutants in selected candidate cell wall-related genes, with direct analysis of saccharification of maize and switchgrass cell-wall mutants.

Genomics of Wood Formation and Cellulosic Biomass Traits in Sunflower

- Steven Knapp, University of Georgia

Goal: Develop genomic resources for woody biomass trait identification in hybrid sunflower, a species that is extremely drought tolerant. This fundamental knowledge will complement the existing body of work on this species with respect to oilseed production.

Identification of Genes That Regulate Phosphate Acquisition and Plant Performance During Arbuscular Mycorrhizal Symbiosis in *Medicago Truncatula* and *Brachypodium Distachyon*

- Maria Harrison, Boyce Thompson Institute for Plant Research

Goal: Identify genes controlling arbuscular mycorrhizal symbiosis, as well as key factors regulating gene function and the acquisition of key nutrients such as phosphate. The results will provide mechanistic and molecular-level understanding of plant-fungal partnerships in natural ecosystems and their role in maintaining a terrestrial soil environment for sustainable biofuel production.

Systems-Level Engineering of Plant Cell-Wall Biosynthesis to Improve Biofuel Feedstock Quality

- Samuel Hazen, University of Massachusetts

Goal: Identify and characterize cell-wall biosynthetic regulatory genomic binding sites using reverse and forward genetic approaches with candidate transcription factors in *Brachypodium* and *Arabidopsis*, two model plant systems. The results will contribute to our understanding of key tissue-specific and developmental regulators of plant cell-wall biosynthesis in monocot and dicot bioenergy crops.

Identification of Genes that Control Biomass Production Using Rice

- Jan Leach, Colorado State University

Goal: Provide an integrated breeding and genomics platform to identify biomass traits in rice, for translation to second-generation bioenergy grasses such as switchgrass and *Miscanthus*.

A Universal Genome Array and Transcriptome Atlas for *Brachypodium Distachyon*

- Todd Mockler, Oregon State University

Goal: Develop an Affymetrix genome tiling array, based on the DOE Joint Genome Institute sequence of *Brachypodium distachyon*, and make the array available for broad community use. The investigators will use the array to generate an expression atlas representing major developmental stages or stress responses in *Brachypodium*, a model species for polyploid, perennial grasses with complex genomes, such as wheat and switchgrass.

Epigenomics of Development in *Populus*

- Steven Strauss, Oregon State University

Goal: Construct a study of the role of chromatin modification (epigenetics) in the regulation of development and dormancy induction in poplar and other woody species. The investigators will characterize changes in DNA methylation patterns on specific tissues during dormancy induction and poplar development.

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2007 Awards

The U.S. Department of Energy's Office of Science, Office of Biological and Environmental Research, and the U.S. Department of Agriculture Cooperative State Research, Education, and Extension Service National Research Initiative have jointly selected 11 projects for awards totaling \$8.3 million for biobased-fuel research*. These awards continue a commitment begun in 2006 to conduct fundamental research in biomass genomics that will establish a scientific foundation to facilitate and accelerate the use of woody plant tissue for bioenergy and biofuels.

Towards a Map of the *Populus* Biomass Protein-Protein Interaction Network

- Eric Beers, Virginia State University

Goal: Map protein-protein interactions relevant to biomass production by focusing on proteins coexpressed in poplar xylem, site of the majority of lignocellulose synthesis and hence biomass accumulation in poplar.

Developing Association Mapping in Polyploid Perennial Biofuel Grasses

- Ed Buckler, USDA-Agricultural Research Service

Goal: Undertake an association-mapping study of two important biofuel grasses, switchgrass and reed canarygrass, to identify molecular markers tightly linked to biomass-related trait loci. This will enable marker-assisted selection and greatly accelerate breeding programs for enhanced biomass production.

Analysis of Small RNAs and mRNAs Associated with Abiotic Stress Responses in *Brachypodium distachyon*

- Pam Green, University of Delaware

Goal: Identify small RNAs related to stresses such as drought, temperature, and nutrient deprivation and relate them to the emerging genome sequence of *Brachypodium distachyon*, thus enhancing its value as a functional genomic model for energy crops and temperate grasses.

Linkage Analysis Appropriate for Comparative Genome Analysis and Trait Selection in Switchgrass

- Christian Tobias, USDA-Agricultural Research Service

Goal: Create a comprehensive marker set for switchgrass based principally on simple sequence repeats, and initiate development of a linkage map.

Development of Brown Midrib Sweet Sorghum as a Dual-Source Feedstock for Ethanol Production

- Wilfred Vermerris, University of Florida

Goal: Maximize the amount of fermentable sugar in the whole sorghum plant by identifying and isolating genes that control the high stalk juice sugar trait and a decreased stalk lignin trait, with the aim of eventually combining both traits in a single germplasm.

Insertional Mutagenesis of *Brachypodium distachyon*

- John Vogel, USDA-Agricultural Research Service

Goal: Create a collection of insertional mutants in *Brachypodium distachyon*. This resource collection can then be used to identify mutations in genes predicted to affect biomass quality and agronomic characteristics of other perennial grass energy crops.

A Functional Genomics Approach to Altering Crown Architecture in *Populus*: Maximizing Carbon Capture in Trees Grown in Dense Plantings

- Jerry Tuskan, Oak Ridge National Laboratory

Goal: Gain a molecular understanding of phytochrome-mediated responses to competition in *Populus* and then use that knowledge to maximize carbon capture per unit of land area for increased biomass production.

Identification of Cell-Wall Synthesis Regulatory Genes Controlling Biomass Characteristics and Yield in Rice (*Oryza sativa*)

- Zhaohua Peng, Mississippi State University

Goal: Examine cell-wall synthesis in rice, a model grass bioenergy species and the source of rice stover residues, using reverse genetic and functional genomic and proteomic approaches.

Development of Genomic Tools to Improve Prairie Cordgrass (*Spartina pectinata*), a Highly Productive Bioenergy Feedstock Crop

- Jose Gonzalez, South Dakota State University

Goal: Develop PCR markers for this species and construct an initial linkage map for prairie cordgrass, a native perennial high-biomass-yielding grass.

Resource Development in Switchgrass, an Important Bioenergy Crop for the U.S.A.

- Katrien Devos, University of Georgia

Goal: Construct a detailed genetic map of switchgrass based on simple sequence repeats and align it with maps produced in rice, maize, and sorghum. This will allow the exploitation of resources and sequence information generated for these well-studied cereals. The genetic maps also will serve as a framework for locating genes that control bioenergy traits.

Strategies for Using Molecular Markers to Simultaneously Improve Corn Grain Yield and Stover Quality for Ethanol Production

- Rex Bernardo, University of Minnesota

Goal: Optimize the use of DNA markers to simultaneously breed for high corn grain yield (for nonenergy and energy uses) and high stover quality for ethanol production.

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2006 Awards

The U.S. Department of Energy's Office of Science, Office of Biological and Environmental Research (BER), and the U.S. Department of Agriculture (USDA) Cooperative State Research, Education, and Extension Service (CSREES) National Research Initiative have jointly awarded nine grants totaling \$5.7 million for biobased-fuel research. CSREES and BER initiated this fundamental research program to facilitate the use of woody plant tissue, specifically lignocellulosic materials, for bioenergy or biofuels. The research projects will focus on poplar, alfalfa, sorghum, wheat, and other grasses.

Manipulation of Lignin Biosynthesis to Maximize Ethanol Production from *Populus* Feedstocks

- Purdue University, \$1.4 million
- Principal Investigator: Clint Chapple
- Co-P.I.: Richard Meilan, Michael Ladisch

Systematic Modification of Monoglignol Pathway Gene Expression for Improved Lignocellulose Utilization

- The Noble Foundation, \$800,000
- Principal Investigator: Richard Dixon
- Co-P.I.: Fang Chen

Sorghum Biomass/Feedstock Genomics Research for Bioenergy

- Texas A&M University, \$800,000
- Principal Investigator: William Rooney
- Co-P.I.: John Mullet; Steve Kresovich (Cornell University), Doreen Ware (Cold Spring Harbor Laboratory)

Streamlined Method for Biomass Whole-Cell Wall Structural Profiling

- USDA-Agricultural Research Service, University of Wisconsin, \$333,000
- Principal Investigator: John Ralph

Development of a Proteoglycan Chip for Plant Glycomics

- Carnegie Institute of Washington, \$359,100
- Principal Investigator: Chris Somerville

Biochemical Genomics of Wood Formation: O-Acyltransferases for Alteration of Lignocellulosic Property and Enhancement of Carbon Deposition in Poplar

- Brookhaven National Laboratory, \$300,000
- Principal Investigator: Chang-Jun Liu

Genomic Knowledgebase for Facilitating the Use of Woody Biomass for Fuel Ethanol Production

- North Carolina State University, \$700,000
- Principal Investigator: Vincent Chiang

Genetic Dissection of the Lignocellulosic Pathway of Wheat to Improve Biomass Quality of Grasses as a Feedstock for Biofuel

- Kansas State University, \$700,000
- Principal Investigator: Bikram Gill
- Co-P.I.: Wanlong Li

Using Association Mapping to Identify Markers for Cell-Wall Constituents and Biomass Yield in Alfalfa

- University of Georgia, \$445,000
- Principal Investigator: Charles Brummer
- Co-P.I.: Kenneth Moore (Iowa State University), Jeff Doyle (Cornell University)

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